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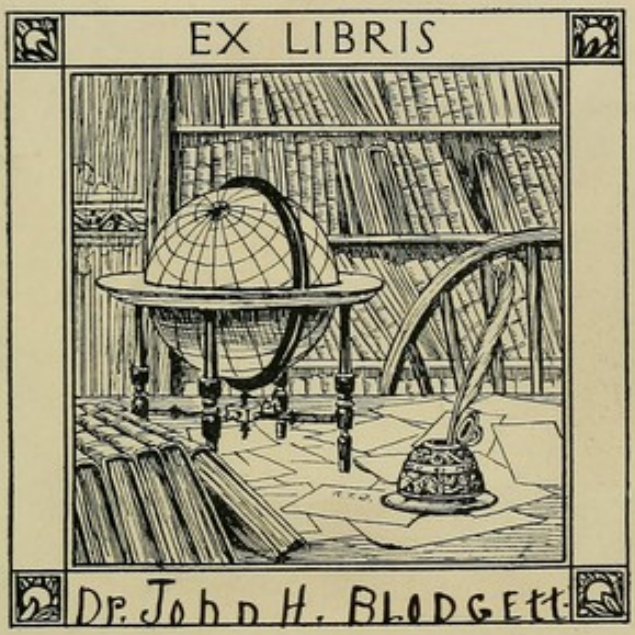
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A TEXT-BOOK

OF THE

DISEASES OF THE EAR

John H. Blodgett, M.D.
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A TEXT-BOOK

OF THE

DISEASES OF THE EAR

BOSTON MEDICAL LIBRARY

BY

DR. JOSEF GRUBER

PROFESSOR OF OTOLOGY IN THE IMPERIAL ROYAL UNIVERSITY OF VIENNA, ETC.

TRANSLATED FROM THE SECOND GERMAN EDITION BY SPECIAL PERMISSION OF THE AUTHOR

AND EDITED BY

EDWARD LAW, M.D., C.M. EDIN., M.R.C.S. ENG.

SURGEON TO THE LONDON THROAT HOSPITAL FOR DISEASES OF THE THROAT, NOSE AND EAR

AND BY

COLEMAN JEWELL, M.B. LOND., M.R.C.S. ENG.

LATE PHYSICIAN AND PATHOLOGIST TO THE LONDON THROAT HOSPITAL

WITH 150 ILLUSTRATIONS AND 70 COLOURED FIGURES ON 2 LITHOGRAPHIC PLATES

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ERRATA.

Page 7, line 11 from top, *for* "aqueductus" *read* "aquæductus."
„ 14, „ 11 from top, *for* "petro-squamosa" *read* "petro-squamosus."
„ 47, last line, *for* "Hen" *read* "Henle."
„ 79, line 12 from bottom, *for* "Amboss-Pankengelenk" *read* "Amboss-Paukengelenk."
„ 104, „ 9 from top, *for* "cochlea" *read* "cochleæ."
„ 139, „ 31 from top, *for* "diplacus" *read* "diplacusis."
„ 164, last line, *for* "bie" *read* "bei."
„ 174, footnote, first line, *for* "invariably" *read* "generally."
„ 253, line 22 from top, *for* "external" *read* "externa."
„ 300, „ 23 from top, *for* "pear-like" *read* "pearl-like."
„ 400, „ 9 from top, *for* "objective" *read* "subjective."
„ 450, „ 4 from bottom, *for* "normal" *read* "abnormal."

PREFACE TO THE ENGLISH EDITION.

THIS translation of Professor Gruber's *Lehrbuch der Ohrenheilkunde* was undertaken, conjointly with my friend and late colleague Dr. Coleman Jewell, at the request of numerous English and American medical friends with whom I was associated during my lengthened connection with aural and laryngological work in the Vienna General Hospital.

The justification for the appearance of an English edition of this text-book will be at once admitted, both on the ground of the position of the author in regard to the specialty, and also from the universal recognition of the value of his treatise by those acquainted with the original.

The size of the book is somewhat lessened, although a few additions have been made, and no matter of importance has been omitted; while the German text has been faithfully followed.

Reference must be made to the exceptional excellence of the illustrations, and more especially to the coloured figures in the plates, which form indeed a complete atlas of the appearances exhibited by the tympanic membrane in different pathological conditions.

The lettering of the figures may strike the reader as somewhat unusual, but is explained by the fact that the original *clichés* have been employed, and that the letters correspond to the German names.

To Dr. Howden, Lecturer on Anatomy in the University of Durham College of Medicine, I am deeply indebted for having kindly rewritten the anatomical part of the work. My thanks are also due to Dr. Wedmore of Bristol for many suggestions in the revision of proofs.

It is hoped that the publication of this translation will be welcomed by the many hundreds of English-speaking students who owe to their old teacher, Professor Gruber, their knowledge of this department of medicine.

EDWARD LAW.

35, Harley Street,
Cavendish Square, W.,
September, 1890.

AUTHOR'S PREFACE TO THE SECOND GERMAN EDITION.

The great advance which has taken place in the theory and practice of otology during the last ten years, imposes upon the teacher of this branch of medicine a task no longer possible to accomplish satisfactorily within the short space of time which it is customary to devote to it in the ordinary medical curriculum. This being the case, it must rest with private study to supply the unavoidable deficiencies left in this department.

A text-book arranged in such a way as to correspond with the method observed by the student in the acquisition of his clinical experience, will best meet these requirements; a general survey of the subject will be thereby facilitated, and the views of other writers will be the better appreciated.

This book should, therefore, prove of special service to the author's pupils, to whom it is submitted in the hope that they will regard it as some sign of his sincere desire to aid their further labours as far as lies within his power. He likewise trusts it may be found useful by those who, while they have not had the opportunity of receiving practical instruction in the specialty, afterwards come to recognise the necessity for an acquaintance with it in the course of their daily practice.

Self-taught in this field of work, the author is well acquainted with its difficulties, and has striven as far as he could to lessen them. He is firmly convinced that its successful cultivation is impossible without an accurate anatomical knowledge of this region; and he has, therefore, commenced this treatise with a complete description of the anatomy of the ear, which is accompanied by many illustrations from the masterly hand of Carl Heitzmann, skilfully engraved on wood by Ferdinand Frohning.

This arrangement is much better, in the author's opinion, than one in which the account of the pathological changes in each region is preceded by the anatomy of the particular part. Considering the intimate connection of the component structures of the organ, such a disjointed description would seem somewhat unnatural, and calculated to render a comprehensive view of the whole more difficult, without offering any compensatory advantage.

When it has appeared desirable, the descriptions in the text have been suitably illustrated by drawings; and the chromolithographic plates will undoubtedly assist in the recognition and comprehension of the various appearances exhibited by the drum-membrane.

The aim of this work is to serve as a text-book for students and practitioners; but should it be perused by others more experienced in the specialty, they may be asked to considerately remember the old adage:

"Indocti discant, et ament meminisse periti."

JOSEF GRUBER.

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DISEASES OF THE EAR.

INTRODUCTION.

THE important progress which has been made in otology during recent times has been owing, for the most part, to a thorough study of the anatomy of the ear, in health and in disease.

The more intimate our acquaintance has become with the minute structure of the different parts of the ear, and with their correlation with one another, with neighbouring parts, and with the general organism, the more satisfactory has become the guide thereby acquired for further investigations, the results of which have now secured for otology a recognised position in medical science.

A more exact knowledge of the topographical relations of the various aural structures has been of assistance in permitting a correct recognition of the nature of clinical cases which are otherwise undeterminable through the corresponding pathological changes. By a further comparison of such changes with those involving similar structures in other organs, it soon became evident that the constituent parts of the ear likewise conformed, both in their normal and abnormal states, to the same natural laws which govern these. It thus became possible to utilise for the benefit of otology the results which had been previously obtained from the far more advanced investigations in other branches of medicine, and in this way to acquire a more accurate foundation for diagnosis, for prognosis, and for treatment.

Had the results of physiological inquiry in the same department been comparable to that of anatomical investigation, the position of otology at the present day might well have vied with that of the most advanced specialty. Notwithstanding, however, the great zeal manifested by the most distinguished pioneers of physiological science, the results obtained are yet not of such a kind as can serve greatly to advance this branch of

medicine. The physiology of the labyrinth, especially, is still very obscure; and consequently it is not at all surprising that but slow advances have been made in the diagnosis and treatment of diseases of the internal ear.

Although the experimental method is undoubtedly not to be undervalued, it would certainly appear that future progress in the physiology of the ear must depend to a large extent upon clinical observation in connection with the elucidations of morbid anatomy in each particular case. Such a mode of procedure is naturally tedious, chiefly on account of the rarity with which it is possible to observe processes of disease limited to particular and defined parts of the aural organism. From the smallness and delicacy of these structures, as well as from their close anatomical connection, a morbid process almost invariably affects several of them at the same time; and it will usually, therefore, become very difficult to determine to which is to be ascribed the derangement responsible for any particular symptom manifested during life.

From what has been said, it must be obvious that a thorough knowledge of the anatomy of the ear is indispensable for the aural surgeon; and it will scarcely be necessary to insist upon the fact that the study of otology should commence with this subject.

The author feels the more inclined to proceed in this manner since it will afford him the opportunity of emphasizing the special otological importance of particular parts; to say nothing of his desire to comply with the request, frequently made of late by his students, to add such an anatomical description to a text-book on diseases of the ear as would be of service in practical work.

The physiological doctrines of chief importance from a practical point of view will be alluded to in their appropriate place.

A description of the organ of hearing ought to be preceded by an account of the cranial bone, which more than any other is in intimate relation with the ear itself; containing, as it does, either sequestered in its interior or in direct connection with it, all the special aural structures. The temporal bone forms, indeed, the bony habitation of the ear, the function of which may become deranged by the slightest disturbance of its osseous tenement. It participates in many ear diseases; while conversely, morbid processes which originate in it are apt to extend so as to involve the auditory organ proper.

ANATOMY AND PHYSIOLOGY OF THE AUDITORY ORGAN.

Description of the Temporal Bone.

Its position and relations. Its constituent parts, in their various stages of development.

The temporal bone (os temporum) is situated at the side and base of the skull, between the parietal, occipital, and sphenoid bones. Thus, it articulates above, by the greater part of its squamous border and by the upper edge of its mastoid process, with the parietal bone; in front, by the anterior part of its squamous border and by the anterior surface of its petrous portion, with the sphenoid; behind, its mastoid process is connected with the supra- and ex-occipitals; while internally, the posterior edge of its petrous portion articulates with the basi-occipital. An accessory connection takes place between it and the malar bone through the zygomatic process; while the apex of its petrous portion is in contact with the cartilage filling up the foramen lacerum medium.

The study of this complicated bone is facilitated by a knowledge of *its anatomy in the infant*, at which time it differs in many respects from that of the adult.

At birth, and for some months thereafter, it consists of three distinct parts, which can readily be separated from each other. These are—(1) the *squamo-zygomatic*, or *squama* (Fig. 1); (2) the *tympanic* (pars tympanica, or annulus tympanicus, Fig. 3); (3) the *petro-mastoid* (pars pyramidalis, Fig. 4).[1]

At birth these three principal parts are held together by connective tissue, which ossifies but slowly; so that, as a rule, towards the end of the first year, the bony connection between them is very imperfect. The process of ossification always commences between the upper extremity of the tympanic portion and the adjacent part of the squama, so that after a certain time the macerated temporal bone separates into two parts only; *the one representing the united squamous and tympanic portions, the other the petro-mastoid portion.*

A. The squamous portion (*squama, pars squamosa*) is flat, with an *external* convex, and an *internal* concave surface (Figs. 1 and 2). The curvature of the surfaces runs both from above downwards and from

[1] To these may be added the fourth, or *styloid* element, consisting of—(1) the *tympano-hyal*, or basal portion, wedged in between the tympanic and petrosal bones; and (2) the *stylo-hyal* portion, which projects downwards and forwards, and the extremity of which is connected with the small wing (*cerato-hyal*) of the hyoid bone by the stylo-hyoid ligament.

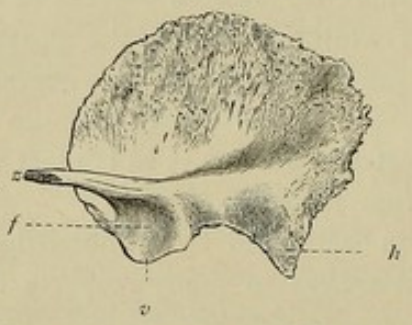
before backwards. The curvature from above downwards is scarcely perceptible in its upper two-thirds, but is well marked below on account of the horizontal direction of the lower third of the bone.

The squama is therefore divided into an upper, *perpendicular*, and a lower, *horizontal*, portion (*pars perpendicularis* and *pars horizontalis*).

The *zygomatic process* (*processus zygomaticus*—Fig. 1, *z*) springs from the outer surface, close to the junction of the vertical with the horizontal portion, and completes the *zygomatic arch* by articulating with the *malar* bone. At the root of the zygomatic process, between two small tuberosities, is seen the *fossa glenoidalis* (*f*), for the condyle of the lower jaw.

Fig. 1.

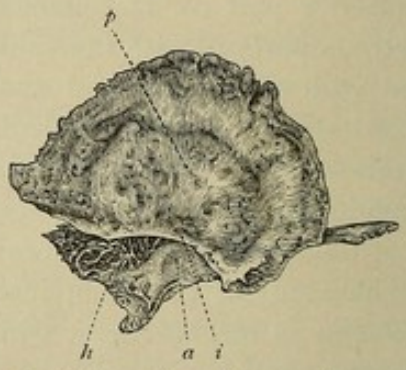
Squamous portion of the temporal bone seen from without.



z, Processus zygomaticus; *f*, Fossa glenoidalis; *v*, anterior, *h*, posterior process of the external plate of the horizontal portion.

Fig. 2.

Squamous portion of the temporal bone seen from within.



p, Vertical portion; *i*, internal, *a*, external plate of the horizontal portion; *h*, posterior part of the furrow between the two plates of the horizontal part.

The upper edge of the zygomatic process passes backwards and upwards as a well-marked ridge, which not only assists in the formation of the arcus temporalis, but also indicates the boundary between the perpendicular and horizontal portions of the squama.

Of the two prominences seen at the root of the zygomatic process, and between which is placed the articular cavity for the condyle of the lower jaw, the anterior (*eminentia articularis*), even in the infant, is rounded, while the posterior is more angular. The latter merely serves as a limitation of the articular cavity, while the former plays a most important part in the temporo-maxillary joint; for the condyle of the jaw passes forward on to this eminence when the mandible is depressed, and glides back into the fossa glenoidalis again when it is raised.

The *inner or median surface* of the squamous portion (Fig. 2) is almost quite smooth in the infant; while in the adult it exhibits depressions (*impressiones digitatæ*) produced by the cerebral convolutions, which in the child are less prominent than in the adult. In the upper two-thirds of the squama the two lamellæ of bone are in close relation to

each other, with but little diploë intervening, whilst at the lower and posterior part they suddenly and very strikingly separate from each other. The inner lamella (Fig. 2, *i*) is considerably shorter than the external at the posterior two-thirds of the bone, and shows much more distinctly the horizontal direction than the external (Fig. 2, *a*). A furrow or sulcus, opening inwards, is thus left between them, and this will presently be more closely considered.

The whole squama is bounded by an irregular margin, which in the case of the perpendicular plate is almost semicircular in shape. Here also it is sharp, on account of the deficiency of the internal lamella.

In the horizontal part this margin presents a somewhat zigzag outline, so that two processes—an anterior and a posterior (Fig. 1, *v* and *h*)—are directed downwards, between which the central portion, concave inferiorly, has a well-marked horizontal direction. At the anterior process (at *v*) the two plates of bone are equal in length, and are joined by a somewhat rounded-off margin; whilst at the posterior two-thirds, as has been already observed, the two lamellæ are separated, and the outer lamella alone forms the lower margin of this process.

On examining more closely the furrow (Fig. 2, above *h*), which opens inwards, and which is situated between the outer and inner lamellæ of the horizontal squamous portion, it will be seen that the anterior part is bounded by smooth walls, whilst the posterior (*h*) exhibits the characteristics of osseous cellular spaces. As we shall subsequently see, the anterior part of this furrow helps to complete the tympanic cavity, while the posterior assists in the formation of the mastoid cells.

The posterior extremity of the outer plate of the horizontal squamous portion, which assists in the formation of the mastoid cells, is described as the *os epitympanicum*, and is said to exist as a separate little plate until the second month of intra-uterine life.

B. The tympanic ring (*annulus tympanicus*) consists of a bony ring, incomplete at its upper and posterior part, and which shows on its concave margin a well-marked furrow (*sulcus tympanicus*). The upper extremities of the ring are distant from each other from 1 to 2 *mm.*; but in exceptional cases they may be in contact, and thus complete the osseous circle. The anterior extremity of the tympanic ring makes, at an early period, a slight twist on its longitudinal axis; so that the internal lip, which bounds the sulcus tympanicus, is visible when the bony ring is seen in its natural connection with the squama. The ring as a whole has a somewhat spiral direction.

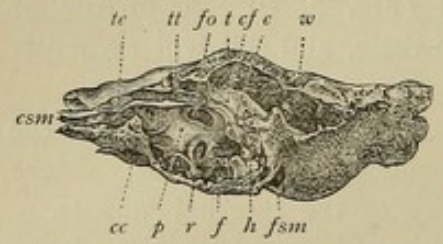


Fig. 3. Tympanic ring.

Hyrtl states that he possesses the temporal bone of an adult in which two tympanic rings exist (Handbuch der topographischen Anatomie in ihrer praktischen und chirurgischen Anwendung, IV. Auflage, p. 248).

C. The petro-mastoid portion (*pyramid* or *pars pyramidalis*) consists of what are generally described as the *petrous* and *mastoid* parts. At birth these are already joined to each other; and are, *for practical purposes only*, described separately.

Fig. 4.
Anterior surface of the petrous portion.



t, Tegmen tympani; *w*, mastoid fossa, or sulcus; *f*, fundus tympani; *fsm*, foramen stylo-mastoideum; *e*, eminentia pyramidalis, with the termination of can. pro musc. stapedis; *r*, foramen rotundum; *p*, promontorium; *cc*, entrance to carotid canal; *te*, tuba Eustach.; *tt*, semi-canalis pro tensore tympani; *fo*, foramen ovale; *cf*, canalis Fallopii; *h*, posterior wall of tympanic cavity; *scm*, septum canalis musculo-tubarii.

The anterior portion of the petro-mastoid element is almost rhomboidal in shape; while the posterior resembles a three-sided pyramid. The rhomboidal part is, on account of its compactness, called the *petrous portion* (*pars petrosa*); while the posterior, three-sided part is named the *mastoid portion* (*pars mastoidea*). An imaginary vertical plane close behind the stylo-mastoid foramen (*fsm*), and at right angles to the whole petro-mastoid portion, indicates the boundary between the antero-internal, or *petrous part*, and the postero-external, or *mastoid part*. The stylo-mastoid foramen represents the termination of the canalis Fallopii, which passes through the petrous portion.

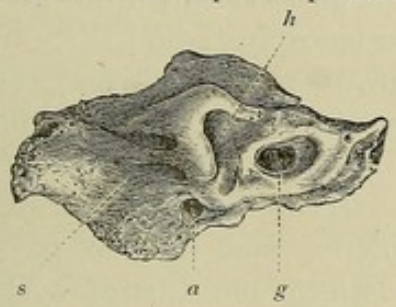
(*a*) *The petrous portion* has four surfaces and four borders. The surfaces may be described as—(1) *superior*, (2) *inferior*, (3) *anterior or external*, and (4) *posterior or internal*. The superior and posterior surfaces are directed towards the cavity of the cranium; the former completing the posterior part of the middle fossa, while the latter forms the anterior part of the posterior fossa of the skull. The inferior surface is turned away from the cranial cavity; and is seen at the basis cranii, between the tympanic ring, the great wing of the sphenoid, and the pars condyloidea of the occipital bone; whilst the anterior surface looks forwards and outwards.

The petrous portion is slightly twisted on its long axis, so that its superior surface is directed forwards and outwards, and its posterior surface somewhat upwards. The four surfaces of the petrous portion are separated by as many borders. They may be described as the superior and inferior median, and the superior and inferior lateral. In the infant the superior median border shows a conspicuous gap, which appears to undermine the eminence corresponding with the position of the superior semicircular canal. Although this gap is subsequently filled by osseous tissue, yet throughout life traces of it remain at this spot, in the form of an irregular depression.

The most important parts of the auditory organ are located in the petrous bone, and even an external inspection of its surfaces exhibits many characteristics which are of the greatest importance in otology.

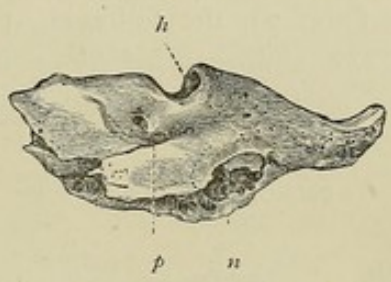
On its *posterior surface* (Fig. 5) is seen a furrow or depression which gradually deepens; and, passing downwards and backwards, leads to an elliptical opening with its long axis directed from before backwards: this is the entrance to the *internal auditory canal* (*meatus auditorius internus*). This canal passes from before, backwards and outwards, and will subsequently be more particularly referred to. At the distance of a few lines from it a fissure (*a*) is seen, which is tolerably wide in the infant, and from which there projects a bony plate. It leads to a very narrow canal, scarcely permeable by a small bristle, which begins in the vestibule of the labyrinth, and is known as the *aqueduct of the vestibule* (*aqueductus vestibuli*). In its immediate neighbourhood posteriorly is found a more or less well-marked impression in the bone, corresponding to the *recessus Cotugnii*, seen here on the dura mater.

Fig. 5.
Posterior surface of petrous portion.



h, Gap under the superior semicircular canal. Above is seen the tegmen tympani, which assists to form the upper surface of the petrous portion; *g*, entrance to internal auditory canal; *a*, aquæductus vestibuli; *s*, sulcus sigmoideus.

Fig. 6.
Upper surface of petrous portion.



p, Apertura spur. canalis Fallop.; *n*, mastoid fossa; *h*, gap below superior semicircular canal.

On the *superior surface* of the petrous bone (Fig. 6), near its centre, are seen one or two shallow grooves, having a direction almost parallel to its long axis, and leading to tolerably wide apertures (*apertura spuria s. hiatus canalis Fallopii*), through which the nervus petrosus superficialis major et minor enter, to join with the nervus facialis. The posterior part of the superior surface is somewhat arched or raised, marking the position of the superior semicircular canal of the labyrinth (*prominentia pyramidalis s. jugum pyramidale s. petrosum—h*). In the temporal bone of the infant this canal is undermined.

Von Tröltsch first directed attention to this cleft, and described it as the *fossa subarcuata s. hiatus subarcuatus*. He says that in the five months' fœtus it exists below the superior semicircular canal as a funnel-shaped cavity, 7 *mm.* high and 5 *mm.* wide; that it is filled up by a thick-walled blood-vessel, which gives off branches in all directions; and that it passes through the petrous bone to end behind the pinna on the outer surface of the future mastoid process, in a large, irregular opening, which is separated from the skin by cartilage. It still opens externally at birth, but is gradually closed by osseous material, and in the adult is

generally only recognised as a very narrow fissure. The large blood-vessel (arteria subarcuata) is accompanied by a small vena diploëtica subarcuata. According to *Wagenhäuser*[1] a trace of the fossa subarcuata is found at the time when the base of the skull in the embryo is cartilaginous.

In the infant it either opens on the exterior of the skull or, if complete ossification has taken place externally, on to the posterior surface of the petrous bone. The tissue which passes through the fossa subarcuata is a continuation of the dura mater, which contains the vessels just mentioned. As was known to *Cuvier*, this fossa, in many mammals, contains brain-substance, and in these it continues throughout life. According to *Voltolini*,[2] there exists, even in the adult temporal bone, a canal which leads to the mastoid cells (*can. petro-mastoideus*). The author has often been able to pass a bristle under the semicircular canal, to appear again on the upper surface of the petrous bone. Connective tissue passes through this opening, and is continuous with that under the semicircular canal. Like *Voltolini*, the author has frequently been able to demonstrate on the cadaver the progress of a purulent inflammation from the mastoid cells into the cranial cavity by this path.

On examining from behind forwards the *under surface* of the petrous bone (Fig. 7), the following points of importance are seen :—

The stylo-mastoid foramen (*foramen stylo-mastoideum—fsm.*), found at its posterior part, and which is the termination of the aquæductus Fallopii. In the temporal bone of the infant a second, smaller opening is seen, anterior and internal to this, through which the Chorda tympani passes ; branching, as it does, usually from the nervus facialis below the foramen stylo-mastoideum.[3]

Fig. 7.
Under surface of the petrous bone.



fsm, For. stylo-mastoideum ; *sj*, sulcus jugularis ; *cc*, entrance into the can. caroticus ; *s*, opening of the aquæductus cochleæ.

Farther forward is seen a furrow, very shallow in this stage of development, which, from the part it takes in the formation of the foramen jugulare, is named the *sulcus jugularis* (*sj*). In it are seen several small openings which lead to the *canalis tympanicus*, and which generally appear wider and more numerous in the temporal bone of the infant than in that of the adult. Still nearer the apex of the petrous bone *the entrance into the canalis caroticus* (*cc*) is seen, and this leads to the curved canal which opens on the upper surface near the apex of the petrous bone. Between the sulcus jugularis and the canalis caroticus, but placed somewhat behind the latter, is seen a tolerably wide triangular orifice (*s*), *the termination of the aqueduct of the*

[1] "Beiträge zur Anatomie des kindlichen Schläfenbeines," Archiv für Ohrenheilkunde, xix. Bd.

[2] Monatsschrift für Ohrenheilkunde, Jahrg. ii., Nr. 2.

[3] In the adult this lateral canal of the canalis Fallopii is found higher up, so that the second orifice is wanting on the inferior surface.

cochlea (*aquæductus cochleæ*), which is a small canal having its beginning in the cochlea. In front of this, at this stage of development, is a slight fossa which indicates the position of the *ganglion oticum s. Arnoldi.*

The *anterior or external surface* of the petrous bone (Fig. 4) is in its natural position partly directed forwards, and is of especial interest since it assists largely in the formation of the tympanic cavity. At its upper margin—*i.e.*, where it joins the superior surface of the petrous portion—a thin lamella of bone (*t t*) is seen projecting over the lateral surface, thus forming part of the roof of the tympanic cavity, and hence called the *tegmen tympani.* It passes uninterruptedly backwards to the mastoid portion, and there forms part of the covering of the mastoid sulcus.

The tegmen tympani is broader at the posterior part of the petrous bone than at its anterior part or at the mastoid process, whereby its external boundary appears undulating. Its anterior extremity lies deeper than the posterior.

Just as the tegmen tympani projects out from the lateral superior surface, so a second lamella of bone (*f*) shoots out from the lateral inferior surface of the petrous bone. This lies below the tegmen tympani, and may be named the *fundus tympani,* since it forms the greater part of the floor of the tympanic cavity. But whilst the tegmen reaches forwards towards the apex of the petrous bone, lying nearly parallel to its long axis; the fundus tympani has a more curved direction, since it stretches upwards behind the canalis caroticus (*c c*) to within 5 *mm.* of the tegmen. The most anterior part of the fundus tympani assists, therefore, in forming the posterior wall of the canalis caroticus.

If we follow the posterior part of the fundus tympani backwards it is seen to fuse with the mass of bone which is collected upon the wall of the canalis Fallopii and its adjacent small canal.

This mass (*h*), which is tolerably large at the lower two-thirds of this canal, terminates superiorly almost at the same height as the anterior extremity of the fundus tympani, and thus does not reach as high as the tegmen tympani.

The fundus tympani thus appears superiorly (*i.e.*, towards the tegmen) as a concave, rough, bony plate, whereas below it is smoother, and incompletely frames on three sides (viz., anteriorly, posteriorly, and inferiorly) a part of the anterior or external surface of the petrous bone; and this part corresponds to the *internal wall of the tympanic cavity.* The roof is formed chiefly by the tegmen tympani, already described; while the floor, together with the defective anterior and posterior walls, is formed by the above-mentioned fundus tympani, with its anterior and posterior processes. These relations will be studied in greater detail later on.

The part of the anterior (external) surface of the petrous bone which does not enter into the formation of the inner wall of the tympanic cavity is rough, and is seen at the basis cranii, where it articulates with the great wing of the sphenoid, and forms with this a groove for the lodgment of the cartilaginous part of the Eustachian tube.

As already stated, the fundus tympani, although stretching forwards and upwards, does not reach the tegmen, but lies about 5 *mm.* below it, and the bony mass in which the fundus terminates posteriorly, and which covers the canalis Fallopii and its adjacent canal, is at about the same level. A furrow, parallel with the long axis of the petrous bone, is therefore seen running from before backwards towards the tympanic cavity; and this furrow is narrower towards the apex of the petrous bone than it is at its extremity next the tympanic cavity (*vide* Fig. 4, near *scm*). Its *roof* is formed by the tegmen tympani, its *floor* by the anterior portion of the fundus tympani, and its *inner wall* by the anterior (external) surface of the petrous bone. On this inner wall, somewhat above the middle, is seen a lamella of bone (*scm*), running from before backwards, and extending almost as far as the centre of the inner wall of the tympanum, where it ends in a hooked extremity. The whole lamella of bone is called the *septum canalis musculo-tubarii*, and its beak-shaped posterior extremity is named the *rostrum cochleare s. processus cochlearis.* This septum is longitudinally grooved on its upper surface, and divides the furrow just described into two small semi-canals, running parallel to each other, of which the upper (*tt*) is small, and forms the *canalis*, or *semi-canalis pro musculo tensore tympani;* while the inferior, somewhat larger, forms *the bony part of the Eustachian tube* (*te*).

A small canal which runs along the whole septum musculo-tubarii, near its free margin, is named, from the nerve which passes through it, the *canalis nervi petrosi profundi minoris.*

Let us now consider more minutely that part of the external surface of the petrous bone which has been specially denoted as forming *the inner wall of the tympanic cavity* (*s*, Fig. 4). From above downwards we observe successively—(*a*) a bony projection running horizontally (*cf*), which indicates the position of the canalis Fallopii; immediately in front of this projection is seen (β) the *rostrum cochleare* of the septum musculo-tubarii; (γ) below the projection of the canalis Fallopii is the *oval fenestra* (*fenestra ovalis, s. foramen ovale, s. fenestra vestibuli—fo*), measuring 3 *mm.* long and 1·5 *mm.* broad, with its long axis directed downwards and backwards. This leads into the vestibule of the labyrinth, is kidney-shaped, and lies in a somewhat deep recess.[1] Behind the oval fenestra is seen (δ) a small bony projection, the *eminentia pyramidalis s. stapedii,*

[1] This recess, according to the researches of the author, exists in the second month of fœtal life, even before the foot of the stapes is developed.

from which (ϵ) a small bony spicule often stretches to the lower border of the oval fenestra or to the promontory.[1]

The apex of the eminentia stapedii is directed forwards, and exhibits a small opening, through which a bristle may easily be passed. This opening leads into a gradually dilating canal, somewhat curved at its commencement, but afterwards passing perpendicularly downwards, to terminate in the substance of the petrous bone. This canal is from 8-10 *mm.* long, and is for the lodgment of the *musculus stapedius*, the tendon of which emerges through the opening at the apex of the eminentia pyramidalis, and is inserted into the adjacent head of the stapes.

On the posterior wall of the canalis stapedius, at its lower part, another foramen is seen, for the passage of the nerve supplying the stapedius; this is derived from the nervus facialis.

Below the oval fenestra lies *the promontory* (*promontorium—p*), a bony projection containing the cochlear canals, and forming the greater part of the inner wall of the tympanic cavity, so that even in the macerated temporal bone only a very small portion of this wall, lying above and behind the promontory, can be seen through the external auditory canal.

While the convex promontorium disappears above, below, and in front, by gradually passing into the surrounding bony tissue, it is much more sharply limited behind. Here it walls round a depression, the nearly three-sided opening of which is directed backwards and outwards, and is named *the recess of the round fenestra* (*foramen triquetrum, Hyrtl*). In the bottom of this recess is seen the *round fenestra* (*foramen rotundum, fenestra cochleæ*).

The outer surface of the promontorium is smooth, but several shallow grooves, having nearly a perpendicular direction, are seen on it. The most important of these is a continuation of the canalis tympanicus, which commences on the upper wall of the petrous bone, and in its further course perforates the osseous substance beneath the processus cochleariformis, near to the anterior extremity of the fenestra vestibuli, and then becomes a simple groove, visible on the promontory. Below the promontory, it pierces the floor of the tympanum as a small canal close to the fenestra cochleæ, and its external opening is seen in the fossa jugularis, on the under-surface of the petrous bone.

From this groove on the promontory several shallower ones proceed forwards and inwards towards the apex of the petrous bone: one of these passes to the little canal in the septum tubæ; the others lead to foramina in the posterior wall of the can. caroticus (*sulci carotico-tympanici*).

Since the entrance to the recess of the round fenestra lies on a plane directed backwards and outwards, it is obvious that the extremities of the promontory do not project equally far backwards. The promontory may be said to end in two limbs—an *anterior* (lateral), and a *posterior* (median)—which meet superiorly in a rounded angle.

[1] As far as the author is aware, *Henle* first called attention to this rod of bone, which he described as always passing to the lower margin of the oval fenestra. The author has, however, often found its anterior end fused with the promontory; and possesses several pathological specimens where the limb of the stapes is united to this rod by pseudo-membrane, so that the movements of this ossicle are diminished.

Thus, while the recess of the round fenestra can be surveyed from the external auditory canal, the round fenestra itself is directed backwards, and cannot be seen from this aspect. In the fœtus, at the third or fourth month, the round fenestra lies nearly parallel with the membrana tympani, while at birth it is placed obliquely towards the drum, and afterwards it turns gradually backwards towards the opening into the mastoid cells. *Von Tröltsch* thinks that the infantile condition may, under certain circumstances, persist.

The relations of the round fenestra and its entrance will be again referred to when describing the labyrinth.

(*b*) *The mastoid portion* (*pars mastoidea*) is the immediate continuation of the petrous portion backwards and outwards. In the infant we can readily distinguish three surfaces.

The *superior surface* (Fig. 6) is the direct continuation, backwards and outwards, of the upper surface of the petrous portion, and like it, is enlarged in its broad diameter by the tegmen tympani. Immediately after birth the boundary between the upper surface of the mastoid portion and the tegmen is indicated by a slight furrow; this however becomes obliterated sooner than that which indicates the junction of the tegmen with the upper surface of the petrous bone. The whole superior surface is triangular, with its apex directed outwards and backwards.

The *outer surface* is convex (Fig. 4), and is interrupted by the mastoid sulcus already alluded to. Immediately above the stylo-mastoid foramen, a smooth protuberance indicates the position where the *mastoid process* is subsequently developed.

The *median surface* (Fig. 5, near *s*) is concave, and exhibits a groove, still very shallow at this stage of development, which passes downwards and forwards. This groove is called the *sulcus sigmoideus*, and serves for the lodgment of the sinus of the same name. In the entire skull it is continuous above with the sulcus transversus on the occipital bone, and below with the sulcus jugularis, which ends at the foramen jugulare.

The *superior median border* is in immediate continuity with the same border of the petrous bone; the *superior lateral border* is connected anteriorly with the squama, while posteriorly it articulates with the posterior-inferior angle of the parietal bone; the *inferior border* articulates with the occipital bone. Of these margins the superior median is quite smooth, while the superior lateral and the inferior are moderately serrated. The substance of the mastoid, as compared with that of the petrous portion, is much more porous.

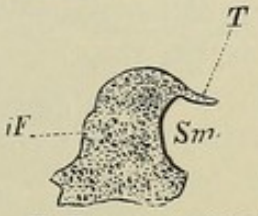
It is frequently pierced obliquely in the vicinity of its upper or posterior border by one or more canals, but sometimes these are only completed by the occipital bone. They are the *mastoid foramina* (*foramina mastoidea*), and open into the posterior part of the sulcus sigmoideus. Through these, small arteries pass to supply the dura

mater, while the accompanying veins establish an anastomosis between the sinus transversus and the veins of the scalp. The individual characteristics of the mastoid portion are much less distinctly marked in the infant than in the adult.

If a section is made through the mastoid process of an infant, perpendicular to the long axis of the sulcus mastoideus, and carefully examined, it is seen that this sulcus is separated from the median surface (*i.e.* from the cranial cavity) by an osseous wall from 6 to 8 *mm.* thick near the petrous bone, but becoming thinner posteriorly. This osseous substance is tolerably compact, but a portion of the mastoid cells is subsequently developed in it. With the development of these, the osseous septum between the sulcus mastoideus and the cranial cavity must necessarily become thinner and thinner, and hence at puberty it is frequently not more than 1 *mm.* in thickness; indeed, in some cases this bony partition is partly absent, especially in the neighbourhood of the greatest concavity of the sulcus sigmoideus, and in these cases the dura mater rests immediately against the lining of the mastoid cells.

Fig. 8.

Section through the mastoid process of an infant.



T, Tegmen tympani; *Sm*, sulcus mastoideus; *iF*, inner (cranial) surface of the mastoid process.

The great importance of this relationship to pathological conditions is evident, if one remembers that the same part of the dura mater contains the sinus sigmoideus, and most frequently furnishes the connection between otitis media suppurativa and inflammation of the structures within the cranium.

When, later in life, the mastoid cells are again filled by osseous tissue, it often happens that those next the cranial cavity disappear first, so that the lamella of bone which bounds the mastoid cells internally again becomes thicker.[1]

Connections of the Principal Parts of the Temporal Bone at Birth.

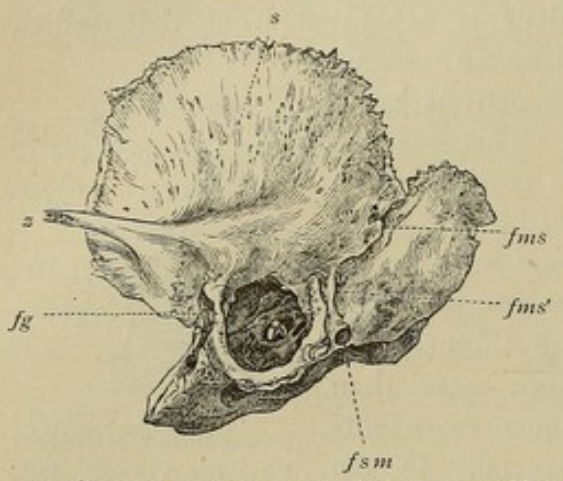
As already stated, the several pieces of the temporal bone are at birth united only by soft connective tissue, and therefore easily separable by maceration; and thus we have an opportunity of studying more closely, not only their manner of union, but also the construction of the essential parts of the auditory apparatus. Such a study also gives us a better insight into the individual pathological processes, which, in many particulars, would otherwise remain hidden.

[1] Compare with the author's article "Ueber die Beziehungen der Otitis int. zu den entzündlichen Affectionen der Gebilde innerhalb der Schädelhöhle," Zeitschrift der k. k. Gesellschaft der Aerzte in Wien, 1864.

1. *Connection of the squamo-zygomatic with the petro-mastoid portion* (Figs. 9 and 10).—Both lamellæ of the horizontal part of the squamous portion join the petro-mastoid. The internal lamella abuts with its free edge against the outer margin of the tegmen tympani, a small amount of soft connective tissue completing the union. This loose connection has the appearance of a fissure, which is called the *fissura petro-squamosa s. sulcus petro-squamosa* (Fig. 10, *sp*). While the anterior part of the internal lamella touches the corresponding part of the tegmen tympani, which forms the roof of the tympanic cavity, its posterior part articulates with the free margin of the posterior part of the tegmen, and assists in the formation of the sulcus mastoideus.

Fig. 9.

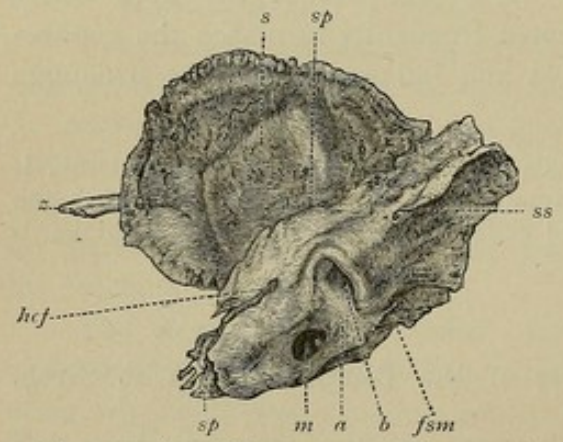
Temporal bone of an infant seen from the outer side.



s, Squama; *fms*, *fms'*, fissura mastoideo-squamosa; *fg*, fissura Glaseri; *fsm*, foramen stylo-mastoideum.

Fig. 10.

Temporal bone of an infant seen from the inner side.



s, Inner surface of the squama; *sp*, fissura petro-squamosa; *z*, processus zygomaticus; *hcf*, hiatus canal. Fallopii; *sp*, apex of petrous portion; *m*, entrance to internal auditory canal; *a*, termination of aquæd. vestib.; *b*, depression below the superior semicircular canal; *fsm*, foramen stylo-mastoideum; *ss*, sulcus sigmoideus, on the inner surface of the mastoid portion.

The outer lamella of the horizontal portion of the squama articulates only by its posterior part with the petro-mastoid, and thus the angular space between its two lamellæ comes into consideration, since its anterior part, bounded, as we have already seen, by smooth walls, serves for the enlargement of the roof of the tympanum; while its posterior part, limited by rougher walls, serves for the completion of the sulcus mastoideus.

The posterior part of this outer lamella projects downwards to the mastoid portion near to the foramen stylo-mastoideum. The connection between the horizontal part of the squama and the mastoid portion is indicated by the *fissura mastoideo-squamosa*, which is of extreme importance in practice (Fig. 9, *fms*). That part, slightly undulating below, between the two processes of the outer lamella of the

horizontal portion of the squama, stands free in the macerated bone, and forms, as we shall see, the posterior superior segment of the inner margin of the external auditory canal.

From this description of the connection between the squama and the petro-mastoid portion, it is evident that the horizontal part of the squama assists in the formation of that section which is generally looked upon as belonging to the mastoid portion.

As has been already shown, the two lamellæ at the anterior portion of the horizontal part of the squama join below in a rounded edge (Fig. 1, *v*); this with the pars tympanica assists in forming the fissura Glaseri, to be subsequently described.

2. *Connections of the tympanic ring with the squamous and petro-mastoid portions.*—The tympanic ring is attached to the squamous and petro-mastoid portions of the temporal bone, so that the greater part of its circumference touches—through the intervention of a little connective tissue—the external margin of the fundus tympani; whilst its extremities reach upwards to the outer plate of the horizontal portion of the squama. The posterior-superior segment of the tympanic ring comes close to the posterior process of this portion of the squama; while the anterior reaches the squama merely with its most external extremity, close to the posterior tuberculum of the zygomatic process.

Through this attachment of the tympanic ring is effected the formation of the osseous part of the external auditory canal (as shown in Fig. 9), as well as the closure, anteriorly and laterally, of the canalis musculo-tubarius. Since the outer edge of the tegmen tympani comes almost into contact with the tympanic ring, a fissure exists between the anterior-superior segment of the tympanic ring and the most anterior part of the horizontal portion of the squama. At birth this fissure (*fissura Glaseri*) is tolerably wide, and is directed from behind, downwards, forwards, and inwards, and is seen under the glenoid cavity for the lower jaw. It serves for the entrance of certain structures to, and for the exit of others from, the tympanum.

The mastoid recess or sulcus mastoideus, which later in life contains the mastoid cells, is closed externally by the junction of the squama with the petro-mastoid portion; the osseous part of the external auditory canal is formed by the union of the squama with the tympanic ring; the canalis musculo-tubarius by the union of the tympanic ring with the petro-mastoid; while the bony cavity of the tympanum is completed only by the union of all three segments of the temporal bone.

Further Development of the Temporal Bone.

The soft connective tissue which at birth forms the bond of union between the principal parts of the temporal bone soon gives place to a more solid osseous material, but indications of the former subdivision

are still to be recognised in the adult. The bony connection is first established between the upper extremities of the tympanic ring and the horizontal portion of the squama, and hence at a certain stage of development one is able to separate the bone into two pieces, one representing the squama with the attached tympanic ring, the other the petro-mastoid. On examining the squamoso-tympanic portion thus obtained, one is able to convince himself that the mastoid portion does not assist in the formation of the external auditory canal, and that the statements which have been made to the contrary by some authors are incorrect. Had the mastoid process taken a part in the formation of the external auditory canal, then the ring in the squamoso-tympanic portion would necessarily have been imperfect posteriorly; but this is not the case

The osseous part of the external auditory canal is formed in front, behind, and below, by the tympanic ring; above, by the outer plate of the horizontal portion of the squama. The extent to which this plate completes the wall of the auditory canal depends on the distance between the two extremities of the tympanic ring. Sometimes in the adult its two extremities come almost into contact, so that the upper wall of the osseous auditory canal may be partly formed by the tympanic ring.[1]

The knowledge of the formation of the osseous auditory canal is of importance from a pathological point of view, since the progress of inflammatory processes and other changes in the bone is influenced to a great extent by the density of its different parts. Thus, while the tympanic ring is almost as compact as the petrous bone, the mastoid portion, on the other hand, is more diploëtic, and contains large cellular spaces, lined by a vascular mucous membrane, to which an inflammation of the neighbouring structures easily spreads.

Even if the osseous connection has already taken place between the extremities of the tympanic ring and the horizontal portion of the squama, traces of the former separation remain. These are distinguished as the *fissura tympanico-squamosa*, *anterior* and *posterior*; they elongate in the further growth of the different parts of the temporal bone, and remain more or less distinct during life, thus rendering possible the penetration of soft vascular tissues into the deeper parts.

After osseous union has taken place between the upper extremities of the tympanic ring and the squama, the same process also commences at the other points of contact between the different parts of the temporal bone, and in some places goes on more rapidly than in others. Thus, the antero-superior part of the tympanic ring, together with its posterior extremity and the lower part of the posterior process of the horizontal portion of the squama, become united with the neighbouring bone sooner than the other portions, and hence in the central part of the fissura

[1] Compare *Dr. Ludwig Joseph*, "Osteologischer Beitrag über das Schläfenbein," &c., Zeitschrift für rationelle Medicin, III. Reihe, xxviii. Bd.

mastoideo-squamosa the soft connective tissue persists much longer than at its two extremities.

About the end of the first year—sometimes a little earlier, and in exceptional cases much later—the osseous union is completed, leaving behind distinct traces of the former separation. The temporal bone now resembles, to some extent, that of the adult, and its further development consists in the growth of its individual parts in various directions; and thus the bone and the individual osseous portions of the auditory organ assume their characteristic form.

So long as the different parts of the temporal bone are united by connective tissue, a slight movement between them is possible. On comparing the peculiarities of the auditory organ of the infant with those of the adult, this slight movement would seem to be indispensable. It will again be more particularly referred to.

Joseph[1] states that in the fœtus at the fourth month the floor of the tympanic cavity is partly formed by fibrous tissue lying between the tympanic ring and the inferior lateral margin of the petrous bone. This the author can confirm from his own observations.

Development of the Temporal Bone after the end of the first year. Description of the fully developed bone in the adult.

After the osseous connection between the individual portions of the temporal bone has been completed, the different parts undergo enlargement, until at puberty the bone reaches its perfect development. The growth takes place in fixed directions, and hence the form of the adult bone differs in many respects from that of the child. It is important, therefore, to follow its development carefully.

(*a*) *Growth of the pars squamosa.*—This, by its further development, increases in all its dimensions, and thus the relationship of its different curvatures is emphasised. The pars horizontalis, especially, assumes the position from which its name is derived. The squama also becomes more compact, and the elevations and depressions on its cranial surface are rendered more distinct. The grooves in which the larger vessels run are also better seen. Thus we perceive, on the outer aspect of the squama, immediately behind the root of the zygoma, a somewhat winding groove for the art. temporalis media, while on the cranial surface is seen the deep groove for the art. meningea media.

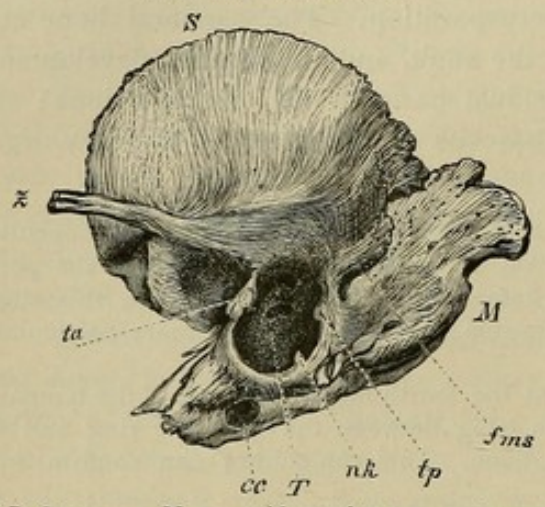
Beginning at the anterior-inferior angle, this groove passes at first almost directly upwards, and then turns backwards. The ridges on its outer surface, which give attachment to the temporal muscle, become

[1] Zeitschrift für rationelle Medicin, 1866, xxvii. Bd., S. 111.

more distinct, the roots of the zygoma more prominent, while the zygoma itself becomes stronger and more arched. On account of the absence of diploëtic tissue at the bottom of the glenoid cavity, and also opposite the impressiones digitatæ, the squama in these positions is tolerably transparent.

Fig. 11.

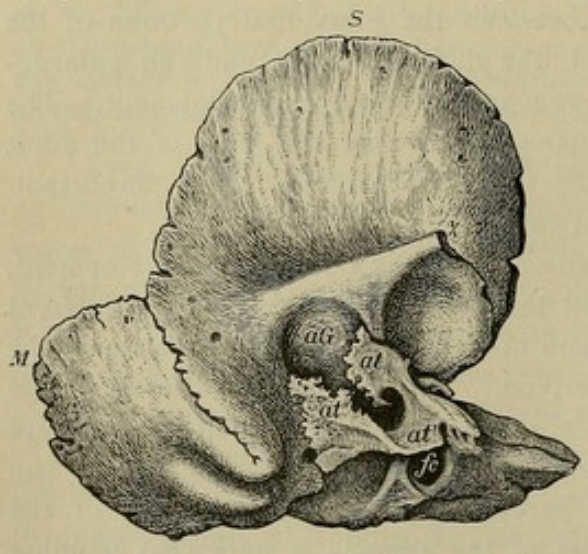
Temporal bone at birth.



S, Squama; *M*, mastoid portion; *z*, proc. zygomaticus; *T*, tympanic cavity; *fms*, fissura mastoideo-squamosa; *cc*, foramen caroticum; *ta*, *nk*, *tp*, epiphyses indicating the commencement of the growth of the tympanic portion.

Fig. 12.

Temporal bone from a boy two and a half years old.



S, Squama; *M*, mastoid portion; *z*, zygomatic process; *fc*, foramen caroticum; *aG*, external auditory canal: the tympanic portion, *at*, *at'*, *at''*, has so far developed that only the anterior wall of the auditory canal appears imperfect. It will be readily seen how *Huschke's* foramen can easily persist in the anterior wall.

The upper border of the zygoma is prolonged backwards as a distinct boundary between the perpendicular and horizontal portions of the squama, and forms the upper part of the outer margin of the meatus auditorius externus. Many anatomists describe the posterior part of this line as indicating the junction between the squama and the mastoid process, but this has already been shown to be quite incorrect. Both above and below that part of the temporal line which assists in forming the external auditory meatus, many small nutrient foramina are seen, into which connective tissue and small blood-vessels pass.

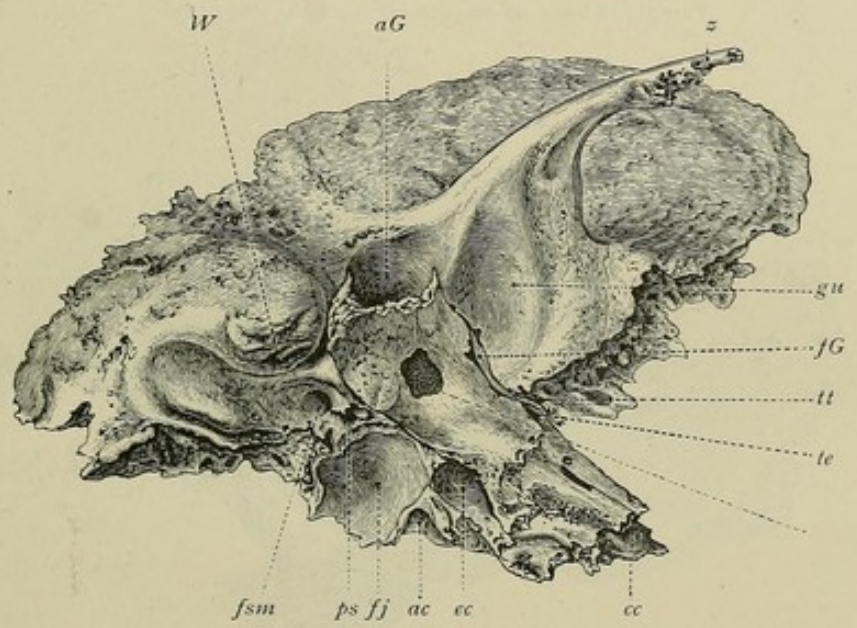
(*b*) *Growth of the tympanic ring.*—Simultaneously with the development of the horizontal part of the squama, the tympanic ring grows backwards, upwards, and outwards, and is thus transformed into a bony furrow. This constitutes the *tympanic part* (*pars tympanica*) of the temporal bone of the adult. Regarding the development of the tympanic portion from the tympanic ring many different views are maintained. *Kölliker* holds that the tympanic portion is developed from the tympanic ring; while *Von Tröltsch* and others maintain that at birth the tympanic ring is united to the cartilaginous part of the auditory canal by a membranous

structure, which subsequently ossifies and forms the tympanic portion. *Böke*,[1] on the other hand, declares that up till the first year of life a cartilage exists where bone is subsequently met with, and that this cartilage undergoes ossification. He found that at the thrid year, the cartilaginous material was almost quite replaced by bone, only a small unossified gap existing at its inner extremity, which is also found in the temporal bone at the age of ten years.

The results of the author's investigations seem to show that in the fœtus, and also in the newly born child, a tolerably firm membranous

Fig. 13.

Temporal bone of adult. The under surface of the petrous portion is also seen.



z, Processus zygomaticus; *aG*, external auditory canal; *W*, mastoid process; *gu*, glenoid cavity for lower jaw; *fG*, fissura Glaseri; *l*, gap in the anterior wall of the external auditory canal; *tt*, entrance to the canal for the tensor tympani; *te*, entrance to the bony part of the tuba Eustachii; *cc*, termination of canalis caroticus; *ec*, entrance to can. carot.; *ac*, opening of aquæductus cochleæ; *fj*, fossa jugularis; *ps*, remains of processus styloideus; *fsm*, foramen stylo-mastoideum.

structure exists between the tympanic ring and the cartilaginous part of the auditory canal. The remains of this membrane persist as the ligamentous structures which unite the bony with the cartilaginous part of the fully developed auditory canal. The growth of the tympanic ring takes place backwards, upwards, and outwards, and is chiefly from the outer lip of the sulcus tympanicus. The formation of new bone does not proceed uniformly along its whole margin; and hence, as development proceeds, irregular outgrowths may be observed. These by their further enlarge-

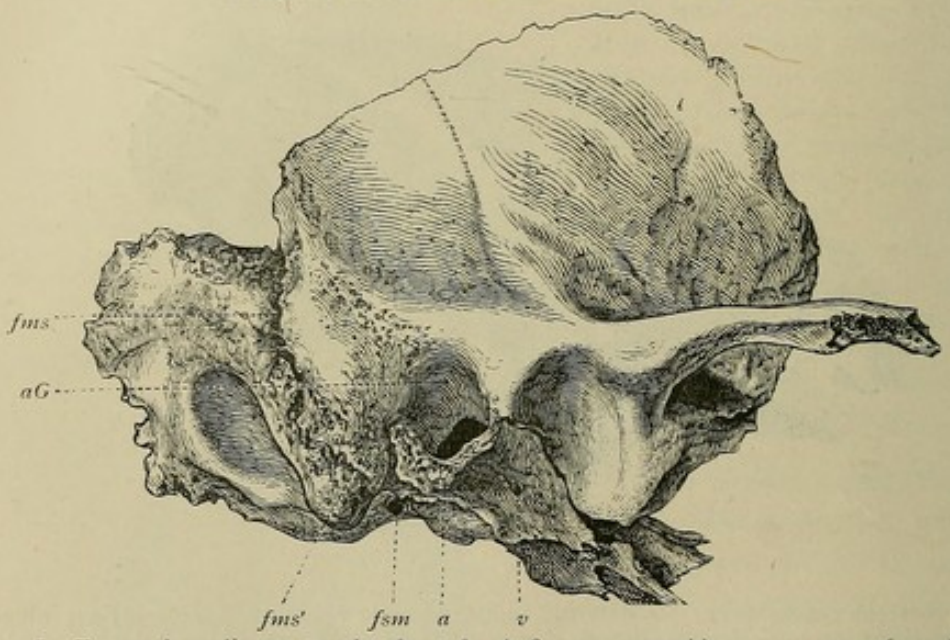
[1] *Dr. Julius Böke*, "Der Meatus auditorius externus in Allgemeinen und die Verknöcherung der vorderen und unteren Wand desselben im Besonderen," *Virch. Arch.*, 29 Bd. p. 472 ff.

ment fuse with each other, and so convert the tympanic ring into that osseous canal which constitutes the future tympanic portion.

On examining the temporal bone of a child at the end of its first year, there are found, both on the anterior-superior and posterior-inferior parts of the tympanic ring, small rods of bone, which, as development proceeds, come to touch each other and coalesce. The remaining part of the bone has not yet developed to the same extent, and thus it happens that about the end of the second year a gap is found in the tympanic portion, situated internally to its united anterior and posterior parts. This gap is only filled later in life with osseous material, and not infrequently

Fig. 14.

Temporal bone of adult seen from the outer side.



aG, External auditory canal; *fms*, *fms*,' fissura mastoideo-squamosa; *fsm*, foramen stylo-mastoideum; *a*, outer margin of the external auditory canal; *v*, anterior wall of the external auditory canal, above which the fissura Glaseri is seen.

persists as a distinct hole (gap in the anterior wall of the auditory canal, to which *Huschke* first directed attention—Fig. 13, *l*). The new bony formation, which is developed at the anterior and posterior parts of the annulus tympanicus, and which maintains a curved direction, having its concavity towards the lumen of the auditory canal, grows also in length. The superior extremities of the tympanic ring, which after birth become united with the squama, still grow outwards, so that the horizontal portion of the squama comes to assume more and more its proper direction; and approaching, both in front and behind, the outward-growing tympanic ring, coalesces more or less closely with it, and thus there result the *fissura tympanico-squamosa, anterior and posterior*. As a rule, the outer part of the tympanic portion is the thicker, while the part between its

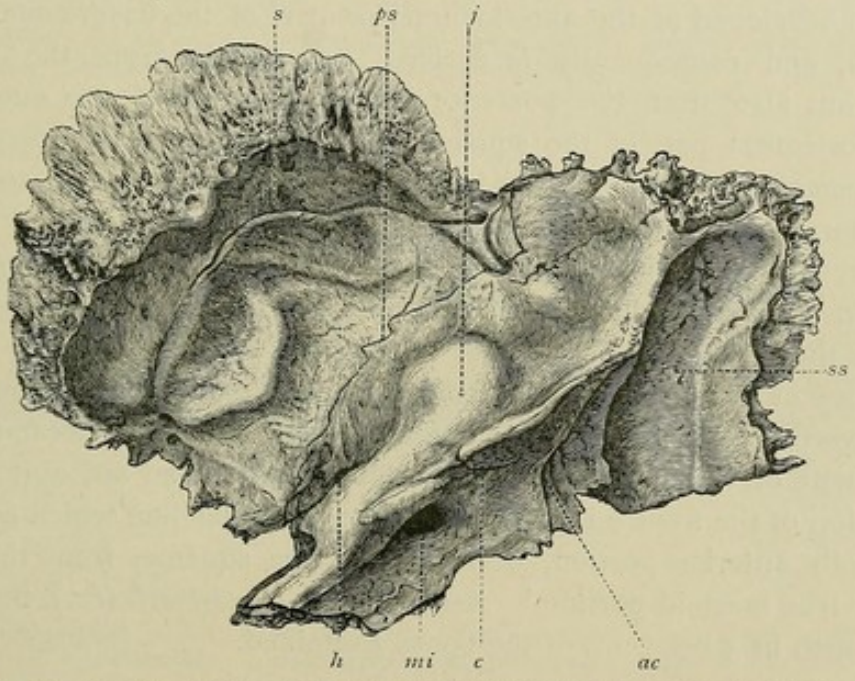
outer and inner extremities is thin even to transparency, if, as already mentioned, it is not entirely deficient.

Bürkner,[1] who examined a large number of temporal bones of different ages and different races, is of the opinion that after the fifth year the gaps or foramina in the pars tympanica occur much less frequently. He also found that they existed oftener in females (41·1 per cent.) than in males (17·3 per cent.). He could not determine as to their frequency of occurrence in different races.

As a result of the further development of the squamous portion and of the tympanic ring, the fissura tympanico-squamosa, anterior and posterior,

Fig. 15.

Temporal bone of an adult, viewed from the inner surface.



s, Sulc. art. mening. med.; *ps*, fissura petro-squamosa; *j*, jugum pyr.; *ss*, sulcus sigmoideus; *ac*, aquæductus vestibuli; *c*, superior opening of the canalis petro-mastoideus (Voltolini); *mi*, meatus auditorius internus; *h*, hiatus canalis Fallopii.

become elongated, so that in the adult bone the former makes a more or less obtuse angle with the fissura Glaseri; while the latter runs somewhat obliquely downwards and outwards, in front of the mastoid process, to the under surface of the petrous bone.

At the lower margin of the perpendicular portion of the squama, immediately above the opening of the external auditory canal, there is often found the *spina supra meatum*, a small horizontal crest of bone, above which is seen a small fossa. Sometimes only the fossa exists, the spine being absent. According to *Kiesselbach*,[2] it occurs in 27 per cent. of

[1] "Beiträge zur normalen und pathologischen Anatomie des Gehörorganes." Archiv für Ohrenheilkunde, xiii. Bd., S. 163, und xiv. Bd., S. 136.

[2] *W. Kiesselbach*, "Beitrag zur normalen und pathologischen Anatomie des Schläfenbeines mit besonderer Rücksicht auf das kindliche Schläfenbein." Archiv für Ohrenheilkunde, xv. Bd., 4. Heft.

adult temporal bones, and is never developed in later years, unless a rudiment of it exists in early life.

It is of importance in connection with the operation of making an artificial opening into the mastoid process. The author has, in his collection, the temporal bone of an adult where, instead of the spina supra meatum, a foramen exists, having a diameter of 1·5 *mm.*, and leading into the mastoid cells.

(*c*) *Development of the mastoid portion.*—The earliest indication of the future mastoid process is seen about the end of the first year, when the union of the squamous and tympanic portions has advanced a certain stage.

It is developed at the anterior-inferior part of the fissura mastoideo-squamosa, and consequently is derived, not merely from the mastoid portion, but also from the posterior-inferior process of the outer plate of the horizontal part of the squama. Hence the *mastoid process* (*processus mastoideus s. mammillaris*) is not derived only from one section of the temporal bone, as was formerly generally supposed, but is an outgrowth resulting from the further development of *two pieces of the os temporum.* As an indication of this, the *fissura mastoideo-squamosa* is found in the adult temporal bone, either as a complete fissure running in a more or less zigzag manner from behind and above, downwards and forwards, or as a series of small linear clefts or foramina, the arrangement of which betrays their origin; or if these are quite closed, the position of the fissure is indicated by an irregular line which separates the smooth anterior portion, derived from the squama, from the rough posterior true mastoid portion.[1] According to *Kiesselbach* (*l.c.*), the fissure is quite open in 3 per cent. of the bones examined.

The author first called attention to the existence of the fissura mastoideo-squamosa, and the remnant of it in the adult, as well as to its great importance in practice. *A. Politzer* disputes this, and quotes *Du Verney* as having first described it. In order to settle the question, it will be sufficient merely to quote a passage from *Du Verney's* work. In his "Tractatus de Organo Auditûs," Norimbergæ, 1684, he shows, in a drawing, the position where, in the infantile temporal bone, the fissure existed between the squama and petrous bone. In explanation he says, "Duæ autem istæ partes osseæ *perfecte uniuntur* in adultis." From this it is clear that *Du Verney* had no knowledge of the fissure in the adult.

Kirchner,[2] who examined the skulls of thirty children and three hundred adults, found this fissure existing either perfectly or partially in most cases, and indeed on both sides. If it is unilateral, then it occurs more frequently on the left side. Sex and age showed no difference. It was present in the skull of a person who died

[1] *Jos. Gruber*, "Beiträge zur Anatomie des Schläfenbeines in ihrer Anwendungen auf die practische Ohrenheilkunde." Wiener medicinische Wochenschrift, 1867.

[2] "Ueber das Vorkommen der Fissura mastoideo-squamosa und deren praktische Bedeutung." Archiv für Ohrenheilkunde, xiv. Bd., S. 190.

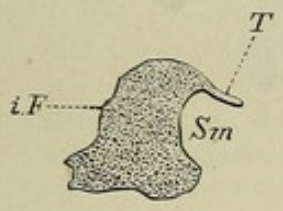
aged eighty-three. In skulls with a well-marked fissura mastoideo-squamosa, the thickness from without inwards of the mastoid process is found to be less in proportion to its breadth and height.

The *mastoid process* in the adult temporal bone has the form of a cone somewhat flattened from without inwards, and having its apex directed downwards, the outer surface being more arched than the inner. Its median surface presents a deep groove (*incisura mastoidea*), which gives attachment to the posterior belly of the m. digastricus.

The inner margin of this groove sometimes forms a prominent crest of bone, running downwards, parallel to the mastoid process.[1]

Fig. 16.

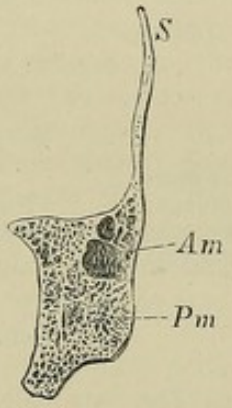
Section through the mastoid portion at birth.



T, Tegmen tympani (posterior part); *iF*, inner surface of the mastoid portion; *Sm*, sulcus mastoideus.

Fig. 17.

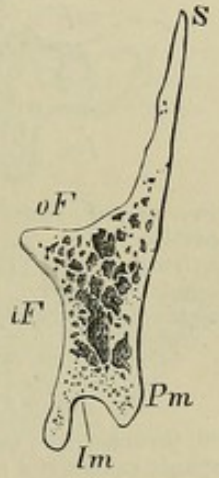
Section through the mastoid portion of a child, aged two years.



S, Squama; *Am*, antrum mastoideum; *Pm*, processus mast. (The antrum mastoideum is surrounded internally and below by diploëtic osseous tissue.)

Fig. 18.

Section of the mastoid portion of a boy, aged three years.



oF, Upper surface of the mastoid portion; *Pm*, processus mast.; *Im*, incisura mast.; *iF*, inner surface. (The cells of the mastoid process, as well as the process itself, are more distinctly developed.)

Internal to this crest is seen the groove for the art. occipitalis (*sulcus art. occipitalis*).

The outer surface of the mastoid process is rough, especially posteriorly, and exhibits many small vascular apertures. It betrays also the internal cellular structure, since its outer wall is frequently very thin, and may in exceptional cases be atrophied at different points, so that the air-cells in its interior open outwards on to the surface of the bone. Through such openings one can reach, not only the mastoid cells, but also the tympanic cavity, and even beyond it.

It will thus be evident that a substance situated in the mastoid cells can

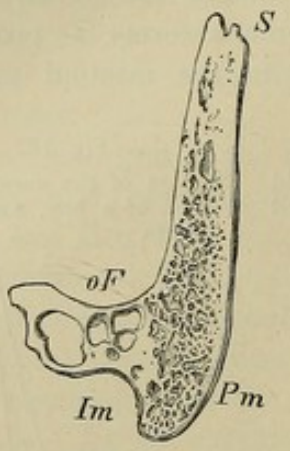
[1] The mastoid process is often separated into two processes by a deep furrow passing across it from before backwards.

pass out through such openings, and reach the occipital and cervical regions. The author has often seen emphysema of the subcutaneous tissue in this region produced by inflation of the tympanic cavity.

Simultaneously with the growth of the mastoid process, its cellular spaces are further developed. This further development takes place

Fig. 19.

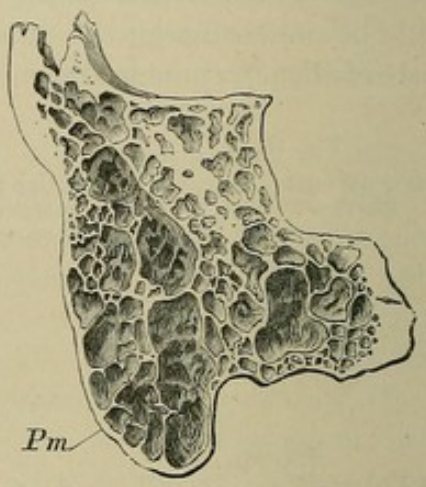
Section through the mastoid portion of a man aged thirty.



S, Squama; *oF*, upper surface of the mastoid portion; *Pm*, processus mastoideus; *Im*, incisura mast. (The largest air-cells are found internally, while the mastoid process itself is more diploëtic.)

Fig. 20.

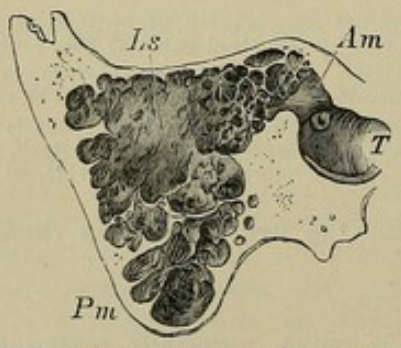
Section through the mastoid portion of a man aged thirty.



Pm, Proc. mastoideus. (The cellular spaces are very strongly developed.)

Fig. 21.

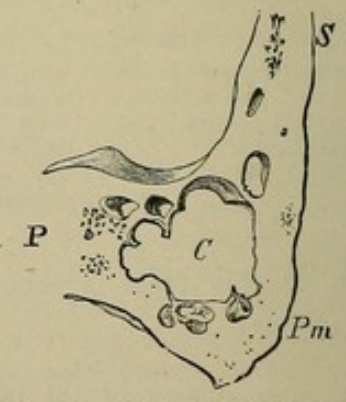
Section through the mastoid portion and tympanic cavity of a man aged thirty.



T, Tympanic cavity; *Am*, antrum mastoideum; *Pm*, processus mast., with the air-cells *Ls*.

Fig. 22.

Section through the mastoid portion of a man aged thirty.



S, Squama; *Pm*, processus mast.; *P*, petrous substance; *C*, a large air-cell, with several smaller ones in its vicinity.

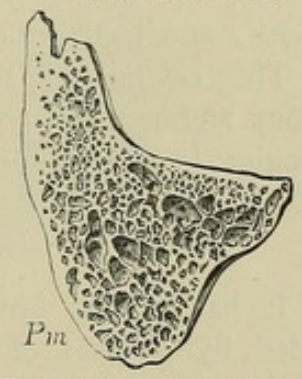
(1) partly in the mass of osseous tissue which separates the sulcus mastoideus from the cranial cavity through the simple enlargement of its diploëtic spaces, and (2) partly from those cellular spaces which we have already seen as existing in the posterior part of the furrow situated between the two parts of the horizontal portion of the squama. From this mode of development, it is evident that the air-cells are

arranged in two sets—a *median*, next the cranial cavity, and a *lateral*, in the mastoid process proper. Coincident with the development of the mesially-placed cellular spaces, there is a gradual thinning of the wall of bone which separates them from the sinus sigmoideus. The furrow on the inner surface of the mastoid portion for the sinus sigmoideus becomes much more distinctly marked than in the temporal bone of the child, and the permanent tissue of the mastoid portion becomes more compact, although still showing numerous foramina for connective tissue and blood-vessels, which pass from both its outer and inner surfaces into its interior.

Dr. Giovanni Zoja, of Pavia, made the processus mastoideus and its cells the object of careful study.[1] Having examined sixty-eight recent and one hundred dried skulls, he shows that if a line be taken from the centre of the incisura mastoidea to the apex of the process to represent the height, a horizontal line from the centre of this incisura to the outer surface of the mastoid process as the thickness, and a horizontal line, crossing the last, from the anterior to the posterior margin of the process as the breadth, the height = 12 *mm.*, the thickness = 13 *mm.*, and the breadth = 19 *mm.*; and further, that in female skulls the measurements are about 1 *mm.* less than in male skulls. *Velpeau's* view, that the proc. mastoideus is more largely developed in old age, is not confirmed by *Zoja*. The average thickness of the lamella of bone covering the mastoid cells externally is from 1 to 2 *mm.*

Fig. 23.

Section through an entirely diploëtic mastoid process of a man aged thirty.



Pm, Processus mastoideus.

The cells are sometimes so large that occasionally only a single cell or cavitas mastoidea is found. Out of the sixty-eight cases examined, this was seen once on both sides, and once unilaterally. The cells in the centre are usually the largest, and communicate with each other, unless closed by the lining membrane. In several cases they were limited to the base of the mastoid process, but sometimes they were found extending to the side of the cranium, or even to the centre of the petrous bone. According to *Zoja*, many of the recorded cases appear to indicate that the development of the cellular spaces follows a definite system. They become gradually larger, are lined by a special membrane, and filled by a gelatinous mass which gradually becomes serous, and is either absorbed by the vessels of the cellular spaces or passes into the tympanum and is there absorbed.

Zuckerkandl[2] found that in one hundred temporal bones taken from fifty cadavera the mastoid process was pneumatic in 36·8 per cent., entirely diploëtic in 20 per cent., and partly diploëtic in 42·8 per cent.

In order to represent clearly the important differences both as to the size and the arrangement of the cells, the author has given in figs. 16-23 drawings of sections of some mastoid processes. The number of variations which exist

[1] "Der Processus mastoideus und dessen Zellen," Ann. univers. clxxxviii., p. 241, Maggio, 1864.

[2] "Monatsschrift für Ohrenheilkunde." xiii. Bd., 1879.

is enormous, and no positive conclusion can be formed as to its internal structure, either from external inspection, palpation, or percussion.

The continuous development of the brain; the extension of the neighbouring cavities with their contained structures; and the soft tissues situated in its vicinity, which from birth have other functions to fulfil, certainly exercise in the development of the temporal bone a powerful influence both upon its external form and the structure of its bony tissue.

Larger Canals and Cavities in the Temporal Bone.

A glance at the temporal bone shows that it is traversed not only by the canals already described, but by others, both large and small; while some are contained in it, the presence of which is partly indicated by the external configuration of the bone. Without mentioning the smaller canals alluded to in the description of the individual parts of the temporal bone, the following are of the greatest importance to us: viz., the *canalis musculo-tubarius;* the *canalis caroticus;* the *canalis Fallopii;* and lastly, the *meatus auditorius externus* and *internus.*

The cavities of the temporal bone are situated chiefly in the petrous and mastoid portions, and may be divided into two sets; one belonging to the middle, the other to the inner ear.

1. *Canalis Musculo-tubarius.*

It has already been described how this is formed, and that it is divided by a plate of bone into two parallel canals, the one being placed above the other. The lower and larger one forms *the osseous part of the tuba Eustachii;* the upper the *canalis s. semi-canalis tensoris tympani.* The canal for the tuba Eustachii has the form of a blunt cone, its summit being directed towards the apex of the petrous bone, and its base towards the tympanic cavity; so that the osseous part of the tube widens out as it approaches the tympanum, through the anterior wall of which it opens.

The semi-canal for the musc. tensor. tympani reaches farther into the tympanic cavity than the tuba Eustachii, since the septum can. musc.-tub. projects backwards a short distance on the inner wall of the tympanum. This septum, which separates the two canals, rarely reaches the outer wall of the canal (the tympanic ring) in the infant; and sometimes this condition persists in the adult; although, as a rule, the septum is then complete.

In the recent bone the two canals are, however, completely separated along their whole course, since the deficiency in the bony septum is made good by membrane. In the macerated bone the entrance

to the canalis musculo-tubarius is to be found in the angle formed by the junction of the anterior margin of the squama with the petrous portion (Fig. 13, near *te*).

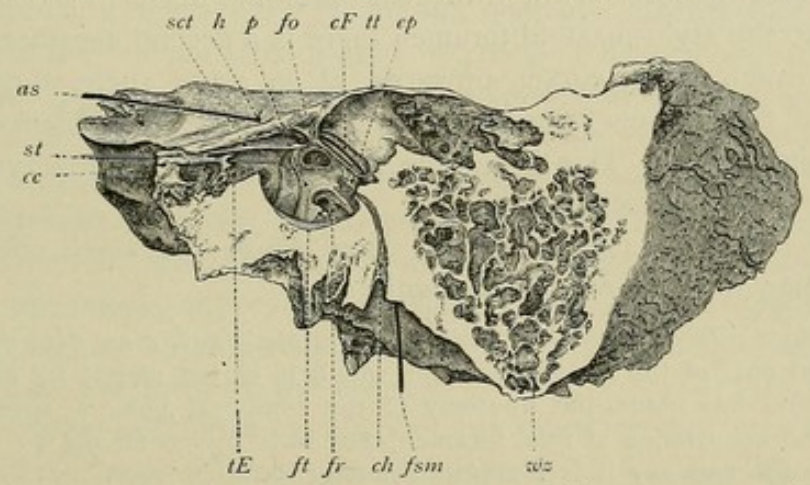
2. *Canalis Caroticus.*

The canal for the transmission of the art. carotis interna through the petrous bone begins on its inferior surface, and ascends in the form of a well-marked arch towards its apex (Fig. 24).

In taking this curved direction it pushes the fundus tympani towards the tympanic cavity, so that it forms its anterior wall, which is imperfect superiorly. The large internal opening of the canal is found at the apex

Fig. 24.

View of the anterior surface of the petrous bone united with the mastoid.



sct, Semican. pro m. tens. tymp.; *h*, apert. spur. can. Fallop.; *p*, promontorium; *fo*, foram. ovale; *cF*, can. Fallop. (at this spot artificially opened); *tt*, continuation of tegmen tympani; *ep*, eminentia pyramidalis; *wz*, mastoid cells; *fsm*, for. stylo-mastoideum; *ch*, can. pro chorda tymp.; *fr*, for. rotund.; *ft*, fundus tympani; *tE*, tuba Eustachii; *cc*, canalis caroticus; *st*, septum can. musculo-tubarii (a bristle has been passed through the small canal found in this septum, and another through the canalis Fallop.).

of the petrous bone, and varies in size; so that the art. carotis, on its entrance into the cranial cavity, is immediately covered by an expansion from the dura mater, differing in size in different cases. The tympanic cavity is separated only by a thin plate of bone from the art. carotis; while a similar lamella intervenes between it and the osseous part of the tuba Eustachii, which runs for a short distance in the same direction as the art. carotis.

The posterior wall of the canalis caroticus is pierced by numerous small foramina, which bring it into communication with the tympanic cavity, and through which pass many small vessels from the carotis (*Langer*), and small nervous filaments from the plexus sympatheticus on the carotis to the mucous membrane of the tympanic cavity.

3. *Canalis Fallopii.*

The *Canalis Fallopii*, through which the nervus facialis passes, begins at the anterior-superior depression in the bottom of the internal auditory canal, and ends at the stylo-mastoid foramen. Between its two extremities the canal makes two angular curvatures. The *first or oblique portion* extends across the long axis of the petrous bone as far as the accessory opening (Fig. 24, *h*, *apertura spuria canalis Fallopii*), situated on the upper surface of the petrous bone. At this point it turns abruptly backwards, so as to form a well-marked angle (the *anterior knee*). The *second or horizontal portion* extends backwards a short distance above the fenestra ovalis, and almost parallel with the long axis of the petrous bone. Lastly, it passes in an easy curve (the *posterior knee*) downwards, to form the *third or vertical portion*, which ends at the stylo-mastoid foramen. In the horizontal part there is a small opening for the transmission of the nerve to the stapedius, while near to the stylo-mastoid foramen there is a second aperture, leading to a small canal, which curves upwards, at an acute angle, through the substance of the petrous bone, and which perforates the posterior wall of the tympanic cavity. This is for the passage of the chorda tympani, a branch of the nervus facialis.

In the horizontal portion of the canal there is a small opening for communication with the canalis tympanicus.

According to *Henle*,[1] there "almost constantly" exists an oval opening in the horizontal part of the canalis Fallopii, which is closed merely by membrane. Every one who has made the anatomy of the temporal bone a special study recognises the occurrence of this foramen, but it is by no means so frequently present that one can say it is "almost constant."

If, as *Rüdinger* says, the canalis Fallopii is developed from a semi-canal which is originally open towards the tympanic cavity, and which subsequently becomes closed into an osseous canal, then such an aperture must be considered as an arrest of development.

That it may be of pathological importance is obvious.

4. *Osseous Portion of the External Auditory Canal (Meatus Auditorius Externus Osseus).*

We have already seen that at birth the external auditory canal is formed in front, behind, and below by the tympanic ring; and superiorly by the outer plate of the horizontal part of the squama. Its measurement at birth from without inwards is necessarily very short, but when the tympanic portion subsequently becomes fully developed and the horizontal part of the squama has completed its growth, the osseous part of the external auditory canal assumes the form of an elliptical bony tube; in which however one can recognise throughout life the traces of its composition.

[1] "Handbuch der Anatomie," i. Bd., 1855, S. 147.

The external margin of the tube, so far as it is formed by the tympanic portion, is rough, for the attachment of the cartilaginous part of the auditory canal; the internal opening, on the other hand, is bounded by a smoother border. On the part of this border, which is formed by the tympanic portion, a well-marked groove exists, which gives attachment to the middle layer of the tympanic membrane. This groove is much more distinctly marked in the annulus tympanicus at birth than in the temporal bone of the adult.

But the inner margin of the external auditory canal is only very seldom of a perfectly elliptical form, because the posterior part of the upper wall usually projects downwards a little, and thus the perfectly elliptical form of the limiting margin is lost.

The anterior wall of the canal is, as a rule, somewhat convex towards the lumen; this being best marked near the middle, and diminishing more or less suddenly towards the membrana tympani. Hence there is formed, internal to the convex part, a kind of recess, which is so far of interest in practice because here foreign bodies readily lodge, and on account of the curvature of the anterior wall are difficult of removal (*H. Meyer*). Such a curvature also will obscure a more or less considerable portion of the membrana tympani, and so render difficult the objective examination. The inferior wall also, in exceptional cases, presents a convexity upwards towards the lumen, and even the posterior and superior walls sometimes exhibit irregular prominences; all of which conditions must have an influence on the form of the canal.

The outer and inner openings of the canal are not parallel, since the margin of the inner is placed more obliquely to the long diameter of the canal than the margin of the outer. This difference is not very considerable; and speaking generally, neither is vertical to the long axis of the canal, but forms with it an acute angle opening upwards and outwards.

Whilst the width of the canal often varies, its length in different temporal bones is pretty constant (14-16 *mm.*). The length of the different walls is almost the same if one measures in a straight line from the outer to the inner opening, irrespective of prominences and depressions. The greater length of the anterior and inferior walls of the entire auditory canal is partly produced by the addition of the cartilaginous part of the canal.

5. *Internal Auditory Canal* (*Meatus Auditorius Internus s. Meatus Acusticus Internus s. Porus Acusticus Internus*).

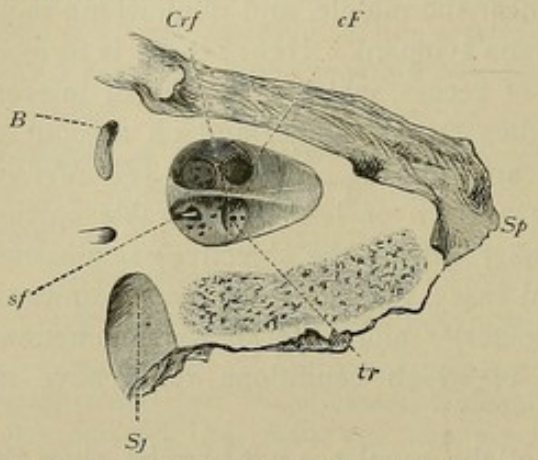
We have already seen the entrance to this canal on the posterior surface of the petrous bone. Here a furrow appears which, gradually deepening, runs backwards and outwards, and forms the approach to the opening, which is obliquely oval, measuring from 4 to 5 *mm.* in

diameter, and sharply bounded at its posterior border. It leads to a canal, 6-8 *mm.* in length, which passes backwards and outwards, and the outer extremity of which abuts against the capsule of the labyrinth. This canal has its long axis in the same plane as the long axis of the petrous bone, and transmits the nerv. facialis, the nerv. acusticus, and the art. auditoria interna. Its anterior wall measures 13-14 *mm.*, and its posterior 6-7 *mm.*

On closer inspection, which is facilitated by the removal of the upper wall of the canal; one sees that its anterior wall is convex towards the lumen of the canal; and that its outer extremity is closed by an osseous shell which is perforated in several places (*fundus meatus auditorii interni*), and which is mainly formed by the labyrinthine capsule.

Fig. 25.

Outer extremity of the internal auditory canal. (The osseous tissue of the petrous bone has been removed from the inner side.) Drawing from *Schwalbe*.



Sp, Apex of petrous bone; at *B*, section through a semicircular canal; *Sj*, sulcus jugul.; *Crf*, crista falciformis; *cF*, commencement of the can. Fallop.; *tr*, tractus foraminulentus; *sf*, foramen singulare, through which a bristle has been passed.

This osseous shell is divided into two parts, an upper and a lower, by a bony crest (*crista falciformis*, Fig. 25, *Crf*), which runs parallel with the upper edge of the petrous portion, and which projects about one-third across the canal.

The superior segment (*fossula superior*) presents at its anterior part, and formed chiefly from the anterior wall of the canal, a tolerably large opening (*cF*), *the commencement of the canalis Fallopii.* The posterior part corresponds to the *lamina cribrosa superior*, and exhibits many small foramina for the transmission of those branches of the auditory nerve which supply the utriculus and the anterior and external ampullæ. These two parts of the fossula superior are separated by a well-marked bony partition, which projects slightly inwards towards the auditory canal.

The *fossula inferior*, situated below the crista falciformis, is also divided, by a low crest of bone, into an anterior and a posterior part. The anterior is named the *fossula cochlearis* (*lamina cribrosa anterior-inferior*), because it exhibits foramina for the passage of the branches of the nervus cochlearis. These small foramina are spirally arranged, around a somewhat larger opening, situated in the centre of the fossula cochlearis; and also extend into the posterior part of the fossula inferior. The larger opening just referred to is named the *foramen centrale cochleare*,

because it leads to the canalis centralis, which runs in the osseous axis of the cochlea; and the whole group of spirally arranged foramina constitute the *tractus spiralis foraminulentus*. The foramina of the tractus in the posterior part of the fossula inferior are separated by a low crest of bone from the portion immediately above; which is called the *fossula vestibularis*, because it is pierced by a number of small foramina for the transmission of the rami sacculi of the auditory nerve; and it forms the *lamina cribrosa media*, on the inner wall of the labyrinth. Posteriorly there is seen a larger aperture, called the *foramen singulare*; which serves for the passage of the *ramus ampullæ posterioris* of the auditory nerve.

The Larger Cavities in the Temporal Bone.

1. *Cavity of the Tympanum.*

The *tympanum* is the largest cavity in the temporal bone. In the macerated bone, where its various contents have been removed, it has generally a very irregular shape. *Hyrtl* very aptly compares it to a hollow cube, the walls of which are unequal in their dimensions, and very different in their form. This cuboidal cavity belongs chiefly to the petrous bone; since the squamous, tympanic, and mastoid portions only contribute very slightly to its formation.

It is generally described as having a *roof*, *floor*, *anterior*, *posterior*, *external*, and *internal* walls. We retain these appellations on account of practical considerations, although they are not quite accurate if we have regard to the mesial plane of the skull.

The *upper wall* or *roof*, somewhat curved, its concavity being directed downwards, is mainly formed by the *tegmen tympani* (Fig. 4, *t*); the small remaining portion being completed by the horizontal part of the squama.

The *lower wall* or *floor* (*vide* Fig. 4, *ft*) is chiefly formed by the *fundus tympani*, already described; this being supplemented in the child by the annulus tympanicus; in the adult by the pars tympanica.

The surface of the floor, which is directed upwards towards the tympanic cavity, is very irregular; and is beset with numerous small osseous plates, which are serrated at their free margins. These stand more or less perpendicularly upwards, so as to leave between them irregular cellular spaces, which from their appearance remind one of the more systematic arrangement of these loculi as they are found in graminivorous animals, beautiful examples of which are seen in the horse.

Hyrtl states[1] that in certain animals where the tympanic cavity is large, osseous growths (osteophytes) occur as a normal condition, and that these are

[1] "Vergleichende anatomische Untersuchungen über das innere Gehörorgan des Menschen und der Säugethiere," Prag, 1855, S. 14.

developed only during the first year of life, and exhibit constant forms. In the posterior part of the bulla of the lion they are very large, and form pyriform masses, attached by slender pedicles. In the upper wall they are smaller, and of less frequent occurrence. Sometimes several are connected by cross bridges of bone, and all consist of compact osseous tissue without medullary spaces. In the giraffe they resemble a comb with damaged teeth.

The *anterior wall* is incomplete at the upper part, where the opening of the can. musc. tubarius is seen (*vide* Fig. 24, *sct* and *tE*).

The *posterior wall* is also imperfect, and is formed by the mass of bone which covers the descending portion of the canalis Fallopii and canalis musc. stapedii, and with which the posterior ascending part of the floor is continuous. In the upper portion of this wall, immediately opposite the defect in the anterior wall, is seen the opening into the mastoid cells (*antrum mastoideum*).

The *outer wall*, formed chiefly by the membrana tympani, is very imperfect in the macerated bone, where only the frame is left, across which the membrane was stretched. This osseous frame, formed by the tympanic portion and the horizontal plate of the squama, has already been described as forming the internal opening of the external auditory canal.

The *inner wall* (*vide* Fig. 24) corresponds to the posterior part of the outer surface of the petrous bone, and has already been fully described.

Thus it is seen that of the six walls which bound the tympanic cavity, only two are complete, viz. the floor and roof; and these only if one leaves out of consideration the smaller openings for the passage of vessels and nerves. The others are defective, so that in the macerated bone the tympanum communicates with the cavities adjacent to it: *e.g.* in front is seen the canalis musculo-tubarius; behind, the opening into the mastoid cells; externally, the external auditory canal; while internally it communicates through the oval and round fenestræ with the labyrinth.

It is necessary, for the exigencies of practice, to know the different diameters of the tympanum, as well as the distances of its individual parts from each other. Its antero-posterior diameter, corresponding with a line drawn from the tympanic opening of the tuba Eustachii on the anterior wall to the opening into the mastoid cells on the posterior wall, is, according to *Von Tröltsch*, 13 *mm.* The vertical diameter, *i.e.* the distance between the roof and floor, varies at different parts. This, according to the same author, measures from 5 to 8 *mm.* opposite the ostium tympanicum; while in the centre of the cavity, close to the malleus, it is 15 *mm.*

The distance between the outer and inner walls also varies at different parts. Opposite the tubal orifice it is from 3 to 4 *mm.*, while opposite the most convex part of the memb. tymp., *i.e.* at the lower end of the handle of the malleus, it is 2 *mm.*

The distance between the most convex part of the promontory and the

membrana tympani is $2\frac{1}{2}$ *mm.*, while that between the most projecting part of the head of the malleus and the inner wall is from $2\frac{1}{4}$ to 3 *mm.*

Here may be mentioned the deficiencies in the temporal bone first described by *Hyrtl* as *spontaneous dehiscences*.[1] These deficiencies are most frequently seen in the tegmen tympani; more rarely in the sulcus jugularis, and in the lamella which separates the sulcus sigmoideus from the mastoid cells; while occasionally they occur in the posterior wall of the canalis caroticus, which is directed to the tympanic cavity. Their mode of origin is variously accounted for. *Hyrtl* thinks they may be due to defective development, in consequence of the increased demand for bone earth during pregnancy; or may occur as a result of increased atmospheric pressure in the tympanum through frequent blowing of the nose. *Von Tröltsch* attributes them to the too frequent use of the Valsalvan method of inflation; while they have also been associated with the glandulæ Pacchioni. That the latter, at least, do not always produce them is evident from the fact that the deficiencies occur in some parts to which the glandulæ Pacchioni have no relation whatever (*e.g.* the sulc. jug., in the floor of the tympanum). Until now the most correct view as to their cause appears to be that of *Flesch*,[2] who associates them with an increased intra-cranial pressure and a consequent reabsorption of bone; but even this appears true only in a few cases. In the author's opinion these dehiscences are produced by an excess of that physiological process of reabsorption to which the air-cavities of the temporal bone partly owe their existence. Their very occurrence in the mastoid process supports this view; for, as we know, the mastoid cells are formed by a process of reabsorption, and this reabsorption cannot be due to increased cerebral pressure. That they are very seldom seen in the tegmen tympani of the newly born child is not inconsistent with the author's view, as the air-spaces of the temporal bone only reach their complete development after birth.[3]

2. *Cavity of the Labyrinth* (*Osseous Labyrinth*).

The second large cavity found in the temporal bone is *the cavity of the labyrinth*, which is destined for the reception of the most important part of the organ of hearing. It is concealed in the petrous part of the petro-mastoid, and does not consist of a simple hollow chamber, but of a series of more or less regular spaces and passages which communicate with each other. Of the nature of these one can form the best representation by having regard to their development both in the embryo and after birth.

Henle very appropriately remarks,[4] "The osseous material of the temporal bone is poured round the membranous labyrinth, at some little distance from its surface, like the plaster of Paris around a structure to be modelled; and just as the modeller troubles himself little about the outer form of his cast, although it may show roughly and generally the outlines of the model; even so little does

[1] "Ueber spontane Dehiscenz des Tegmen tympani und der Cellulæ mastoideæ," Sitzungsberichte der mathematisch-naturwissenschaftlichen Classe der kais. Akademie der Wissenschaften, xxx. Bd., Nr. 16, S. 273, Wien, 1858.

[2] "Zur Kenntniss der sogenannten Dehiscenz des Tegmen tympani," Archiv für Ohrenheilkunde, xiv. Bd., S. 15 u. ff.

[3] Compare *Jos. Gruber*, "Zur Entwickelungsgeschichte der Hörorganes der Säugethiere und des Menschen," Monatsschrift für Ohrenheilkunde, xii. Jahrg., Nr. 5.

[4] "Handbuch der system. Anatomie des Menschen," Braunschweig, 1866, ii. Bd., S. 718.

the outer surface of the temporal bone betray the form of the structures enclosed in it.

"Yet, by the removal of the bone surrounding the cavity of the labyrinth, an osseous capsule can be obtained which varies in thickness, and which repeats the form of the contained membranous labyrinth somewhat closely.

"We are entitled to take this as the groundwork of our description, for the following reasons:—

"1. From the history of its development; for an osseous capsule for the labyrinth exists before the ossification of the rest of the petrous bone. 2. From the compactness, both in the infant and adult, of the bony tissue immediately surrounding the labyrinth, as compared with the spongy bone in its vicinity; and from the fact that in the softened adult bone, probably on account of the peculiar arrangement of its bony lamellæ, the labyrinth can be detached from its surroundings. 3. Lastly, it is easier to handle the bony labyrinth, and thus to become acquainted with its topography, than is the case with the membranous labyrinth; which can only be prepared with difficulty. One must look at the relationship of the bony to the membranous labyrinth as corresponding with that of the skeleton to the soft parts; viz. it forms its support and determines its position."

The *osseous labyrinth*, or *capsule of the labyrinth*, is constructed in conformity with the membranous labyrinth. *Schwalbe*[1] says it is about 20 *mm.* in length; and that a line passing through its long axis intersects the mesial plane of the skull at an angle of 50°. The cavity in its interior exhibits almost the same shape as that of the membranous labyrinth. A portion of the osseous corresponds to each division of the membranous labyrinth, but is negatively formed in relation to it; so that the concave inner surface of the former corresponds with the convex outer surface of the latter; and *vice versâ*.

In addition to the internal auditory meatus already described, the true cavity of the labyrinth consists of three parts: viz. the *vestibule* (*vestibulum*); the *cochlea* (*concha*); and the *semicircular canals* (*canales semicirculares*).

(*a*) The *vestibule* (vestibulum) is the middle division of the cavity of the labyrinth. It communicates not only with the other parts of the labyrinth bordering on it; but in the macerated bone opens freely into the tympanum; while the so-called *aquæductus vestibuli* brings it into communication with the cavity of the skull. Besides the smaller foramina (in the macula cribrosa) for the entrance of the nervus vestibuli, seven large openings are found in the osseous wall of the vestibule; which together with an elongated fissure bring about the communications mentioned.[2] The vestibule will therefore be seen to form to some extent the place of reunion of the other parts of the labyrinth. It consists of an elliptical shell of bone in which one distinguishes an upper, a lower, an anterior, a posterior, as well as an

[1] *G. Schwalbe*, "Lehrbuch der Anatomie der Sinnesorgane," Erlangen, 1885, Seite 297.

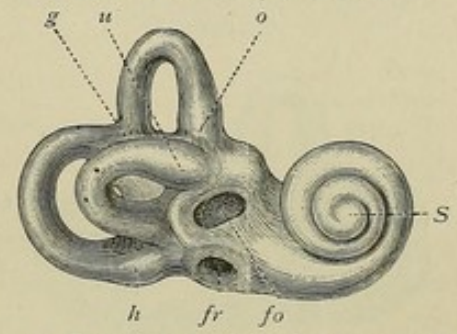
[2] Like *Retzius*, the author also finds that the anterior and external ampullæ open into the vestibule by a common orifice.

internal (median), and an external (lateral) wall. The anterior part of the ellipsoidal chamber looks forwards towards the cochlea; the posterior backwards towards the semicircular canals.

In the *outer* wall is seen the fenestra ovalis, which in the recent temporal bone is occupied by the foot of the stapes and the membrana obturatoria; these shut off the vestibule from the tympanum. Its *inner* wall is in contact with the outer extremity of the internal auditory meatus; and exhibits, running from above downwards, a ridge of bone—the *crista vestibuli*. This is well marked at the upper part; while inferiorly it divides into two branches which are gradually lost on the inner wall. This crest separates two depressions: an anterior (*recessus hemisphæricus s. rotundus*), deeper and more rounded, and a posterior (*recessus hemi-ellipticus s. ovalis*), somewhat shallower and of an elliptical shape. Between the two ridges into which the crista vestibuli divides inferiorly, is seen a third very shallow depression, which was described by *Reichert* as the *recessus cochlearis*.[1]

Fig. 26.

Bony labyrinth of the right ear, two-and-a-half times enlarged.



o, Superior semicircular canal; *h*, posterior semicircular canal; *u*, inferior semicircular canal; the lines in all cases point to the ampullæ; *g*, opening of the canal common to the superior and posterior canals; *fo*, foramen ovale, leading to the vestibule; *fr*, foramen rotundum, which leads from the tympanum into the cochlea: *s*, cochlea.

In the *upper* wall of the vestibule, immediately above the recessus hemi-ellipticus, and separated from it by a transverse ridge, is seen the opening of the ampullæ of the anterior and external semicircular canals. The remaining openings of the semicircular canals are found—according to the position of the curved tubes—behind or below the ampullary extremities just described. On the anterior wall of the vestibule—beneath the *recessus hemisphæricus*—is seen the entrance into the scala vestibuli of the cochlea; while in the floor, just below the fenestra ovalis, there is a fissure through which the vestibule communicates with the recess of the fenestra rotunda.

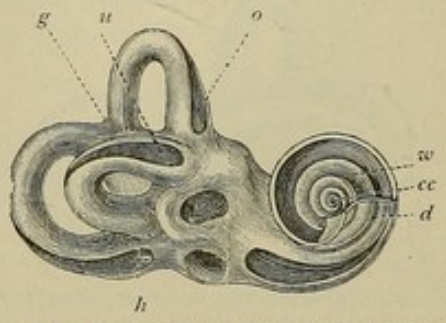
Besides these larger openings, a number of small foramina—arranged in groups,—are found in the vestibule for the entrance of nerves. These are generally larger in the fœtus than in the adult, and correspond in position with the *lamina cribrosa*.

(*b*) *The semicircular canals* open from the posterior part of the vestibule, and each forms more than half a circle. They are three in

[1] *Reichert:* Beitrag zur feineren Anatomie der Gehörschnecke des Menschen und der Säugethiere.—Aus den Abhandlungen der königl. Akademie der Wissenschaften in Berlin, 1864.

number, and lie in three planes almost perpendicular to each other. They have been named *superior*, *posterior*, and *inferior*, from their relationship to the petrous part of the temporal. Since, however, they do not occupy strictly these positions, it is better, with *Retzius*, to distinguish them as *anterior*, *external*, and *posterior*. The *anterior* (*superior or sagittal*) is nearly vertical, and lies transversely to the long axis of the petrous bone, pushing forward the osseous wall towards the cranial cavity, as the jugum pyramidale. It is the most slender of the three, and approaches more nearly the circular form than the others. The *posterior* (*frontal*) lies more or less parallel with the posterior surface of the petrous bone; while the *external* (*inferior*) is nearly parallel with the under surface of that bone. This last may be said to be embraced by the others, and is the shortest of the three. According to *Crum Brown*, the external canals of both ears lie almost in the same plane; whilst the plane of the anterior canal of one ear is almost parallel with the plane of the posterior canal of the other ear. Regarding the length and curvature of the canals, there are many individual differences: the length and diameter are said to increase constantly in the later years of life (*Hyrtl*).

Fig. 27.
Right bony labyrinth with the canals laid open.



o h u, Ampullæ of the three canals; *g*, common crus unopened; *w*, coils of the cochlea opened, with the lamina spiralis ossea; *cc*, terminal openings of the canalis centralis cochleæ; *d*, rest of the bony covering of the coils.

Henle distinguishes in them generally two curvatures: viz., (1) a "curvature of the plane," and (2) a "curvature of the border," —the last name he applies to the principal curvature of the canals. Besides, each canal is somewhat flattened, so that on section its lumen appears elliptical in form. The absolute length of the canals varies according as one measures along their convexity or concavity. Measured along their convexity, the superior is 20 *mm.*, the posterior 22 *mm.*, and the inferior 15 *mm.* in length (*Huschke*). The corresponding canals on opposite sides of the same skull are of equal length, but they vary much in different individuals (*Schwalbe*). The width also varies at different places.

One extremity of each canal is dilated close to its opening into the vestibule. This dilated portion constitutes the *ampulla* (*sinus ellipticus Scarpæ*), and has a diameter almost equal to twice that of the rest of the canal (2·5 *mm.*). Of the three ampullæ, those of the anterior and external canals open by a common orifice into the upper and fore part of the vestibule; whilst that of the posterior canal opens into the lower and back part of the vestibule. Of their non-ampullated extremities, the posterior crus of the anterior (superior) canal and the superior crus of the posterior canal unite and open into the vestibule by a common canal, from 2 to 3 *mm.* in length; whilst the posterior crus of the external canal opens inde-

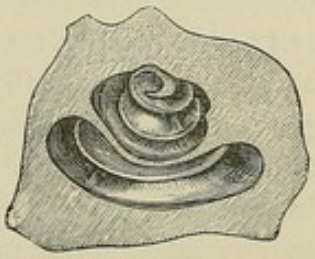
pendently. Hence only four openings are found in the vestibule for the six crura of the bony semicircular canals.

(*c*) *The cochlear canal* (*canalis cochlearis*) *of the labyrinth* passes from the anterior inferior part of the vestibule into the promontory (Fig. 28).

It coils spirally round an osseous axis (*modiolus*) 4-5 *mm.* in length. Its base is directed backwards and inwards towards the outer extremity of the internal auditory canal, while its apex projects forwards and outwards. From its commencement at the anterior and lower part of the vestibule, the cochlear canal runs with a slight S-shaped curve for a distance of 4-5 *mm.* It then twists upwards in a spiral manner, so that the canal becomes gradually narrower; and each subsequent turn rises above the preceding one.

Fig. 28.

Section parallel with the axis of the cochlea.



The lamina spiralis ossea is seen with the scala vestibuli above it, and the scala tympani below it. At the apex is seen the hamulus Scarpæ.

The canal forms $2\frac{1}{2}$-$2\frac{3}{4}$ turns; measures 28-30 *mm.* in length; and is somewhat ellipsoidal on section. Near its commencement, the width (*i.e.* the diameter at right angles to the modiolus) is 2 *mm.*, and is greater than the height; while after reaching the centre of the first turn, the reverse is the case, since the height (*i.e.* the diameter parallel to the modiolus) is 2 *mm.*, and the width only $1\frac{1}{2}$ *mm.* In the last halfturn the width once more increases at the expense of the height.

The cochlear canal at first runs for a short distance without twisting spirally. From the point where it first commences to coil upon itself, the upper wall of each underlying coil appears to be united with the lower wall of that situated immediately above it; and thus a spiral partition wall is formed which becomes more and more attenuated towards the apex of the cochlea.

With *Retzius*, we distinguish the coil situated at the base as the *basal coil*; that at the apex as the *apex coil*; while the intermediate one is the *central coil.*

Since the coils turn upon themselves, they form towards the modiolus concave limiting surfaces, which, on account of the turns being united to each other, form a hollow cone into which the axis of the cochlea may be said to be inserted. In the earlier embryonic stages, and even at birth, the boundary between the tube and the modiolus is discernible, since the osseous tissue forming the wall of the tube is much more compact than that of the modiolus. This distinction, however, gradually disappears, and then the modiolus differs but slightly from the other osseous tissue.

On opening the cochlear canal along its entire length, it is seen that osseous laminæ (*laminæ spirales osseæ*) project towards the lumen from both the inner and outer walls of the canal. These laminæ,—of which the

internal (*lamina spiralis ossea*) is much the broader,—do not meet each other, but end in free edges along their entire length. The external, named the *lam. spir. oss. accessoria s. secundaria*, soon decreases in width, and disappears entirely about the middle of the first coil. The interval between the laminæ is filled up in the recent bone by the *membranous ductus cochlearis* (*lamina spiralis membranacea*); and thus the cochlear canal is divided into two passages or *scalæ*, one above the other. The upper is called the *scala vestibuli*, because it opens into the vestibule; the lower the *scala tympani*, because it communicates with the tympanic cavity through the fenestra rotunda. In the first coil the lam. spir. ossea and the partition wall between the coils each form with the modiolus a right angle; but as we ascend the tube, this angle becomes more and more acute, since the lam. spir. ossea and the partition wall both incline towards the modiolus. Hence the floor of the last part of the cochlear canal stands almost upright (*i.e.* in the same direction as the modiolus); with the result that the apical part of the cochlear canal is situated, not over, but partly to the side of the preceding coil.

At first the scala tympani is considerably wider than the scala vestibuli; but as we proceed upwards the latter gradually enlarges, since the lam. spir. ossea more and more approaches the floor of the cochlear canal.

At the commencement of the scala tympani a *semilunar crest* (*crista semilunaris*), described by *Huschke*, is seen stretching from the attached margin of the lamina spiralis towards the fenestra rotunda. Close to this crest is found the orifice of the *aquæductus cochleæ*, the outer opening of which we have already studied in connection with the under surface of the petrous bone.

At the apex of the cochlea the lamina spiralis ossea ends in a sickle-shaped process (*hamulus*, *v.* Fig. 28). Between the convex border of the hamulus and the cochlear wall is stretched the membranous ductus cochlearis, whilst an opening is left between its concave border and the border formed by the united extremities of the modiolus and the partition wall between the coils. Through this opening (*helicotrema*), the two scalæ of the cochlea communicate with each other.

On closer inspection, the modiolus and lamina spiralis are seen to be pierced —especially in young individuals—by numerous openings, through which vessels and nerves pass from the modiolus and meatus audit. int. to reach the membranous lining of the cochlear canal. These foramina are found chiefly at the bottom of furrows which are arranged partly in a concentric and partly in a radial manner. The outer half of the lamina spiralis is smooth, and destitute of these foramina; whilst the inner part of it exhibits them in great numbers.

The bony axis of the cochlea (*modiolus*) conceals within it two comparatively large canals. One—the *canalis centralis modioli*—runs in

the axis of the modiolus, and is cylindrical. It begins in the recessus cochleæ as a large central orifice, and reaches to the apex of the modiolus, where it ends, either in one comparatively large foramen, or is closed by a plate of bone which is perforated by a number of small foramina.

The other of these canals—the *canalis spiralis modioli* (*Rosenthal*[1]) runs along the line of attachment of the lamina spiralis to the modiolus, and has a very irregular lumen, which is divided by a septum into an upper and a lower passage. At the base of the modiolus it is separated from the central canal by a considerable thickness of osseous tissue; whilst towards the apex, this osseous layer becomes thinner on account of the tapering of the modiolus.

The bony walls of the canalis spiralis are perforated by many minute foramina, through which there pass, on the one hand, vessels and nerves from the central canal into the canalis spiralis, and on the other, vessels and nerve-fibres from the spiral canal out between the two plates of the lamina spiralis ossea.

In the lower passage of the spiral canal, a filamentous ganglionic mass is placed, through which the fasciculi of the nervus acusticus pass in their course to the lamina spiralis. A vein is found in the upper passage.

The *aqueducts*, of which two exist (*aquæductus vestibuli* and *aquæductus cochleæ*), each possess an external (lateral), and an internal (median) orifice.

The *aquæductus vestibuli* commences at the lower border of the recessus hemi-ellipticus in front of the opening of the common crus of the superior and posterior semicircular canals. It runs upwards across the common crus, and then turns downwards to end on the posterior surface of the petrous bone. It is 5-7 *mm.* long, and 0·25 *mm.* wide.

The *aquæductus cochleæ*, which is somewhat longer and larger than the last, has its external opening on the inferior surface of the petrous bone, and its internal orifice on the floor of the scala tympani. Particulars regarding both of these aqueducts will be given with the description of the membranous labyrinth.

[1] *Meckl's Archiv* 1823, S. 74. "Auf älteren Abbildungen" (Sömmering, Tafel iv., Fig. 14), "schon in seiner unteren Hälfte dargestellt."

DESCRIPTION OF THE ORGAN OF HEARING.

Taking into consideration the development of the auditory organ, one would naturally divide it into two parts—an *internal* and an *external*. The former comprises the labyrinth, and is derived from the dorsal plates of the embryo; while the latter includes what are usually described as the external and middle portions (*E. Huschke*[1]), and is developed in connection with the ventral laminæ. It has, however, long been customary to describe the organ of hearing as consisting of three portions—viz. *external*, *middle*, and *internal*. This subdivision was adopted by *Valsalva*[2] and *Blumenbach*,[3] and is not without its practical advantages.[4]

I. External Portion of the Ear.

(*a*) *The Pinna* or *Auricle.*—The *pinna* (*auricula s. cartilago auris*) is the most external part of the organ of hearing (Fig. 29), and is situated at the side of the skull, in the region of the fossa mastoideo-mandibularis. Its attached portion occupies the interval between the head and neck of the jaw on the one hand, and the mastoid process on the other, while it also projects upwards towards the squama. The upper extremity of the pinna is on a level with a line drawn horizontally backwards from the eyebrows, whilst its lower extremity would meet a similar line from the tip of the nose.

As a rule the cartilage projects from the skull at an angle, opening backwards, of 35° to 40°. Superiorly this angle decreases somewhat, but is seldom less than 10°.

Very rarely the integument covering the side of the skull passes directly on to the anterior surface of the auricle, so that its upper part is partially fixed to the wall of the cranium, and only a small angle exists posteriorly between it and the occiput.

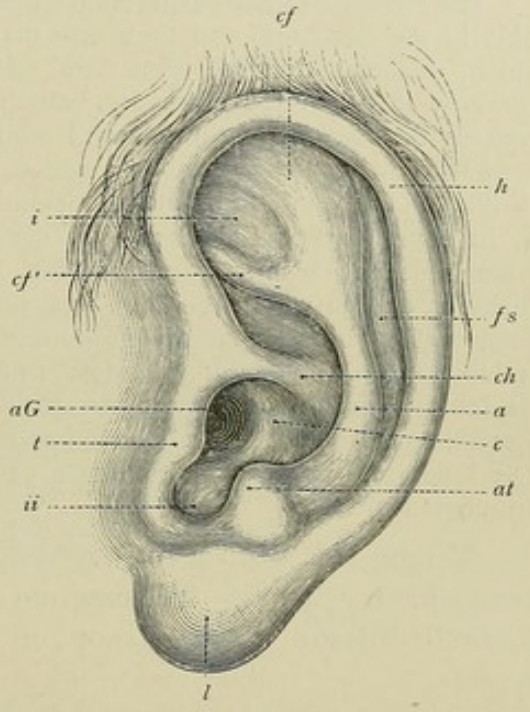
Of the two surfaces of the pinna, one—*anterior*—looks somewhat forwards, the other—*posterior*—is directed backwards. Setting aside the general concavity of the former and convexity of the latter, each exhibits elevations and depressions so arranged that an elevation on one surface has its corresponding depression on the other.

[1] *Meckl's Archiv*, 1832, S. 40.
[2] "De Aure Humana," Cap. i., § 1.
[3] "Beschreibung der Knochen des menschlichen Körpers." Göttingen, 1807, S. 144.
[4] The nomenclature "external, middle, and internal portions of the ear," used by *Huschke*, is more logically chosen than that of the "external, middle, and internal ear," since one associates with the term *ear* the whole auditory apparatus.

On the anterior surface a crest is seen running almost horizontally from behind forwards, and gradually increasing in height as it proceeds. It is on a level with the upper border of the external auditory canal, and divides the anterior surface into two nearly equal parts, while in front it is continued into the outer border of the pinna. This outer border of the pinna is turned over towards the anterior surface, like the brim of a hat, and is called the *helix*; while the crest leading to it is named the *radix s. spina s. crista helicis*.[1] In form and size the *helix* presents many individual differences. As a rule it is most turned over near its commencement, and, becoming flatter in its course upwards and backwards, it is gradually lost towards the lobe of the ear. Below and in front of the helix, and running almost concentrically with it, is a prominent angular ridge—*antihelix* (*a*)—which begins superiorly in two converging branches (*crura furcata*), and passes downwards and backwards to join what will presently be described as the antitragus.

Fig. 29.

Pinna.



ch, Crista helicis; *h*, helix; *cf*, *cf'*, crura furcata; *a*, antihelix; *fs*, fossa scaphoidea; *fi*, fossa intercruralis; *c*, concha; *aG*, entrance to the external auditory canal; *t*, tragus; *at*, antitragus; *ii*, incisura intertragica; *l*, lobulus auriculæ.

Between the helix and the antihelix there is a shallow fossa (*fs*) called the *scaphoid fossa* (*scapha*, *fossa navicularis s. scaphoidea*); whilst the depression between the crura furcata is termed the *fossa intercruralis*, *triangularis*, *s. innominata antihelicis*.

Below the antihelix there exists a deep depression (*c*) named the *concha*, which is divided by the crista helicis into an upper smaller part (*cymba*) and a lower larger portion (*concha*).

At the anterior and deepest part of the concha the entrance into the external auditory canal (*aG*) is seen, the cartilage of which is a continuation of that of the pinna. The entrance into this canal is partly concealed by two valve-like flaps, one in front and the other behind. The anterior is named the *tragus* (*t*), the posterior the *antitragus* (*at*), and

[1] Many authors apply the name 'spina helicis' to the small cartilaginous process which is seen at the anterior part of the crest, and which serves for the attachment of some of the fibres of the musc. auricularis sup. (musc. attollens aurem).

the intervening notch the *incisura intertragica* (*ii*). Below this incisura the pinna terminates in the so-called *lobe* (*l*) of the ear (*lobulus auriculæ s. auricula intima*), to be subsequently described.

The corresponding elevations and depressions on the posterior surface have received similar names, and hence we speak of an *eminentia scaphoidea*, an *eminentia conchæ*, etc.

The form of the pinna is obtained from the cartilage constituting its foundation. This cartilage is of the reticular variety, and has an average thickness of about 2 *mm.*

The elevations and depressions are produced by corresponding curves and folds in the cartilage, and these are maintained in position by connective tissue; which, on being divided, allows the folds to be obliterated. The cartilage ends inferiorly in a pointed extremity, which passes in front of the mastoid process towards the margin of the external auditory canal. A smaller projection passes downwards towards the lobule; which otherwise consists only of a duplicature of integument containing fat and cellular tissue. This cartilaginous projection is, in some exceptional cases, of considerable size, and may descend almost throughout the whole extent of the lobule. In a girl who exhibited this anomaly, and in whom the lobe was pierced in the usual manner, a very acute inflammation of the ear was produced—probably on account of injury to the perichondrium. The inflammatory process spread to the tissues between the mastoid process and the lower jaw, with the formation of an abscess from which the child suffered for several weeks, and which required very energetic treatment. The lobe, moreover, exhibits the greatest variety in shape, size, and mode of attachment.

Whilst the cartilage of the pinna is prolonged inwards to form the cartilaginous part of the external auditory canal, it is also fixed by connective-tissue to the root of the zygoma and to the mastoid process.

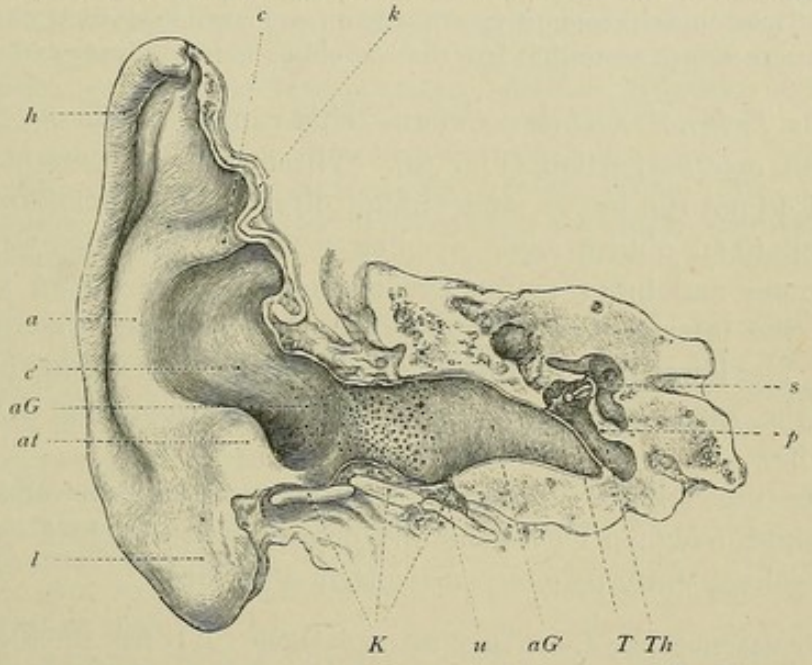
It is covered by perichondrium, to which is attached a series of larger and smaller muscles which are of more interest to the anatomist than to the aural surgeon. They are described as the *musc. tragicus, antitragicus, helicis minor* and *major*, on the anterior surface; and as the *musc. transversus auriculæ* and *obliquus auriculæ* on the posterior surface of the pinna. The names of those on the anterior surface denote their position; of the two last, the musc. transversus passes from the eminentia scaphæ to the eminentia conchæ over the furrow corresponding to the antihelix; and the musc. obliquus bridges over the furrow on the back of the pinna, which corresponds to the lower limb of the crura furcata of the antihelix. These small muscles exhibit considerable variety both as to their magnitude and their course, and frequently become atrophied in later life, so that little trace of them may be seen. The muscles which move the pinna as a whole are: (1) the *musc. attollens auriculæ*, which arises from the fasc. temporalis, and is inserted into the posterior surface of the cartilage; (2) the *musc. attrahens auriculæ*, which passes from the fasc. temporalis to the anterior extremity of the helix; and (3) the *musc. retrahens auriculæ*, which passes from the mastoid process to the posterior surface of the cartilage. *Rollett*[1] says the elastic fibres

[1] *S. Stricker's*,—Handbuch der Lehre von den Geweben des Menschen und der Thiere, Leipzig, 1868.

of the cartilaginous reticulum pass into those of the perichondrium. *J. Pollak* found isolated patches in the auricular cartilage, where its matrix had a striated structure, and where the cartilage cells were quite absent. The author has repeatedly seen in his examinations in the post-mortem room of *V. Langer* strong muscular fasciculi passing from the musc. sterno-cleido-mastoideus to the posterior surface of the pinna, where they had a tendinous insertion into the region of the eminentia conchæ. If one pulls upon such a tendon, the pinna is drawn downwards and backwards, so that possibly in certain positions of the head such a fasciculus may exercise, by its action on the pinna, an influence on hearing. *Luschka*[1] states he has twice found a similar muscular slip.

Fig. 30.

Section through the ear parallel with the long axis of the external auditory canal.



h. Helix ; *a*, antihelix ; *c*, *c'*, concha ; *k*, cartilage of the pinna ; *aG*, *aG'*, external auditory canal ; *at*, antitragus ; *l*, lobulus ; *K*, cartilage of the external auditory canal, with the incisura Santorini auris ; *u*, subcutaneous cellular tissue and integument of the auditory canal ; *T*, membrana tympani ; *Th*, tympanic cavity ; *p*, promontorium ; *s*, stapes : the line pointing to its base passes through the internal auditory canal.

The skin of the pinna is continuous with that of the scalp, and is closely adherent to the anterior surface of the cartilage by means of a dense subcutaneous tissue destitute of fat. Hence it can here only be raised in isolated places, and then merely in small folds ; whereas on the posterior surface it is more movable, since the subcutaneous tissue is looser and contains some fat. By palpation, one can readily feel that the cartilage at the lower part of the helix is more scanty than it appears on superficial inspection ; and that the lowest part of it is merely formed by a duplicature of the integument.

In the neighbourhood of the incisura intertragica, as well as on

[1] *Luschka, Prof. Dr. Hubert :* "Die Anatomie des menschlichen Halses." Tübingen, 1862, I. S. 165.

the surfaces of the tragus; the skin exhibits, especially in the later years of life, numerous long hairs (*Hirci*).

The sebaceous glands of the skin attain their largest size in the concha, where their mouths may be readily seen as small pits. They are rendered still more distinct if their ducts are obstructed, so that the follicle is filled with sebaceous secretion (*comedones*).

According to *V. Tröltsch*, the height of the pinna in the embryo increases according to the age of the fœtus as follows:—At the tenth week it is 2 *mm.*; at the third month, 4-5 *mm.*; at the fourth month, 5½-7½ *mm.*; at the fifth month, 8-12 *mm.*; at the sixth month, 14-17 *mm.*; at the seventh month, 16-24 *mm.*; at the eighth month, 26 *mm.*; at the ninth month, 26-28 *mm.*; and at birth, 33-36 *mm.* These measurements were made on preparations which had been in spirit, and are therefore somewhat less than would be found in fresh specimens.

(*b*) *The External Auditory Canal.*—This canal consists of a *cartilaginous* and an *osseous* portion (Fig. 30). These two parts are of different length, and do not run in the same straight line, but together form at their place of union an obtuse angle opening forwards and downwards; and hence the outer and inner extremities of the canal are placed somewhat lower than the intermediate portion, where the cartilage is contiguous to the bone. The lower part of the circumference of the external orifice lies almost in the same horizontal plane as the corresponding part of the internal orifice.

Besides this angular curvature, both the cartilaginous and osseous portions exhibit irregular elevations and depressions, the chief varieties of which will subsequently be more particularly described.

Huschke describes the direction of the canal thus: "It has three curvatures. It first proceeds forwards (pars externa) for a distance of 7 *mm.* It then makes a somewhat rounded angle, and rises backwards (pars media) for about 5 *mm.*, where it forms a second angle, so that its third and most descending part (pars interna), measuring 11 *mm.*, again passes forwards to the membrana tympani. The first part is wide and somewhat compressed from before backwards; the middle portion is compressed from above and in front, downwards and backwards; while the inner part is especially flattened from above downwards."

On making a transverse section of the canal, it is seen to be elliptical, with its longest diameter connecting the upper and lower walls. This relation should always be kept in mind by the aural surgeon during his manipulations in this region.

According to *Urbantschitsch*,[1] the external auditory canal is not formed from the first branchial cleft, but arises in consequence of an elevation and outgrowth of the formative material around the membrana tympani. At first it appears as a funnel-shaped opening, with its widest extremity directed outwards; but which is

[1] "Ueber das Lumen des äusseren Gehörganges bei Embryonen und Neugebornen." *Schenk's* embryologische Mittheilungen. Wien, 1878, S. 431.

later on closed in the embryos of mice and rabbits, so that newly-born mice and rabbits, as well as horses, cows, cats, and pigs, have an impervious auditory canal, which is only opened on the fifteenth day.[1] In the newly-born child no agglutination is found, but there is a complete coaptation of the walls, while the membrana tympani lies close to the inferior wall. The air-containing space is only subsequently developed, and has at first the form of two funnels joined to each other at their apices; the persistent narrow part of the lumen corresponding with the place where they met.

The length of the canal is variously stated by different authors, and this because the measurements have not been made according to the same fundamental plan. Thus, if we consider the tube as a whole, it is seen that the outer orifice is parallel with the mesial plane of the skull; whereas the inner is placed at an angle to it, on account of the difference in the length of the walls of the tube; hence the measurements obtained vary according to the part of the wall measured.

From what has been said in connection with the osseous part of the canal, one would therefore get the greatest length on the anterior and inferior walls; the least on the superior wall. *Von Tröltsch*[2] has given the most accurate measurements, and he estimates the average length of the canal at 24 *mm.*, of which 16 *mm.* belong to the osseous, and 8 *mm.* to the cartilaginous portion. He obtained these figures by taking as the most external boundary of the tube a plane projected from the commencement of its posterior wall at right angles to the longitudinal axis of the canal. From this to the membrana tympani he measured each of the four walls in a large number of specimens, and took the average. He gives as the average length of the different walls the following figures: Anterior, 27 (9, 18); inferior, 26 (10, 16); posterior, 22 (7, 15); superior, 21 (7, 14) *mm.* Of the numbers within the brackets, the first indicates the length of the cartilaginous, and the second that of the osseous, part of the canal.[3]

The width of the canal is so very variable that one rarely finds it equal on the two sides in the same individual, and thus the appearance of a section cut transversely to its long axis varies much; for, while in the majority it is oval, it sometimes approaches more to the circular in form. The width is greatest near the outer orifice (greatest diameter 8-9 *mm.*); somewhat less at its inner end near the membrana tympani (greatest diameter 6-7 *mm.*); and least of all at the junction of the cartilaginous with the bony portion. Besides, it is modified here and there by occasional prominences and depressions which are met with on its different walls. Some of these irregularities occur so frequently that we might almost

[1] *Piédagnel: Magendie's* Journal de Physiol., 1823, Janvier, S. 29.

[2] "Die Anatomie des Ohres in ihrer Anwendung auf die Praxis und die Krankheiten des Gehörorganes." Würzburg, 1861.

[3] Many authors (e.g. *Henle* and *J. Fr. Meckel*) refer the tragus to the external auditory canal, and thus get a greater length.

Symington ("The Anatomy of the Child," Edinburgh, 1877), taking the same external boundary of the meatus as Von Tröltsch, gives the following table, showing the length of the meatus in children at different ages:—

Age.	Length of Floor.	Length of Roof.
Fœtus 7 months old	16 *mm.*	10 *mm.*
„ 9 „ „	20 „	15 „
Child 2 „ „	17 „	13 „
„ 6 „ „	19 „	14 „
„ 12 „ „	20 „	15 „
„ 2 years „	22 „	16 „
„ 5 „ „	23 „	16 „
„ 6 „ „	24 „	17 „

Eds.

consider them as normal. Thus, the anterior and lower walls of the cartilaginous part, about 3-4 *mm.* behind the external opening, are often bulged outwards from the canal, so that at this part it is dilated and somewhat trough-like; while the anterior wall of the bony part is frequently seen pushed inwards towards the lumen so as to narrow it. These relations are to be taken into consideration in connection with the examination of the auditory canal.

As has already been stated, the cartilage of the pinna is continued inwards so as to form the cartilaginous portion of the auditory canal. This, however, does not form a complete tube, but is deficient at the upper and posterior part, where the gap between its free margins is filled up by fibrous membrane. This membranous tissue is continuous with that which fixes the cartilaginous to the osseous part of the canal, and is itself attached to the adjacent portion of the temporal bone by tough tissue —which, however, allows of a considerable degree of abduction of the auditory canal from the bony parts.

The continuity of the cartilaginous part is also interrupted by several fissures, which run more or less parallel with the outer extremity of the osseous canal. These are named the *incisuræ Santorini*, and are filled up by fibrous tissue. They are two or three in number, and are found chiefly on the antero-inferior aspect of the canal, but sometimes they extend to the posterior wall, while occasionally they are somewhat forked.

At birth the cartilaginous basis of the canal consists of two or three segments, which subsequently become only imperfectly united by fibrous tissue, so as to leave between them the fissures of Santorini.

The osseous part of the external auditory canal has already been described.

Towards the lumen of the canal the cartilaginous portion is covered with *perichondrium*, and the osseous portion with *periosteum*; these exhibit the same structure here as elsewhere in the body, and are bound to the *integumentary lining* of the canal by firm subcutaneous tissue, which becomes denser as we pass towards the inner part of the canal. This integumentary lining is continuous with that covering the pinna; in the cartilaginous part it resembles ordinary skin; while in the osseous part it is thin, and so altered in colour that it has somewhat the appearance of a mucous membrane. It preserves, however, all the characteristics of the integument; and, as we shall subsequently see, is liable to be the seat of diseases which are found in other parts of the general integument, and not of those occurring in mucous membranes.

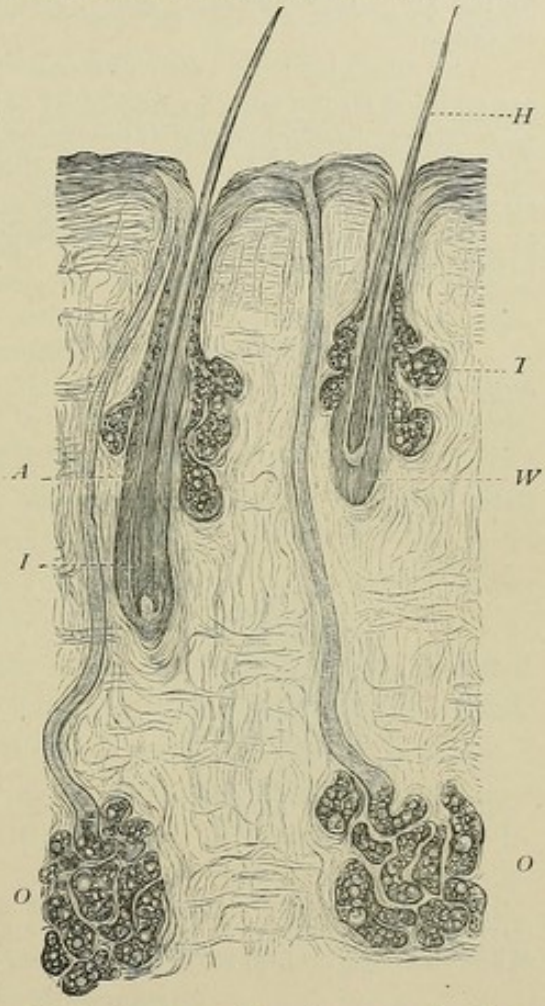
The cutis of the canal is covered by stratified epidermal cells on its free surface, and besides showing the ordinary structure of every cutis (*e.g.* connective and elastic tissues, etc.), it exhibits (1) hairs (*Hirci*), in connection with which there are sebaceous glands; (2) *vascular papillæ* arranged in rows; and (3) *ceruminous glands*.

The hairs are found over the whole of the cartilaginous portion, while sometimes they are tolerably numerous—in rare cases very abundant—in the osseous part.

According to *Em. Kaufmann*,[1] the structures described as vascular papillæ are ridge-like formations of an incomplete annular form, which are only provided with papillæ in rare cases, and which are found both in the embryo and in the adult. They run parallel with the plane of the tympanic membrane, and are said to be best marked on the superior wall of the canal.

Fig. 31.

Section through the integument of the cartilaginous portion of the external auditory canal.



H, Hair-stem; *T*, sebaceous gland; *W*, hair-bulb; *A*, outer root-sheath; *I*, inner root-sheath; *O*, ceruminous glands, with their excretory ducts.

The *Ceruminous glands* (glandulæ ceruminales s. ceruminosæ[2] (Fig. 31), begin about 2 *mm.* from the outer orifice of the canal, and reach to within 1-2 *mm.* of the membrana tympani, and hence they are found in both the cartilaginous and osseous portions. They are most numerous at the junction of the two parts of the canal, where there may be ten or more in a square millimetre. *Buchanan* says there are from one to two thousand in the entire canal. On stripping off the epidermis from a partly macerated canal, the openings of their ducts are seen as small dark points; but as some of the ducts open into the hair follicles, the glands are more plentiful than the number of dark points would indicate. One sees also that they cease in a zigzag boundary line before reaching the tympanic membrane. As *V. Tröltsch* correctly observed, they generally project deepest into the superior wall of the canal. They are found in the cutis; and are convoluted tubular glands which in structure resemble sweat glands. Their excretory ducts, somewhat

[1] "Ueber ringförmige Leisten in der Cutis des äusseren Gehörganges." Jahrbuch der k. k. Gesellschaft der Aerzte in Wien, 1886, S. 201.

[2] They were discovered by *Stenon*, but were first more minutely described by *Du Verney* and *Valsalva*. Their microscopic structure was demonstrated by *R. Wagner*, *Krause*, and *Hen.*

shorter than those of sudoriferous glands, have a diameter of 0·05—0·06 *mm.*; whereas the gland measures 0·2—0·8 *mm.*

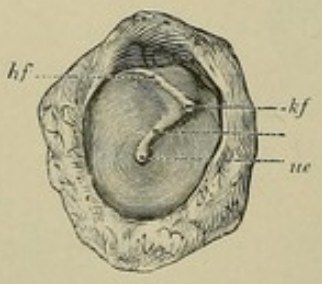
According to most observers, the gland duct consists of a homogeneous membrane surrounded externally by a layer of longitudinal smooth muscular fibres, beyond which is a layer of connective tissue. The lumen of the duct is lined with cells (*Kölliker*). These glands secrete the cerumen, which in the fresh condition is of a bright yellow colour, and nearly fluid. On exposure to the air it becomes firm and darker in colour, and may form brown plugs or crusts.

The muscular bands which are described as the *muscles of the auditory canal*, are situated on the anterior wall of its cartilaginous portion, and consist of: (1) *The m. incisuræ Santorini*, which passes over the fissures on the anterior surface of the cartilage; (2) *The stylo-auricularis*—described by *Hyrtl*, and said to be present in about one out of every six cases—which arises from the upper part of the styloid process, and is inserted by a fan-shaped tendon close to the inner part of the cartilage of the canal.

(*c*) *The Tympanic Membrane.—The tympanic membrane* (*membrana tympani, s. diaphragm, s. myrinx, s. septum membranaceum, s. operimentum auris*) (Figs. 32, 33) is stretched across the inner end of the auditory canal, forming the partition wall between it and the tympanic cavity.

Fig. 32.

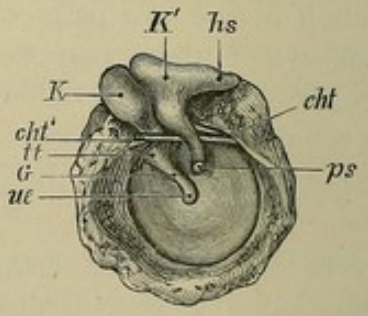
Outer surface of the tympanic membrane. (1½ times the natural size).



G, Handle of malleus; *kf*, short process (cartilaginous structure); *ue*, lower end of handle of malleus; *hf*, posterior fold.

Fig. 33.

Inner surface of the tympanic membrane, with malleus and incus.



K, Head of malleus; *K'*, body of incus; *hs*, horizontal (short) process of incus; *ps*, perpendicular (long) process of incus; *cht*, *cht'*, chorda tympani; *tt*, place of insertion of tensor tympani; *G*, handle of malleus; *ue*, lower end of handle of malleus.

The membrane, like the opening which it fills up, has the form of a somewhat bent ellipsoid, its greatest diameter (vertical) being from 9-10 *mm.*, while its transverse diameter is from 8-9 *mm.* So far as the inner end of the auditory canal is formed by the tympanic portion (tympanic ring), the membrane is fixed in a groove (*sulcus tympanicus*); but there is no proper groove for its insertion into that portion which is formed by the horizontal part of the squama.

In the child, the membrana tympani lies more horizontal than it does

in the adult; but as the development of the temporal bone progresses, the membrane becomes more vertical; its long diameter, however, even in the adult, forms an obtuse angle with the roof and posterior wall, and an acute angle with the floor and anterior wall of the auditory canal.[1] As regards its inclination towards the mesial plane of the body, most authorities agree that if the long axes of both membranes were prolonged downwards, they would meet to form an angle of 130—135°. The upper borders of the membranes of opposite sides are said to be 8·70 *cm.* distant from each other, the lower borders 7·75 *cm.*

The direction of the tympanic membrane as compared with that of the external auditory canal can be most easily realised by drawing lines at right angles to the canal from the margin of the membrane. Thus, if such a line be drawn either from the upper edge of the membrane to the floor, or from its posterior edge to the anterior wall of the canal, it touches the wall about 6 *mm.* distant from the lower and anterior attachments of the membrane respectively. Hence it is seen that at all periods of life the antero-inferior part of the membrane is most distant from, while the postero-superior is nearest to, the outer orifice of the auditory canal.

From its position, one surface of the membrane is directed inwards (*internal* or *median surface*) towards the tympanic cavity, the other outwards (*external* or *lateral surface*) towards the auditory canal. The former generally appears convex, the latter concave. The greatest concavity is almost at the centre of the membrane (*i.e.* corresponding with the lower end of the handle of the malleus), and is called the *navel* (*umbo*).

Since the upper end of the handle of the malleus (*i.e.* the so-called *short process*) is connected in its entire length with the membrana tympani, and projects farther outwards than the lower extremity of the handle, it follows that the membrane is pushed more prominently outwards above than it is below; with the result that two folds are produced in it—one in front, and the other behind the short process—the latter being the best marked. These were first described by the author, who named them the *anterior and posterior folds of the membrana tympani.* As we shall see later, they play an important part in diagnosis.

The supposition that the normal tension and arching inwards of the tympanic membrane are dependent upon the position of the handle of the malleus is quite erroneous; for if one removes, in the cadaver, a normal membrane from all its connections, and separates carefully the malleus, it still retains completely—as the author first pointed out—its tension and inward convexity, which would not be possible if its connection with the malleus determined the same. Besides, its anterior segment appears somewhat more tense than the posterior. For further

[1] *Symington* (*Op. cit.*) is inclined to agree with *J. Pollak*, who maintains there is no perceptible difference between the inclination of the membrane in the new-born child and in the adult. The former observer says: "In the new-born child the external auditory meatus passes inwards with a decided downward inclination, so that the floor of the meatus lies nearly parallel with the outer surface of the membrane; hence probably the view that the membrane is nearly horizontal."—EDS.

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particulars on this subject refer to the author's contribution: "Ueber Spannungsverhältnisse des Trommelfelles" (Monatsschrift für Ohrenheilkunde, Jahrgang xi., Nr. 5, 1877).

The colour of the membrana tympani varies considerably even in the cadaver,—this difference being due partly to the nature of the membrane itself, and partly to the individual peculiarities of its neighbouring structures. It is generally described by anatomists as possessing a more or less "pearl grey" colour; but when the epidermis has been destroyed by long maceration, it appears somewhat darker and less brilliant; while its borders, as well as the outlines of the structures embedded in it (*e.g.* malleus, etc.) strike the eye less distinctly than during life.

The individual differences in the appearance of the membrane are much more readily recognised during life than in the cadaver, so that even a general description of it presents some difficulties: for one cannot speak in such a description of a colour as belonging to the whole membrane, since the histological structure of its different segments, as well as the varying conditions of the objects in its vicinity, must exercise a great influence in modifying it (*vide* Plate I., 1, 2). Accordingly, we shall postpone a general description of the colour of the membrane until we have studied more minutely its neighbouring structures.

Attachments of the Membrana Tympani.—The membrane is fixed in the sulcus tympanicus as far as this encircles the inner extremity of the auditory canal; while around the same extent of the circumference the so-called *cartilaginous ring* (*annulus cartilagineus*) is also seen. But at the upper part this structure is absent, and here the cuticular tissue is continued directly from the auditory canal on to the tympanic membrane.

This cartilaginous ring was recently described by *Arnold* and others as the *annulus tendinosus s. membranaceus*, and the presence of cartilage cells in it denied. But the author's researches have shown that cartilage cells—occurring singly or in groups, and containing one or more nuclei—are found between the fibres of the tendinous ring, both in the infant and adult; and hence it is better entitled the cartilaginous ring (annulus cartilagineus). The cartilage cells are found chiefly in the part which is nearest the bone, and are easily seen in sections of the decalcified bone where the membrane has been left in its natural position.

Histological Structure of the Membrana Tympani.—Forming, as it does, the partition between the external auditory canal and the tympanic cavity, the membrana tympani receives part of its tissue from the lining of these cavities, that of the tympanum being continued on to it as well as that of the auditory canal.

Its chief part is, however, furnished by its own peculiar elements, which form a membranous structure—the so-called *membrana propria*. This gives to it a considerable amount of strength and firmness; whilst its inner and outer coverings are weak, and serve chiefly to support its

blood-vessels and nerves.[1] One distinguishes, therefore, three layers in the membrana tympani, viz. :—

(1) *An external, integumentary layer;*

(2) *A middle, fibrous layer* (*membrana propria, s. stratum fibrosum*); and

(3) *An internal, mucous layer* (*membrana mucosa*).

1. *External* or *Integumentary Layer.*—This is composed of the same elements as are found in the integumentary lining of the inner part of the external auditory canal. The continuity of the stratified epidermis covering the membrane with that lining the canal can readily be demonstrated in a temporal bone which has been macerated for a short time, when the whole can be separated, and is seen to form a *cul de sac* resembling the finger of a glove. The tissue of the cutis, or true skin, is most abundant at the periphery of the membrane, and becomes more scanty as we approach the centre; while, on the other hand, the epidermal layer is thickest in the immediate vicinity of the handle of the malleus. Here there is observed a fairly well marked band of tissue, beginning superiorly with a broad base (3-4 *mm.*), and passing downwards in the direction of the malleus. It is less distinct at the lower end of the handle, round which it runs in almost circular bands, and from which it radiates partly outwards. These fibres, lying close to the handle of the malleus, contain the larger blood-vessels and nerves of the tympanic membrane, and may be seen with the naked eye, but are more distinctly observed under a low power. Besides, a larger amount of cutaneous tissue is found at the upper part of the integumentary layer—a condition which influences the development of the objective pathological appearances.

Kessel describes a gland layer which is said to extend from the postero-superior wall of the canal behind the malleus, downwards almost to its lower extremity. So far as the author is aware, the existence of this has not yet been confirmed.

2. *Fibrous Layer* (*membrana propria*).—This consists of more resistent tissue than that of the integumentary and mucous layers.

Wharton Jones[2] described the membrana propria as consisting of two strata, which were easily separated from each other under water. These are described as: (1) *the external* or *radiating-fibre layer*, immediately subjacent to the integument; and (2) *the internal* or *circular-fibre layer*, next the mucous membrane. *Gerlach*[3] says that the main part of the tissue

[1] According to *Schmidekam* ("Experimentelle Studien zur Physiologie des Gehörorganes," Kiel, 1868, S. 6) the resisting power of the tympanic membrane is much greater in man than in most animals. It required a column of mercury 143 *cm.* in height to rupture the membrane of an ear which had been preserved for some weeks in spirit. The rupture was in a straight line parallel with the handle of the malleus, and corresponding with its lower three-fourths. Even supposing the spirit to have rendered the membrane somewhat tougher than normal, the experiment proves it to possess a very considerable amount of resistance.

[2] 'Organ of Hearing' in *Todd's* "Cyclopædia of Anatomy and Physiology," vol. ii., p. 545. London: 1839.

[3] "Mikroskopische Studien aus dem Gebiete der menschlichen Morphologie." Erlangen, 1858, S. 53, u. f.

composing the membrana propria may be said to be intermediate between the ordinary fibrillated and the homogeneous tissue of *Reichert*. The fibres (Fig. 34) are 0·0068—0·0095 *mm.* broad, and possess "sharp but fine outlines, which bound on either side the perfectly homogeneous substance of the fibre. Not even the least trace of fibrillæ, such as characterise ordinary connective-tissue, is seen in these fibres. They run parallel with and close to each other, but are frequently connected so as to form a fibrous meshwork containing elongated narrow spaces which taper above and below. Notwithstanding this meshwork, the direction of the fibres is well marked."

Fig. 34.

Fibres of the membrana propria of the tympanic membrane.

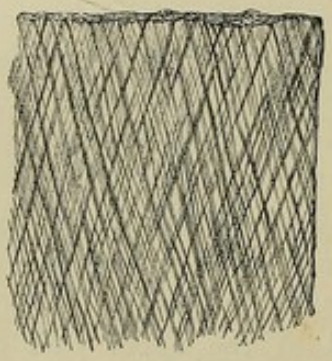


Fig. 35.

Connective-tissue corpuscles, as they are met with between the fibres of the membrana propria of the tympanic membrane, in longitudinal sections.



Everard Home[1] erroneously considered they were smooth, muscular fibres. On attempting to isolate the fibres from one another under a lens, they constantly tend to resume their former position. When however they are teased out, one can recognise on careful examination, small spindle-shaped cells (Fig. 35) at the margins of the fibres. These are granular in the centre, and terminate in fine filaments at either end. They are the *young connective-tissue corpuscles* which are lodged in the spaces remaining between the fibres.

Gerlach showed that, if the fibres of the membrana propria be treated with acetic acid, two very different conditions are recognised, depending upon whether one is examining a longitudinal or a transverse section. The acid causes the fibres to swell up and become clearer; so that, on looking at a longitudinal section, the spaces between the fibres have disappeared, while the spindle-shaped corpuscles are rendered evident in great numbers (Fig. 35). The nuclei in the body of the corpuscles become distinctly visible, and one sees in some cases connections between the filiform processes of adjacent corpuscles. On transverse section the oval outline of the fibres has disappeared, and they now form a homogeneous mass; and, instead of the previously mentioned spindle cells, star-shaped corpuscles come into

[1] "On the Structure and Uses of the Membrana Tympani of the Ear." Philosophical Transactions, vol. xc., p. 1, 1800.

view, having three to four processes passing in different directions. They each have a rounded nucleus distinctly visible in the central part of the cell, and resemble certain forms of corneal corpuscles (*V. Tröltsch, Gerlach*), or even the stellate cells of the enamel organ (*Gerlach*). The connective-tissue corpuscles are especially numerous in the membrana propria of children; while on the other hand the fibres are much more delicate, and resemble the loose connective-tissue found in the fœtus. In this respect the membrana tympani of the infant approaches the condition which exists in the lower animals (birds).

The spindle-shaped cells are, according to the views of most observers, nothing but the nucleus fibres of *Henle*, or the connective-tissue corpuscles of *Virchow*, or the so-called lymph or formative cells of *Kölliker*. Through the action of a 20 per cent. solution of nitric acid for a short time, one obtains both in the longitudinal and transverse sections of the membrana propria, very pretty isolated, but never star-shaped cells; while, if such sections be treated for twenty-four hours with acetic acid, the isolated cells are now destitute of processes, and seem to represent the nuclei only, these alone being able to resist the action of the acid.

If treated with carmine, the spindle-shaped cells appear very distinctly in the longitudinal sections, since they are more deeply stained than the fibres; but if transverse sections are examined, the star-shaped cells do not appear. If, however, acetic acid is added to such sections, the fibres lose gradually their crimson colour; and if they have not been deeply stained, may become quite colourless; while, on the contrary, both the spindle-shaped cells in the longitudinal section, and the star-shaped cells in the transverse section come into view, having a dark reddish colour.

The histological elements of the membrana propria which have just been described are arranged in two layers: (1) *an external* or *lateral*, situated immediately under the integument; and (2) *an internal* or *median*, next the mucous membrane.

The fibres of the external layer radiate outwards from the malleus, being fixed on the one hand to the cartilaginous structure of the malleus, and on the other to the cartilaginous ring at the periphery of the membrane. Hence this is called the *radial layer*, and on account of the arrangement of its fibres they appear more closely packed together in the vicinity of the malleus; this being especially marked at the lower end of the handle. A small triangular area of the tympanic membrane, with its base directed upwards, is found above the small process of the malleus, where the radial fibres are altogether wanting. This will subsequently be considered.

The fibres of the *internal* or *median* layer, lying next to the mucous membrane, have in general a circular direction; and hence they are spoken of as forming the *circular layer*. In successful sections one can readily convince oneself that these circular fibres reach into the annulus cartilagineus at the periphery of the membrane, and that many of them are even connected with the periosteum of the auditory canal. These fibres are not uniformly arranged, being more numerous in some parts than in others; but the author cannot agree with *V. Tröltsch's* statement that they are altogether wanting in the neighbourhood of the annulus cartilagineus

and handle of the malleus respectively. They are certainly more scanty in those two regions, but nevertheless they exist. If one imagines the membrane divided by lines, placed at equal distances, into five concentric areas; it is found, on examining these from without inwards, that the circular fibres are scanty in the outer fifth, but plentiful in the next two-fifths,[1] becoming again scattered in the central two-fifths—near the handle of the malleus. Above the short process of the malleus they are found only in its immediate vicinity, while they are quite absent over that triangular area where we have already described the radial fibres as being deficient.

Besides these circular and radial fibres, others may be seen on carefully removing the integumentary and mucous layers from a fresh membrana tympani; so that it still remains attached to the cartilaginous structure to be subsequently described as existing at the handle of the malleus. These lie on the outer side of the radial layer; and taking their origin from the upper segment of the annulus cartilagineus, run obliquely downwards towards the middle line, in order to be inserted into the outer aspect of the cartilaginous structure at the handle of the malleus. Below the end of the handle they are feebly marked, and consist at best only of isolated fibres. They lie immediately subjacent to the integumentary layer, and the author has named them the *descending fibres of the membrana propria.* The outer and inner layers of the membrana tympani are loosely held together by delicate patches of connective-tissue; whilst, on the other hand, the former is intimately connected with the integumentary, and the latter with the mucous layer.

Fig. 36.

Dendritic fibrous structure of the Membrana Tympani.



(3) The *Mucous Layer* (*membrana mucosa*) forms the inner covering of the membrana tympani, and is a continuation of that which lines the tympanic cavity. It is strongest at the upper part of the membrane; while, like the integumentary layer, it thins off somewhat as we approach its centre. It is, as a whole, very delicate, and covered with pavement epithelium.

Dendritic Fibrous Structure in the Membrana Tympani.—Besides the layers already described, a structure is met with in the tympanic

[1] According to *Gerlach*, the thickness of the radial layer at this spot is 0·018‴, whilst the thickness of the circular layer at the same place is 0·026‴.

membrane, which was first described by the author, and which, on account of its peculiar arrangement, he named the *dendritic fibrous structure* (Fig. 36). If one brushes away under water the epithelium of the mucous layer and the epidermis of the integumentary layer, a structure comes into view which can generally be recognised with the naked eye, but which is rendered very evident by a low power, and which is most strongly developed in the posterior segment of the membrane. Its fibres arise in a somewhat fanlike manner out of the substance of the membrane ; then draw closer together in their further course, to be again divided into processes which radiate in different directions and become lost in the membrane. Just as the structure began with a broad base at the periphery, so also the ends of its branches broaden out through the separation of their fibres where they pass into the substance of the membrane.

When well developed, it is not confined to the posterior part of the membrane—where however it is always best marked—but is seen also in its anterior part; and the fibres arise, not only from the periphery, but from other parts of the membrane, to be inserted again into the membrane itself. The fibres of the different bands frequently join or become interwoven, so that the whole structure has an irregular arrangement. In some parts it is altogether wanting, while in others it is well marked ; and its fibres are seen crossing those of the membrana propria in various directions.

In the central part of the membrane it lies immediately beneath the mucous layer ; whilst near the periphery it is found between the radiating and circular fibre layers. It consists essentially of connective tissue resembling that of tendinous structures generally.

Under polarised light, the dendritic structure appears in light bands, while that of the other tissue is darker. This structure materially strengthens the membrane, and may assist in bringing it back to its natural position when too tensely bulged outwards or inwards ; or may be for the purpose of preventing its over-distension.

Kessel[1] associates the dendritic fibrous structure with the lymph-vessels of the membrane. He considers the spaces which exist between its bands as lymph-sinuses which communicate with the lymph-vessels in the integumentary and mucous layers of the membrane. These sinuses are said even to be lined with epithelium, which may be displayed by treating with silver nitrate.

Connection of the Membrana Tympani with the Malleus.

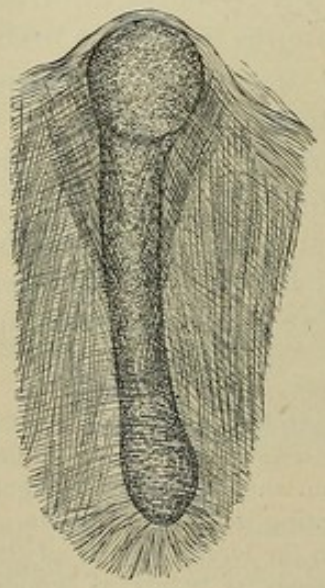
On examining the membrana tympani while it is still connected with the malleus, it is seen that this ossicle is attached to its inner surface, so that the inner two-thirds of the circumference of its handle project free and crest-like, while the outer third appears as if embedded in the membrane (Fig. 33).

[1] "Nerven und Lymphgefässe des menschlichen Trommelfelles," Centralblatt für die medicinische Wissenschaft, 1869, Nr. 23, 24.

If in a fresh preparation, one makes a circular incision round the neck of the malleus, and a longitudinal cut along the entire inner edge of the handle, and then shaves off the mucous membrane from it with a small knife, it is found that the membrana tympani can be separated readily from the upper third of the handle, whilst its lower portion is firmly attached to the bone. The connection is especially loose in the vicinity of the short process; but after disengaging the mucous membrane from the handle, one can succeed in removing the membrane from the entire handle, and is thus in a position to study that portion which is in relation to the outer third of its circumference. On inspecting this with the naked eye, or on palpating it with the sound—but still better on examining it with a lens—one can convince oneself that another structure is here met with besides the elements of the membrana tympani already described. This appears under the microscope as a cartilaginous formation, and was discovered by the author; who like *Kölliker* regards it as a constituent part of the malleus; forming indeed a residue of that stage of development when the entire hammer was cartilaginous. On examining this structure (Fig. 37) it is seen to be grooved, the concavity being directed towards the handle of the malleus, so as to form as it were the negative of the outer third of its circumference which is lodged in it. It begins at the short process, and extends for about ½ *mm.* below the handle. On examining transverse sections of it, it is seen that the cartilage is most largely developed at its upper part; and that here also the largest and most perfect cartilage cells are found. In its lower part, and also along its sides, the cells resemble those of young cartilage; so that the hyaline nature of the structure is only pronounced at its upper part.

Fig. 37.

Cartilaginous structure, with the fibres of the membrana propria.



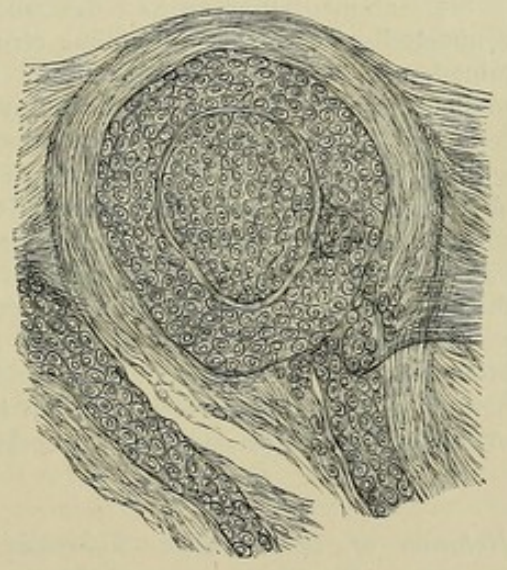
The author found this cartilaginous structure not only in man, but also in the horse, bullock, sheep, pig, fox, polecat, hare, rabbit, dog, cat, rat, and mouse; so that there can no longer be any doubt as to its presence in all mammals; although it was always found best developed in man. A cartilaginous structure—formed, it is true, in quite another manner, but embedded in the membrana tympani of the bird, and connecting it to the single auditory ossicle (the columella)—serves as an analogue.

The individual layers of the membrana tympani are connected with this cartilaginous structure; the more deeply placed fibrous bundles

of the integumentary layer, which descend from the postero-superior segment of the annulus cartilagineus, pass mostly downwards and forwards, and are somewhat tense. These cross each other in their course downwards; and, opposite the lower part of the neck of the malleus, wind themselves in circular bands round the cap-shaped extremity of the cartilaginous structure, so as partly to cover its outer aspect (Fig. 38). The upper end of the cartilaginous structure hangs, therefore, in a sort of sling, the extremities of which are attached to the upper aspect of the inner extremity of the external auditory canal. From these circular bands which surround its upper part, slender fibres pass downwards towards the anterior and posterior segments of the membrana tympani. These were by many observers erroneously described as fibres of the membrana propria.

Fig. 38.

Upper end of the cartilaginous formation, with the fibres winding round it. The largest cartilage-cells are seen in its central portion.



Externally the integumentary elements descend from the upper part of the external auditory canal to the cartilaginous structure, and form its outer, although not its only covering, since the fibres of the membrana propria also reach it.

The generally accepted view that the fibres of the membrana propria are inserted directly into the handle of the malleus must now be abandoned. The fibres arise in the annulus cartilagineus, and pass to the cartilaginous structure just described, into which they are inserted. This is also the case with the descending fibres lying externally to the radiating fibres, as well as partly so with the circular fibres of the membrane; so that properly speaking this cartilaginous structure gives attachment to the fibres of the membrana propria.

Above the cartilaginous structure—*i.e.* above the short process of the malleus—the radiating fibres are quite wanting for about 1 *mm.*, while the circular fibres are very scanty in this vicinity. Hence the membrana tympani is looser in this situation, being composed only of the integumentary and mucous layers, and was described by *Odo Shrapnell*[1] as the *membrana flaccida*. It is very variable in size, and here also is found the

[1] "On the Form and Structure of the Membrana Tymp." London Medical Gazette, vol. x., p. 120.

so-called *foramen Rivini*; for this reason *Helmholtz* has applied the name "*pars Rivini*" to this part of the membrane.

The *foramen Rivini*, which has also been considered as a normal condition by *Bochdalek*, occurs as a single or double perforation, either above the short process, or immediately in front or behind it. The author believes that it is most frequently to be explained as a simple perforation occasioned by an inflammation of the middle ear.

A discontinuity is sometimes met with between the upper part of the handle of the malleus and the corresponding part of the cartilaginous structure. Repeated examinations have convinced the author that this is by no means a regular occurrence. It extends more or less downwards, and is most perceptible at the posterior part of the handle; whilst anteriorly the cartilaginous structure is more frequently found adherent to the handle.

The assertion that the author has spoken of "*a true joint*" as existing between the handle of the malleus and the cartilaginous structure, is devoid of foundation. Even in his preliminary communication concerning it, it is said that the short process of the malleus as well as a large part of the handle of the bone is found in "*a kind of*" articular connection with the membrana tympani (S. Wochenblatt der k. k. Gesellschaft der Aerzte in Wien, 1867, Nr. 1). Equally erroneous is the statement that he has described "the whole handle" as being movably connected with this cartilaginous structure. What the author has always maintained, and what he repeats to-day after many recent observations, is that the malleus is united to the membrana tympani in such a way that a displacement of a part of the hammer, up to a certain degree, and in a fixed direction, is possible without the membrana tympani being compelled to follow all its movements, as has up till now been supposed. This independent movement is rendered possible by the discontinuity which has been described as sometimes occurring between the upper part of the handle of the malleus and the cartilaginous structure; and also by the elasticity of the cartilaginous structure itself, which is of considerable thickness in the region of the short process. Moreover, *Helmholtz*, in his treatise "Die Mechanik der Gehörknöchelchen und des Trommelfelles,"[1] has not only corroborated the author's statements, but has experimentally proved that such a mode of connection is a physiological necessity.

Relation of the Chorda Tympani Nerve to the Membrana Tympani.—Description of the Pouches of the Membrana Tympani.

As already stated, the mucous layer covers the inner two-thirds of the handle of the malleus—*i.e.* the part of the handle which projects free towards the tympanic cavity. The mucous membrane covers the handle closely, and passes from it to the anterior and posterior segments of the membrane. It is, however, otherwise with the covering which it gives to the chorda tympani nerve as it passes from behind, forwards and upwards between the descending process of the incus and the neck of the malleus towards the fissura Glaseri (Fig. 33, *cht* and *cht'*). After the mucous membrane which descends from the roof of the tympanum has covered the

[1] See, "Archiv für die gesammte Physiologie des Menschen und der Thiere." Herausgegeben von *E. F. W. Pflüger*, 1868, i. Jahrgang, 1. Heft.

chorda tympani, it passes upwards again to reach the circumference of the membrane, so as to be reflected on to it as its inner or mucous layer. The chorda tympani nerve is therefore situated at the free margin of a duplicature of the mucous membrane, which forms, with the membrana tympani lying external to it, a pouch opening downwards. This is divided by the adhesion of the chorda tympani to the malleus, into a large posterior, and a small anterior pocket (*posterior and anterior pouches of the membrana tympani: V. Tröltsch*). Moreover, a small lamella of bone (spina tympanica) on the annulus tympanicus, also takes part in the formation of the anterior pouch.

V. Tröltsch, who first directed attention to the significance of these pouches in relation to pathological conditions, regards the folds of mucous membrane as true duplicatures of the membrana tympani, and says he has discovered in them fibres similar to those in the membrana tympani. The author, after the most careful examination of many human specimens, as well as those of a considerable number of mammals, in which these pouches are also found, has never succeeded in proving the existence of the fibres of the membrana propria in these folds. No doubt dense connective-tissue in large quantity is seen passing in this fold from the postero-superior part of the annulus cartilagineus towards the malleus, but the author could not discover any fibres of the membrana propria. He is therefore obliged to regard these folds, not as "true duplicatures of the membrana tympani," but as folds of mucous membrane. *Rüdinger* regards them as forming bands of attachment for the upper part of the malleus.

Gerlach describes peculiar villous processes as existing on the mucous layer of the membrana tympani. They occur in considerable numbers in the peripheral third of the lower half, and in the peripheral two-thirds of the upper half of the membrane. The author has found them well marked in delicate children. They occur as peculiar processes which their discoverer states may be regarded as papillæ or villi. In sections from hardened preparations of the membrane, they appear more or less spherical; while sections of fresh specimens show them to be finger-like and resembling the intestinal villi. *Gerlach* says the spherical have a diameter of 0·10—0·12‴, and a length of 0·12—0·14‴; while the digitate are 0·06—0·08‴ in thickness, and 0·10—0·12‴ in length. Their central portion consists, according to their discoverer, of ordinary connective tissue, in which are seen one or more capillary loops. "At the periphery of the process the connective tissue appears more homogeneous; and like the mucous membrane is covered by several layers of flattened epithelial cells." *Gerlach* was not able to discover nerve fibres in these structures; and this, together with the fact that some of them are only connected to the mucous membrane by pedicles, determined him to regard them as villi. *Moos* found similar structures on the inner wall of the tympanum in two cases: viz. once in a newly born child, and again in a four-months' fœtus.[1]

Besides the two pouches just described, *A. Prussak*[2] mentions as a third the space which exists between the head of the malleus and the outer wall of the tympanum: *i.e.* the uppermost part of the tympanic membrane. *Helmholtz* has, however, called attention to the fact that the so-called opening into this pouch situated above and in front of the head of the malleus does not lead into the space over the ligamentum mallei ext.: *i.e.* does not lead to the membrana tympani.

[1] "Ueber gefässreiche Zotten der Trommelhöhlenschleimhaut." Zeitschrift für Ohrenheilkunde, xiv. Bd., 1. Heft.

[2] Centralblatt für die medicinische Wissenschaft, 1867, Nr. 15.

Blood and Lymph Vessels of the External Portion of the Ear.

I. Arteries.

1. *Arteries of the Pinna.*

(*a*) *The arteria auricularis anterior superior* arises from the art. temporalis, and passes backwards to the helix. As a rule only one vessel is present, but occasionally there are two.

(*b*) *The arteriæ auriculares anteriores inferiores* are from two to four in number; they spring from the art. temporalis and pass to the lower part of the pinna, in order to supply the lobe, the tragus, and the region of the concha. Smaller branches are also carried along the lower wall of the auditory canal, to terminate in its cartilaginous portion. All these branches run on the anterior surface of the auricle.

On the posterior surface of the pinna are seen the *rami auriculares posteriores*, which represent the terminal branches of the *art. auricular. posterior*. These rami not only supply the posterior surface of the pinna, but send their *rami perforantes* to its anterior surface, where they anastomose with the art. auric. anteriores.

2. *Arteries of the External Auditory Canal.*

The canal receives a small part of its vascular supply from the terminal branches of the art. auric. ant. inferiores just described; but its principal artery is the *arteria auricularis profunda*, a branch of the art. maxillaris interna. After perforating the anterior wall of the auditory canal, this supplies both its cartilaginous and osseous portions, and sends a tolerably large terminal branch to the membrana tympani.

3. *Arteries of the Membrana Tympani.*

This membrane derives its blood supply from two different sources: viz., (1) the *art. auric. profunda* above mentioned; and (2) the *art. tympanica*. The latter, a branch of the ramus tympanicus of the art. stylo-mastoidea, is reinforced by small branches from the art. auric. profund., and enters the tympanic cavity through the *fissure of Glaser*. The art. tympanica ext., derived from the art. auric. profunda, ramifies in the integumentary layer of the membrane; while the art. tympanica int., arising from the art. stylo-mastoidea, spreads out in the mucous layer. Each artery forms a vascular network in its own layer, while between the two is found the non-vascular membrana propria. The vascular networks of the mucous and integumentary layers anastomose with each other only at the periphery of the membrane.

The integumentary layer has the more abundant vascular supply. One large branch descends from the upper wall of the auditory canal, while other smaller branches pass inwards from the sulcus tympanicus. The branch (sometimes represented by two twigs), which descends from the upper wall, passes downwards along the handle of the malleus towards the centre of the membrane. It gives off numerous radiating branches in its course, and finally breaks up into a capillary network, which anastomoses with the small vessels passing inwards from the sulcus tympanicus. Under the microscope, small vessels can be distinctly seen passing from those of the integumentary layer to the cartilaginous structure. They form a sort of wreath-like arrangement around its upper part, but are irregularly arranged in relation to its lower portion.

Kessel says the membrana propria possesses a delicate capillary network which anastomoses with the vessels of the integumentary and mucous layers. *Wendt* corroborates this; while *Moos* only observed communications between the veins of the two layers.

Gerlach says the vessels in the mucous layer are much finer, and form a complete network, which is chiefly derived from the art. tymp. inf., accompanying the handle of the malleus. He states that he was once able to inject the vessels of the mucous layer when he injected the brain through the internal carotid arteries after ligature of the art. vertebrales. He thinks that the filling of the inner network in this case was brought about through anastomoses between the art. auditiva interna and the arteries of the tympanic cavity. According to *V. Langer*[1] the carotis interna itself gives small twigs to the mucous membrane of the tympanum, and thus it would be easy to fill these vessels directly by injecting the carotis interna.

II. Veins.

The *venous blood* from the structures of the external portion of the ear is drained away by the *vv. auriculares anteriores, superiores et inferiores* into the *v. temporalis*, and through it into the *v. jugularis externa*. The blood from the pinna is carried away chiefly by the vv. auriculares superiores, whilst that from the external auditory canal passes through the vv. auriculares inferiores.

III. Lymph Vessels.

The *lymph vessels* of the external portion of the ear communicate with the *glandulæ subauriculares* (*gl. auricul. posteriores*), found in the neighbourhood of the mastoid process, and with the *glandulæ faciales superficiales* (*gl. auriculares inferiores*), found in the region of the parotis. The *glandulæ cervicales superficiales*, which lie between the m. subcutaneus colli and the m. sterno-cleido-mastoideus, also receive lymph-vessels from the external ear.

Nerves of the External Portion of the Ear.

The *external portion of the ear* is supplied with nerves from the *cervical plexus*, the *nervus facialis*, the *n. vagus*, and *n. trigeminus*.

[1] "Lehrbuch der Anatomie des Menschen," Wien, 1865.

The *n. auricularis magnus*, from the anterior branch of the third cervical, ramifies in the skin on the anterior surface of the pinna; while the n. occipitalis minor sends also a small branch (*n. auricularis superior*) to the pinna.

The *ramus auricularis nervi vagi* supplies the posterior surface of the auricle, the lower part of its anterior surface, and the cartilaginous part of the external auditory canal.

The n. facialis also sends branches (the *rami auriculares posteriores externi*, and the *ramus auricularis ant.*) to supply the muscles of the pinna.

The n. auriculo-temporalis from the third division of the n. trigeminus gives off two branches—the *n. meatus auditorii externi inferior* and the *n. meat. aud. ext. superior*—to the external auditory canal. The former ramifies in the integument of the cartilaginous part of the auditory canal; while the latter, ascending behind the art. temporalis and the head of the inferior maxilla, divides into two branches. One of these—the ramus externus—gives branches to the helix, concha, and upper wall of the auditory canal; whilst the other perforates the auditory canal to reach the membrana tympani, on which a branch accompanies the handle of the malleus, and spreads out in the membrane.

Most of the nerves of the tympanic membrane are found in its integumentary layer—indeed, *V. Tröltsch* says he has never found nerve-fibres either in the mucous layer or in the membrana propria; while, on the other hand, both *Gerlach* and the author have seen fine nerve-filaments in the mucous layer. No definite statements have as yet been advanced as to the mode of termination of the nerve-filaments in the membrana tympani. The largest branches descend from the upper wall of the auditory canal, and accompany the vessels along the handle; while smaller twigs likewise accompany the vessels passing in from the periphery. They form a coarse network in the integumentary layer.

Gerlach states that he once saw unmistakeably the division of a primitive tube. The author has also made a similar observation in a preparation which was also seen by *Herr Professor Wedl.* With chloride of gold, a rich network is seen; but the author questions whether all the fibres are nerves.

Kessel says nerve-fibres also occur in the membrana propria. According to this author, they are derived from the integumentary layer, and penetrating between the fibres of the radiating layer, either end in the fibres or form connections with the nerves of the mucous layer.

II. Middle Portion of the Ear.

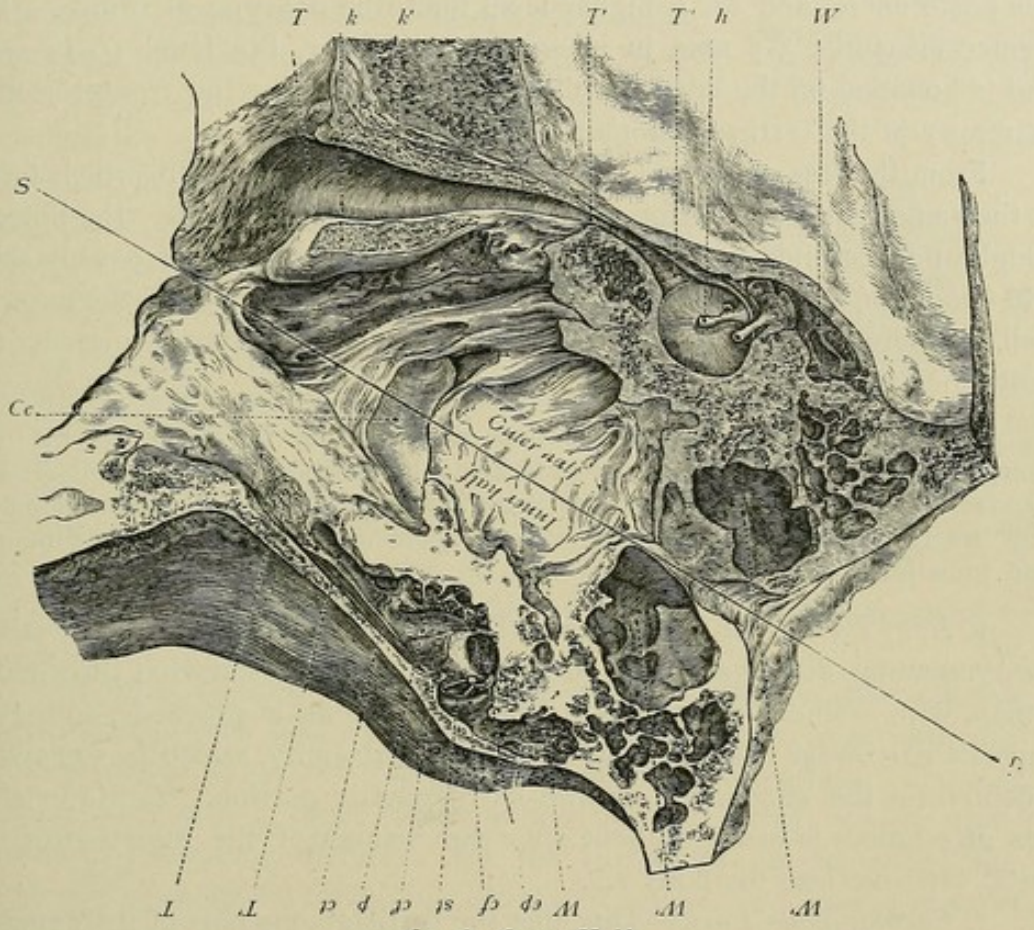
(*a*) *The Eustachian Tube* (*tuba s. ductus Eustachii, canalis palatino-tympanicus, tuba acustica*).

The Eustachian tube is the passage between the naso-pharynx and the tympanic cavity. It somewhat resembles in its structure the external auditory canal. Thus it is not a straight, but an angular tube,—the obtuse, somewhat rounded-off angle opening forwards and downwards; and it

consists of a *cartilaginous* and an *osseous* portion (*pars cartilaginea et pars ossea*), which together have a length of 33-40 *mm.*,—10-15 *mm.* belonging

Fig. 39.

View of the entire middle portion of the ear, after it has been divided through the centre by an incision parallel with its long axis. The outer (lateral) half is represented above the line *S S'*, the inner (median) half below it.



On the Outer Half.

T, *T'*, *T''*, Tuba Eustachii (*T'*, isthmus, *T''*, tympanic orifice); *k*, *k'*, cartilaginous portion. Below the Tuba the muscles are indicated; *h*, handle of the malleus, with remains of the tendon of the m. tensor. tymp. Behind the handle is seen the descending (long) process of the incus; and above, the connection between the head of the malleus and the crown of the incus. Between the handle of the malleus and the process of the incus is seen the chorda tympani nerve, passing from behind and below, forwards and upwards. It also represents the margins of the folds of the membrana tympani. The tympanic membrane itself is accurately limited; *W*, opening into the mastoid cells; *W'*, large cavity in the mastoid process; above it are seen smaller cells.

On the Inner Half.

Cc, Part of the canalis caroticus laid open; *T T'*, Tuba Eustachii; *ct*, canalis musc. tensor. tymp.; *ct'*, rostrum cochleare, with a portion of the tendon of the musc. tensor.; *p*, promontorium on inner wall of tympanum: at its posterior part is seen the recess of the fenestra rotunda; *st*, stapes; *cf*, transverse part of the canalis Fallopii; *ep*, eminentia pyramidalis with tendon of musc. stapedius attached to head of stapes; *W*, entrance to mastoid cells; *W'*, mastoid cells.

to the osseous part, while the angle referred to occurs at the junction of these two portions. The osseous part has already been described, while

the cartilaginous portion is situated at the base of the skull, and occupies the groove which, in the macerated cranium, is seen between the great wing of the sphenoid and the petrous portion of the temporal bone. The openings of the tube are named after the cavities with which they communicate; and hence we speak of a *pharyngeal orifice* (*ostium pharyngeum*), and a *tympanic orifice* (*ostium tympanicum*). Of these two the tympanic lies posterior to, and on a higher level than, the pharyngeal orifice. The former measures 3-5 *mm.* in its vertical diameter, the latter 10-13 *mm.*, and is bounded on the lateral wall of the pharynx by the free projecting extremity of the cartilage (*limbus cartilagineus*).

From the free margin of the posterior cartilaginous wall, which forms at the same time the anterior wall of the *fossa of Rosenmüller*, the mucous membrane descends to the lateral wall of the pharynx as a tolerably thick fold (*plica salpingo-pharyngea*); and from the free margin of the anterior wall, a more slender fold (*plica salpingo-palatina*) passes towards the posterior nares.[1]

According to *Urbantschitsch*[2] the difference in the form of the ost. pharyng. tubæ E. depends upon the individual conditions of the cartilage and mucous membrane, as well as on the ligam. salpingo-palatinum, the development and direction of which varies. In infants and in very old people the opening is said sometimes to be circular.

1. *Bony Part of the Tuba Eust.*—This extends from the anterior wall of the tympanum, downwards and forwards; and has a somewhat three-sided lumen, with rounded-off angles. This narrows as it proceeds, so that it appears narrowest (2-3 *mm.*) at its lowest extremity, which is somewhat indented for the attachment of the cartilaginous portion. *L. Mayer* says this attachment is brought about after the manner of the insertion of the costal cartilage into the bony rib.

2. *Cartilaginous Part.*—This, like the cartilaginous part of the external auditory canal, is not formed by a complete tube of cartilage, but by a *cartilaginous furrow* opening downwards and forwards. One distinguishes, in connection with this furrow, *a posterior* (*median*) and an *anterior* (*lateral*) cartilaginous plate. These are continued into each other superiorly without a break; the median plate being much broader than the lateral. This fundamental type of tubal cartilage is found, according to *Rüdinger*, in the other mammalia. The posterior (median) plate is attached to the base of the skull, while the anterior (lateral) is movable. The cartilaginous part of the tube gradually expands as it descends, so that it is widest where it opens into the pharynx; and hence the narrowest part

[1] Compare *Zaufal*, "Ueber die Plica salpingo-pharyngea." Archiv für Ohrenheilkunde, Band xv.

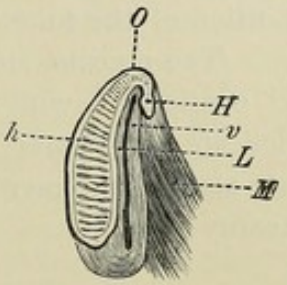
[2] "Anatomische Bemerkungen über die Gestalt und Lage des Ostium pharyngeum tuba E. beim Menschen." Archiv für Ohrenheilkunde, x. Bd., S. 1.

of the entire tube (*isthmus tubæ Eust.*) is found where the cartilaginous and osseous parts are joined. Here the diameter is 2-3 *mm.*

We are indebted to *Rüdinger* for more accurate information concerning the structure of the cartilaginous part of the tube.[1] According to him the cartilaginous plates, which are continuous with each other superiorly, form a hook which is open inferiorly. The median plate is much broader than the lateral; but whilst the former becomes narrower as we pass backwards, the latter broadens somewhat as it approaches the osseous part of the tube. In the middle of the cartilaginous part of the tube its walls come into apposition by means of their folds of mucous membrane, which will be subsequently referred to.

Fig. 40.

Transverse section of the cartilaginous part of the tuba Eustachii.



O, Upper wall; *h*, posterior wall; *v*, anterior wall; *H*, cartilaginous hook; *L*, lumen of tube lined by mucous membrane; *M*, tubal muscle.

The tubal cartilage is, according to *Rüdinger*, attached to the fibro-cartilago-basilaris in such a manner that the surface which looks backwards and upwards is intimately connected with it, while the hook projects downwards and outwards free. The fibres of the basilar cartilage pass into those of the tubal cartilage, and bind the two structures firmly together, so that only the lowest part of the latter, which projects free towards the pharynx, possesses a proper perichondrium.

The tubal cartilage belongs to the variety known as fibro-cartilage. In its median, and less frequently in its lateral plate, interruptions are found, to which *Zuckerkandl* and *Moos* first called attention. The neighbouring parts are in those cases united by soft tissue, which may be studied in transverse sections. On the surface of the fibro-cartilage is found a fibrous layer, containing elongated nuclei, and closely connected with the vascular perichondrium. Where the tube is not supported by cartilage—*i.e.* in front and below—the so-called *membranous part of the tube* is found, which with its lining mucous membrane has a tolerably thick diameter. This membranous part consists of a dense membrane (*tunica propria*) containing nuclei and permeated by vessels, which is continued on to the inner surface of the cartilaginous furrow. Near the upper part of the fissure, the mucous membrane forms, through the greater development of its tunica propria, two constant valve-like projections, which cannot be obliterated, and which, according to *Rüdinger*, are capable of completely closing the middle part of the lumen below the cartilaginous hook.

Accessory cartilages are frequently found at the lower extremity of the cartilaginous tube, also in the lig. salpingo-pharyngeum, and in the membranous

[1] "Ein Beitrag zur Anatomie und Histologie der Tuba Eustachii von *Dr. Rüdinger* in München, mit einer Tafel" (Separatabdruck aus dem baierischen ärztlichen Intelligenzblatt, 1865, Nr. 37); auch Monatsschrift für Ohrenheilkunde, Jahrgang i., ii., iii.

part of the tube. They appear in the form of small rods or nuclei, and have no physiological significance. *Zuckerkandl*, *Moos*, *Urbantschitsch*, and others have instanced such conditions. The author has, in his collection, a preparation in which a small cartilaginous plate is met with behind the median plate: *i.e.* a sort of double median plate connected by fibrous tissue.

The membranous part, taken as a whole, is about 2 *mm.* thick; this thickness being due to the layer of adipose tissue which intervenes, even in thin individuals, between the mucous membrane and the adjoining muscle. The muscles of the soft palate partly arise from this membranous portion of the tube.

The mucous membrane which lines the interior of the tuba Eustachii is continuous with that of the pharynx. It becomes more and more delicate the nearer we approach the tympanic cavity; while its glands are also less numerous, and its submucous tissue becomes gradually more scanty.

As a continuation of the pharyngeal mucous membrane, its structure exhibits, first of all, a ciliated layer of epithelium resting on a basement membrane. The submucous layer, according to *Rüdinger*, is a thick fibrous layer traversed by vessels, which takes the place of the perichondrium in the concavity of the cartilage.

Several well-marked vascular longitudinal folds, belonging to the membranous part of the tube, are found at the ostium pharyngeum tubæ. These folds allow of a dilatation of the lumen of the tube without necessitating a simultaneous stretching of its mucous lining.

The glands of the tube are numerous at the pharyngeal orifice, but are most abundant in its middle part, again decreasing in number as we approach the tympanic orifice. *Rüdinger* says they are found chiefly in the membranous part, and are quite wanting below the cartilaginous hook. They are acinous glands, and their lumen is lined by ciliated cylindrical epithelium. The mucous membrane, according to *Henle*, has at its thickest part a diameter of 0·6 *mm.*, while the glands have a diameter of 0·15—0·6 *mm.* The direction of the ciliary movement is from the ostium tympanicum towards the ostium pharyngeum.

Ludwig Mayer found, in many transverse sections of the tubal mucous membrane villous-like structures projecting into the lumen of the tube.[1]

In the cartilaginous part, with the exception of its uppermost portion, the lumen of the tube appears as a narrow fissure, in which the surfaces of the mucous membrane are in contact, or only very slightly separated. Under normal conditions this fissure is always found open at its pharyngeal orifice. Below the cartilaginous hook is found the canal, which in exceptional cases is open along the entire length of the tube. This was first described by *Rüdinger*, and confirmed by *Ludw. Mayer*, *Rebsamen*,[2] and *Lucæ*[3]). As a rule, however, this is not the case, as the canal, especially

[1] "Studien über die Anatomie des Canalis Eustachii," München, 1866.
[2] Monatsschrift für Ohrenheilkunde, 1868.
[3] Archiv für Ohrenheilkunde, ii. Bd.

towards the isthmus tubæ, is usually closed, owing to the contact of its walls.

Lucæ says that the part of the lumen situated below the hook ends blindly where it joins the osseous portion, and that only the upper part of the lumen is immediately continued into the bony portion. The author finds, from his own examinations, that a pouch sometimes exists where the cartilaginous joins the bony tube, but this appears to be of little importance, as such recesses are found quite as frequently in the membranous wall.

The tuba Eustachii of the child differs essentially from that of the adult, both as regards its direction and its various measurements. As a whole, the tube is relatively wider in children, especially at the isthmus and at the ostium tympanicum. The osseous portion is much shorter than in the adult;[1] the angular flexion much less; consequently the tube is more horizontal. According to *Kunkel*[2] the pharyngeal orifice is below the plane of the hard palate in the fœtus; in the newly born child it has reached this plane, while at the fourth year it is 3-4 *mm.*, and in the adult 10 *mm.* above it. The ostium pharyngeum, on the contrary, is much less gaping in children; and the cartilage of the tube, as a whole, projects less towards the middle line of the pharynx. The membranous part preponderates over the cartilaginous part in the infant, and *hence the lumen of the cartilaginous part can be much more easily expanded in the child than in the adult.*[3]

Concerning the question whether the tuba Eustachii is normally open or closed, opinions are still divided, although the literature on the subject is very voluminous. That the tube is normally so far open as to allow a stream of air passing its pharyngeal opening to enter it directly, certainly cannot be accepted; for clinical experience shows us that people with wide, easily permeable tubes are troubled with morbid subjective symptoms; proving that a continually patent tube cannot be normal. Its form and structure would even indicate that a too easy passage does not correspond with its physiological purpose. The angular curvature between its cartilaginous and osseous portions, as well as the fact that the cartilaginous part is not surrounded by rigid cartilaginous walls, would support the view that a too free communication between the naso-pharynx and the tympanic cavity would not be desirable. Again, if one takes into consideration the fact, as proved by *Hartmann*,

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[1] According to *V. Tröltsch*, the length of both sections is said "to vary less in the child; the osseous canal being proportionately longer than in the adult," which the author cannot in the least confirm.

[2] *Hasse's* "Anatomische Studien," 1869, Heft 1.

[3] *Symington* (*op. cit.*) gives the following table, showing the length of the tube at different ages:—

Age of Subject.	Length of Tube.
Two 9 months fœtuses.	17 *mm.* and 18 *mm.*
Child 6 weeks old.	17 *mm.*
„ 1 year „	20 „
„ 1 year 3 months old.	20 „
„ 2 years old.	23 „
„ 4½ „ „	31 „
„ 5 „ „	30 „
„ 7 „ „	30 „
Three adult subjects.	35 *mm.* 35 *mm.* 36 *mm.* Eds.

that the pressure could be raised up to 200 *mm.* of mercury in the pneumatic chamber with the muscles of the tube at rest, without air entering the tympanum, one is easily convinced that the tuba Eust. is normally closed when the muscles are at rest.

Of much greater practical importance is the question *concerning the degree of this closure, in connection with the necessary power for opening the tuba Eustachii.* The individual differences—all within the normal limit—are so numerous that a general average cannot be laid down. Cases are found within the latitude of normal hearing where the passage is extraordinarily easy, and others where it is tolerably difficult; but the author has never seen a case of perceptible respiratory movement of the membrana tympani with, at the same time, normal hearing and absence of morbid subjective symptoms. He considers a tube sufficiently patent which is so far opened during deglutition that the air can enter from the pharynx into the tympanic cavity, and *vice versâ*. On the other hand, he regards a tube as abnormally dilated in which the respiratory movements produce perceptible subjective or objective pressure oscillations in the tympanic cavity. No one to-day seriously doubts that the tuba Eustachii is under normal circumstances opened during deglutition, and indeed during the first stage of the act. *Nicoladoni*[1] saw, in a case which was operated upon, a hæmatoma at the orifice of the tuba Eust. sink deeper into the tube during each act of swallowing, and return again to its previous position after the act was over. This speaks irrefutably for the opening of the tube during the act of swallowing.

(*b*) *The Tympanic Cavity* (*tympanum, cavum tympani*).

We distinguish as the tympanic cavity the part of the middle ear situated between the Eustachian tube and the mastoid cells. Externally it is separated from the external auditory canal by the membrana tympani; internally it is contiguous to the labyrinth; above to the cranial cavity; and behind to the cells of the mastoid process. On its anterior wall the canalis musculo-tubarius opens at the upper part; while the bulbus venæ jugularis, lying in the fossa jugularis, is the nearest adjacent structure to it below. The opening of the canalis musculo-tubarius lies at a variable distance from the floor of the tympanum, while the opening into the mastoid cells is found high up in the posterior wall. In the tympanic cavity is situated the complete chain of auditory ossicles; the outer extremity of the chain is formed by the handle of the malleus connected with the membrana tympani, whilst its inner extremity—represented by the foot of the stapes—is fixed in the oval fenestra. The tendons of the muscles which control the movements of the ossicles lie partly free in the tympanic cavity. These, together with the small blood-vessels and nerves, will subsequently be spoken of in greater detail. Since the osseous walls of the tympanum have already been described, we can at once pass to the more minute description of the structures found in it.

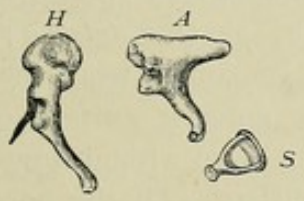
[1] "Beobachtungen am Lebenden über die Bewegung der Tuba Eust." Monatsschrift für Ohrenheilkunde, 1875, Nr. 8.

The Auditory Ossicles (ossicula auditus).

In the tympanic cavity of the mammalia three small bones are found, which constitute the *auditory ossicles* (Fig. 41). They are the *hammer* (*malleus*, *H*), the *anvil* (*incus*, *A*), and the *stirrup* (*stapes*, *S*).

Fig. 41.

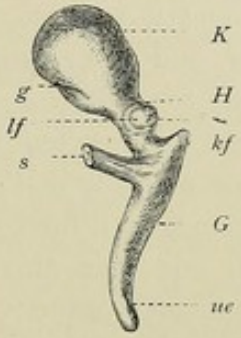
The three auditory ossicles from an infant, represented approximately in their natural position.



H, Malleus; *A*, incus; *S*, stapes. From the neck of the malleus is seen the long process, the ligamentum anterius, passing forwards. The articular surface of the incus is directed forwards towards the malleus. The extremity of its descending process is bent somewhat inwards, whilst its horizontal process passes directly backwards. On the foot of the stapes one can see the broad limiting margin.

Fig. 42.

The malleus (about four times enlarged).



K, Head; *H*, neck; *G*, handle; *g*, articular surface; *lf*, long process; *t*, protuberance; *kf*, short process; *s*, part of the tendon of the m. tensor tympani; *ue*, lower end of handle.

1. *The Malleus* (*hammer*).

This ossicle, which was named by *Vesalius*,[1] consists of a *head* (caput s. capitulum), a *neck* (collum s. cervix), and a *handle* (manubrium) (Fig. 42).

The *head of the malleus* (*K*) is the uppermost and most prominent part of it, and in the natural position of the ossicle is concealed by the outer part of the arched roof of the tympanic cavity. On its posterior aspect is seen the cartilaginous articular surface for the crown of the incus. This surface runs somewhat spirally outwards and downwards, and its margins project more or less prominently, especially at its extremities.

According to *Hyrtl*, two foramina nutritiva are found in the embryo on the anterior aspect of the head, for the transmission of capillary vessels to the spongy tissue of the bone. By the third year these foramina are said to be closed, and the bone also is destitute of medullary spaces.

The head is continued into the short neck (*H*)—flattened somewhat on both sides—and this again into the handle (*G*). The head and neck form with the handle an obtuse angle. This angle, according to Hyrtl, measures 150° in man, and in the natural position of the bone opens towards

[1] Corp. Humani. Fabr. lib. I. cap. 8.

the tympanic cavity. Close to the bend of this angle is seen the *short* (small) *process* (*kf*), and from the fore part of the neck the *long process* (*lf*) (*processus longus, spinosus, s. Ravii*) passes off. This last appears longer in the fœtus and infant (Fig. 41, *H*) than it does in the adult, where it is rudimentary, since the greater part of it coalesces with the neighbouring bone in the fissura Glaseri, and separates itself from the part projecting free into the tympanic cavity. This portion is still found on the malleus of the adult (Fig. 42, *lf*).

The handle consists of a slender plate of bone having the form of an elongated triangle, in which one can distinguish two surfaces, three borders, and three angles. Of the surfaces, one (the *anterior*) is directed forwards towards the anterior wall of the tympanum, while the other (the *posterior*) is directed backwards. On the anterior surface one notices almost constantly a slight projection running from without inwards, which corresponds to a furrow on the posterior surface. Of the borders of the handle, one (the *external* or *lateral*) is directed outwards towards the tympanic membrane; another (the *internal* or *median*) projects towards the tympanic cavity; while the third (or *superior*) is directed upwards, and is very short. The outer and inner borders meet at the lower end of the handle, and this extremity (*ue*) generally appears somewhat flattened from without inwards. The border of the handle which is directed upwards is only free in its outer half; its inner part is lost on the lower part of the neck.

The short process of the malleus is, properly speaking, not an independent process, but represents only the upper end of the handle, which is partially free. This end projects upwards to form a more or less pointed process, which is generally bent backwards; so that, as a consequence, it resembles in some measure a separate process. That which is generally described as the short process of the malleus (*kf*) is therefore nothing more than the upper end of the handle; and the structure which is distinguished in the complete organ of hearing from the external auditory canal as the short process, is not the upper osseous extremity of the handle, but the cartilaginous structure of the hammer previously described. The internal border of the handle is, as compared with the external, more convex, but exhibits many individual varieties.

According to *Moldenhauer*,[1] the handle of the malleus in the vicinity of the umbo is almost oval in transverse section, with its greatest diameter parallel to the plane of the tympanic membrane; whilst higher up, its greatest diameter is perpendicular to the plane of the membrane. By this arrangement the bone is strongest where it has the greatest weight to carry—*i.e.*, the resistance of the tympanic membrane; while the broader extremity of the handle is suited for the better attachment of the tympanic membrane.

[1] "Vergleichende Histologie des Trommelfelles." Archiv für Ohrenheilkunde, xiii. Bd., S. 113.

2. *The Incus* (*anvil*).

On account of the resemblance of this ossicle to a molar tooth, the older anatomists also called it the *dens molaris* (Fig. 41, *A*). One distinguishes in it a body or *crown* (*corpus*), and *two processes* (*crura, s. processûs, s. radices*). The body has somewhat the form of a molar tooth-crown, flattened more or less from without inwards. According to *Huschke*, its diameter from below upwards is $1\frac{3}{4}'''$, from before backwards $1'''$, and from without inwards $\frac{4}{5}'''$. The body exhibits a somewhat spirally running articular surface, with well marked edges, directed—in the normal position of the bone—forwards towards the head of the hammer. Of the two processes, one is placed horizontally—*horizontal process of the incus* (*crus horizontale, s. transversum, s. breve, s. posterius*); the other more or less perpendicularly—*perpendicular, long, descending*, or *inferior process* (*crus perpendiculare, s. descendens, s. longum, s. inferius*). The horizontal is the thicker and shorter of the two, having a long diameter of from 3 to 4 *mm.* Its apex is directed towards the posterior wall of the tympanum, with which it is connected. The perpendicular process proceeds downwards from the body, and measures from 3 to 5 *mm.* in length. It forms, with the horizontal, almost a right angle, opening backwards and outwards, and having the corner of the angle rounded off. The lowest extremity of the perpendicular process is bent inwards for articulation with the head of the stapes; and this inwardly directed portion was formerly described as a *sesamoid bone* (*ossiculum Sylvii s. lenticulare*). The articular surface on the body of the incus, as well as the free extremities of its processes, are covered by a thin layer of cartilage.

3. *The Stapes* (*stirrup, s. deltoida*).

The *stapes* is named from its shape; and in it one distinguishes *a foot, two crura*, and *a head*. The foot is kidney-shaped, and is thinner at its centre than at its border, where it is almost 1 *mm.* in thickness. It is about 3 *mm.* in length and 1·5 *mm.* in breadth, and in the natural position of the bone it is fixed into the oval fenestra. Its surface, which is directed towards the vestibule, is somewhat convex, while that directed towards the tympanic cavity is concave. *Henle* calls attention to a more or less distinct, though delicate, crest (crista stapedis), which connects the two extremities of the arch formed by the crura.[1]

The *two limbs* (*crura stapedis*) may be distinguished, the one as anterior, and the other as posterior. Together they form an arch, and where they meet, *the head of the stapes* (*capitulum stapedis*) is found. This

[1] This crest was already known to *Wildberg* and *Fischer* ("Tractatus Anat.-Physiol. de Auditû Hominis." Mosqu., 1825, § 12, p. 101). Huschke says he has seen it not infrequently.

is covered on its free surface by cartilage, while there is a slight roughness on its posterior aspect for the attachment of the tendon of the musc. stapedius. A tolerably wide medullary cavity is seen on making microscopical sections of the head, while both crura are furrowed on their concave sides. According to some authors, a sort of double interosseous membrane (*membrana obturatoria stapedis, s. tympanum secundum, Teichm.*) is said to fill up the whole interval between the crura. This, however, is found only in very rare cases, and is of no physiological significance.

Connection of the Auditory Ossicles with each other.

1. *Union of the Malleus with the Incus.*

The articular surfaces on the head of the malleus and the crown of the incus are joined together so as to form an articulation with two cavities, these being separated by an interarticular cartilage, or *meniscus*, as in the temporo-maxillary joint. The capsular ligament is, according to *Rüdinger*, stronger externally than internally, and sends a synovial fold between the articular surfaces; while the interarticular cartilage, which is fixed to the capsule, is strongest internally, and becomes attenuated externally.

Magnus[1] disputes the existence of a synovial articulation between the malleus and the incus. The joint is certainly very rigid, and its cavity small, so that it is difficult to prove the presence of synovial fluid in it; nevertheless, the form of the articular surfaces and the gaping of the joint cavity on opening the capsule, support the view that it is a synovial joint *Magnus* says that the only true joint in the whole chain of ossicles is that which is found between the descending process of the incus and the head of the stapes. *Helmholtz* says: "The articulation between the malleus and incus permits, it is true, of only slight rotation around an axis passing through the head of the malleus towards the short process of the incus. This rotation for the movement inwards is opposed by a pair of locking teeth; whilst, on the other hand, the handle of the hammer can be moved outwards without dragging the incus with it."

So long as the malleus and incus stand in their natural relation to each other, but with the incus separated from the stapes, they can execute movements with each other, in which the handle of the malleus and the descending process of the incus move inwards or outwards simultaneously with the tympanic membrane. According to *Helmholtz*, the incus, suspended as it were in the air, is carried by the malleus, since it has no connection except with the latter, which would fix it in position.

Helmholtz, after further describing the different movements which the ossicles may execute, writes: "At the same time it is evident that, with this displacement, the short process of the malleus must also slide a little on the tympanic membrane: a condition which is rendered possible by the peculiar connection which exists between them, as described by *J. Gruber*."

[1] "Beiträge zur Anatomie des Mittleren Ohres." *Virchow's* Archiv xx., 1, 2, 1860.

When the joint between the malleus and incus is fixed, the excursion of the extremity of the long or descending process of the latter is only two-thirds of that of the handle of the former. On the other hand, the force of the pressure which the incus exercises upon the stapes is one-and-a-half times as great as that which operates against the end of the handle of the malleus (*Helmholtz*).

When the membrana tympani is driven outwards, the capsule surrounding the joint between the malleus and incus relaxes, and this allows of a separation of the articular surfaces.

2. *Connection of the Incus with the Stapes.*

The lower extremity of the descending process of the incus (ossiculum Sylvii) is covered with cartilage, and is united to the somewhat socket-like head of the stapes, which also has a cartilaginous covering. This last is so thick that, as *Rüdinger* correctly observes, in a transverse section the area of cartilage exceeds in size that of the bone. The author has not been able to find a distinctly defined interarticular cartilage, as *Rüdinger* supposed; and hence he cannot regard this joint as exhibiting two cavities. The connection is brought about by a fibrous capsule, somewhat stronger anteriorly, which certainly permits of a movement of the articular extremities.

The end of the descending process of the incus has, according to *Helmholtz*, a slightly rounded surface, with its convexity towards the stapes. The lowest side of the capsular ligament possesses stronger fibres, which when the incus is drawn upwards are put on the stretch, and carry the stapes along with it.

Connection of the Auditory Ossicles with the Membrana Tympani and with the Walls of the Tympanic Cavity.

Articulated together in the manner just described, the bones of the middle ear form the so-called "chain of auditory ossicles"; the outer extremity of which is formed by the malleus, and the inner by the foot of the stapes. The descending process of the incus has a direction almost parallel to the handle of the malleus, while the former is joined to the stapes almost at a right angle. Thus, if we imagine the chain so placed in the tympanum that the handle of the malleus is directed outwards towards the tympanic membrane, while the foot of the stapes is turned inwards towards the oval fenestra, the direction of the other processes is easily understood. The connected upper extremities of the malleus and incus are situated above the tympanic membrane within the outer part of the roof of the tympanic cavity in the so-called *recessus tympanicus*—*i.e.* the anterior part of the sulcus found between the two plates of the horizontal portion of the squama. The short process of the incus is directed backwards, and the long process of the malleus—*i.e.* the

ligamentum mallei anterius—forwards, towards the anterior wall of the tympanic cavity.

The relation of the malleus with the tympanic membrane has already been spoken of. As for the remaining connections of the tympanic ossicles, they are attached to the different walls of the tympanum by special structures: the head of the malleus to the roof by a tolerably strong band (*ligamentum superius s. suspensorium mallei*); and the horizontal process of the incus to the posterior wall by means of an articulation, the end of the process being covered with cartilage, and articulating with a shallow cartilaginous surface on the posterior wall of the tympanic cavity (*Henle, Helmholtz*[1]). From the long process (*p. gracilis*) of the malleus the *ligamentum mallei anterius* passes to the fissura petro-tympanica, s. Glaseri. This is the strongest ligament of the malleus, and was formerly described by many authors under the name *musculus laxator tympani.*

The ligament which fastens the upper extremity of the malleus to the roof varies in length in different individuals, on account of the fact that the bone itself is situated at a variable distance from the roof of the tympanic cavity.

The base of the stapes is covered on its vestibular aspect by a layer of hyaline cartilage which also extends over the margin (*Rüdinger, Brunner, Eysell*). The interval which exists between the margin of the oval fenestra and the base of the stapes is occupied by a delicate ligament which brings the two into connection with each other. This is called the *ligamentum obturatorium stapedis* (*membrana obturatoria*); it is seen from the vestibular side to be a distinct continuation of the periosteum, and is strengthened next the tympanic cavity by a thin layer of the lining membrane of the latter.

According to *Helmholtz*, this ligamentum obturatorium is not everywhere of the same strength, but is thicker at its posterior and inferior margin. On account of this, the foot of the stapes makes greater excursions during its movements with its upper and anterior than with its lower and posterior part, and a kind of lever movement is brought about by which the head is displaced backwards and downwards.

According to the same observer, the malleus is joined to the spina tympanica major s. anterior by a band of short tendinous fibres which passes between it and the processus mallei longus. This band has been named by *Helmholtz* the *ligamentum mallei anterius.* Further, a *ligam. mallei externum* passes from the crista colli to the upper part of the inner margin of the auditory canal ("notch of Rivini"). This ligament consists of a number of separate glistening tendinous fibres which radiate from the crista of the malleus to their much broader and curved line of attachment into the temporal bone. Of these bundles the posterior is the strongest and most stretched, and has been named by *Helmholtz* the *ligam. mallei posticum.* This forms, together with the lig. mallei anterius, the axis around which the malleus rotates (*axis ligament of the malleus*). The fibres of

[1] According to *Arnold*, the crown of the incus is also said to be attached to the roof of the cavity; but this is not the case.

the lig. externum, lying above this axis ligament, and passing directly outwards, serve as check ligaments for the outward movement of the handle of the malleus.

On strong contraction of the tensor tympani, the handle of the malleus is prevented from being drawn too far inwards by the tension of the tympanic membrane, and the above-mentioned fibres of the external ligament prevent the axial ligament from being dragged outwards beyond a certain degree. This can only take place until those fibres are stretched, and this stretching can be distinctly seen when one makes the experiment.

Just as the lig. externum prevents the axial lig. from being too strongly dragged inwards, so the upper and lower fibres of the ligamentum anterius prevent it from being too forcibly pulled upwards or downwards.

According to *Henle* and *Helmholtz*, there exists an amphiarthrosis between the horizontal process of the incus and the posterior wall of the tympanum; a thin layer of cartilage being found both on the short process of the incus and the corresponding part of the posterior wall of the tympanum.

Voltolini[1] has shown that the joint which *Toynbee*[2] described between the margin of the oval fenestra and the foot of the stapes does not exist.

Bochdalek, jun., describes, under the name of *ligam. transversum mallei, s. ligam. mallei internum*, a tendinous band about 1 *mm.* in length and breadth, which passes from the pars squamosa to the lower part of the head of the hammer. It is however certainly not constant, and appears only to be an accidental fold of mucous membrane.

Du Verga[3] describes on the malleus a band which represents a remnant of Meckel's cartilage, and which he calls the *lig. malleo-maxillare*. It is said to pass from the malleus to the lower jaw, and is easily demonstrable in the human fœtus during the last five months of fœtal life, and also for some months after birth.

According to *Eugen Körner*,[4] the auditory ossicles consist of compact osseous tissue, which at the periphery forms a dense cortical layer of firmly compressed lamellæ. These lamellæ surround the numerous Haversian canals, while the bone-corpuscles increase in size as we pass towards the deeper layers, and are largest where the joint-extremities are covered with cartilage. A medullary canal, which was pointed out by *Rüdinger*, is found running in the long axis of the malleus and incus. Towards this the Haversian canals run radially, and open into it. The same author says[5] that in old persons, the entire medullary system may be widened out as if a process of osteoporosis had been going on; while on the other hand signs of osteosclerosis may also be seen. *Brunner* denies the existence of the medullary spaces in the tympanic ossicles. The covering of hyaline cartilage is, according to *Körner*, thicker on the incus than on the malleus: it varies from 0·912 to 0·916 *mm.*

The Lining of the Tympanic Cavity and Mastoid Cells.[6]

This is a continuation of the mucous membrane of the tuba Eust., but is much more delicate than that which lines the tube itself. It covers, not only the different walls of the tympanum, including the inner aspect of the

[1] Deutsche Klinik, 1860, Nr. 6.
[2] Medico-chirurg. Review, 1853, xi., p. 235.
[3] Journ. de Méd. Chir. et Pharm., Bruxelles, 1864, pp. 417-25.
[4] Monatsschrift für Ohrenheilkunde, 1878, Nr. 12.
[5] *Ib.*, 1879, Nr. 4.
[6] The relations will be more easily understood if we first describe the lining membrane of the tympanum, and then consider the muscular apparatus of the middle ear as a whole.

tympanic membrane, but also the different structures found in the cavity. It represents also the periosteum of the bony structures, and is therefore the carrier of many blood-vessels and nerves. As it covers the various structures in the cavity it sometimes forms duplicatures, or folds, in passing from the one to the other, and to some of these folds has been attributed the importance of ligaments. It forms as a whole a delicate membrane covered by epithelium, which secretes a mucous fluid. No glands have yet been seen in it, and hence many authors are inclined to regard it as being of the nature of a serous membrane.

The epithelium is differently described by different authors. *Kölliker*, in the fifth edition of his handbook (1867), still describes it "as a delicate single or double layer of ciliated epithelium"; and adds that, in the case of a man who was executed in Würzburg, "it was replaced by a single layer of non-ciliated pavement epithelium over the tympanic membrane." According to *V. Tröltsch*, ciliated epithelium is found only on the floor of the tympanum. The author, as a result of his own investigations, admits the presence of ciliated epithelium in the anterior third, but he has never been able to find it in the posterior two-thirds of the tympanum.

The air-cells of the mastoid process are lined by a continuation of the mucous membrane of the tympanic cavity. Here it also represents the periosteum in the mastoid cells, and sometimes forms folds in passing from one osseous lamella to another; these folds serving to limit the cellular spaces.

The tympanic cavity of the infant presents some peculiarities which are not seen at a more advanced age, and which are to be associated with the incomplete development of the cavity. In the fœtus of five months, as *V. Tröltsch* has pointed out, the tympanic cavity is filled with a gelatinous substance, which at this stage seems to represent the lining membrane of the cavity. Gradually however this substance is removed by absorption, and thus the lining of the cavity with its normal epithelium is brought about. Depending therefore upon the stage to which this course of development has advanced, the tympanic cavity will, after birth, exhibit more or less of the residue of this embryonic formation. Thus it is frequently found filled with a fluid rich in leucocytes (*Kutscharianz*), which resembles a muco-purulent exudation; whilst in other cases it is found to contain air, as in the adult. The mucous-membrane in the infant is, as a rule, much thicker and more vascular than in the adult, especially on the inner wall of the tympanic cavity; it may also form abnormal connections between the different structures contained in the cavity. This embryonic condition disappears on further development, and the folds and threads met with in the tympanic cavity of the adult, by which irregular connections may be brought about, are in this way accounted for. The condition of the tympanic cavity in the newly born child bears no relation to the respiratory process; so that nothing is to be realised in this direction for forensic purposes; and the "ear-test," so highly esteemed by many authors, appears quite deceptive.

The "*pedunculated structures*," described by *Kessel* and *Politzer*, are sometimes found in the tympanic cavity and in the cells of the mastoid process. They are situated mostly on folds of the mucous membrane, or bands of connective tissue, and consist of the latter tissue. A connective-tissue band—"pedicle"—forms a somewhat large oval or triangular structure, having a concentrically stratified

lamellar arrangement, and this again becomes a more attenuated cord. These structures have some resemblance to the Pacinian corpuscles, but are essentially different. *V. Tröltsch* first observed them, but regarded them as pathological. *Kessel*, on the other hand, declared from the first that they were not to be so regarded. The author considers them as structures of involution, and produced by an active metamorphosis of the embryonic mucous membrane.

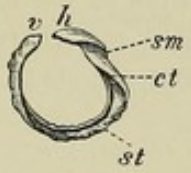
Observations concerning the Fissura Glaseri (fissura petro-tympanica).

This fissure is of special interest, not only because important structures pass through it—*e.g.* art. tympanica anterior passing into, and the lig. mallei anterius with the chorda tympani passing out of, the tympanum—but also for the reason that it sometimes serves as a passage by which purulent inflammations may spread from the tympanic cavity into the region of the parotid gland.

If one observes the *annulus tympanicus* somewhat more closely from its inner aspect (Fig. 43), there is seen on its anterior section (to the right hand in the figure), close to its upper extremity, a somewhat oblique furrow (*sm*), running from behind and above, forwards and downwards, which in the recent condition of the temporal bone lodges the handle of the malleus (*sulcus malleolaris*, *Henle*). Below this furrow, and having a similar direction, a crest is seen (*ct*), which the author has described as the *crista tympanica*.[1] It is this which later on unites with the tegmen tympani that advances to meet it; and which draws nearer and nearer to the anterior part of the lower margin of the squama, so separating the fissura Glaseri from the can. musculo-tubarius. The fissura Glaseri appears disproportionately wide in the infant, and is in communication with the can. musc.-tubarius (*vide* Fig. 9); but in the later stages of development, the union just described takes place; and thus the Glaserian fissure is separated from the canal. Both the crista tympanica and the tegmen tympani, but especially the latter, are lengthened during the further growth of the temporal bone; and since the tegmen tympani is united with the os tympanicum, the upper part of the lateral or outer wall of the canalis musculo-tubarius is formed. The crista tympanica in adults is normally united superiorly with the tegmen tympani (*vide* Fig. 14); but temporal bones are sometimes met with where this is not complete. In such cases the tympanic cavity communicates through the fissura petro-tympanica, not only with the fossa retro-maxillaris, but also farther below

Fig. 43.

Left tympanic ring of an infant, seen from within.



h, Anterior, *v*, posterior upper extremity; *sm*, sulcus malleolaris; *ct*, crista tympanica; *st*, sulcus tympanicus

[1] *Gruber*, "Zur Pathogenese der Entzündungen in der Gegend de Ohrspeicheldrüse, etc.," Wiener allgemeine medicinische Zeitung, 1884, Nr. 4.

with the pharynx. It is not difficult to understand that, according to the varieties which this fissure exhibits, extension of an inflammation may more or less readily take place from the tympanum to the neighbouring structures, and that it is indispensable to be familiar with this relation in order to understand the pathology of such conditions.

Muscles for the Various Structures of the Middle Ear.

Both anatomists and aurists have, until recently, considered only those muscles as belonging to the middle portion of the ear which are situated within it, and are inserted by their tendons into the auditory ossicles. They had solely the movements of the ossicles in view, and left all the other structures out of consideration. On a more accurate estimation of the physiological facts, it is however evident that a great part of those muscles which have been associated solely with the soft palate or pharynx are of great importance in connection with the tuba Eustachii; and that some of the structures which until now have been regarded only as *palato-pharyngeal muscles*, must also be enumerated with the muscular apparatus of the middle ear.

We can therefore describe the muscles belonging to the middle ear, according to their position, as *internal* and *external*.

1. *Internal Muscles of the Middle Ear.*

These are: (*a*) *the tensor of the membrana tympani* (*musc. tensor tymp.*); and (*b*) *the muscle of the stapes* (*musc. stapedius*).

(*a*) *The m. tensor tympani* (also *m. mallei internus*) arises from the cartilaginous portion of the Eustachian tube, and from the portion of the great wing of the sphenoid situated close to it (*Schwalbe*). It increases in size as it passes through the upper compartment of the can. musc. tubarii, since it receives some fasciculi which arise from the septum of that canal. It is bound to the walls of the canal in which it lies by connective tissue, and, reaching the inner end of the canal, its tendon passes round the rostrum cochleare, in order to reach the outer wall of the tympanum, where it is inserted into the inner edge and anterior surface of the handle of the malleus, the fasciculi of the tendon spreading out in a fanlike manner. According to what has been said, the tendon passes outwards almost at a right angle from the muscular belly, and crosses from the inner to the outer wall of the tympanic cavity. The fibres of the muscle run almost parallel with the long axis of the canalis tensoris tympani, and are closely surrounded by perimysium; whereas the mucous membrane covering the tendon is only loosely connected with it.

Ludwig Mayer found the tensor tympani constantly in connection with the musc. tensor veli palati, and in the following manner: "a tendinous fasciculus of

fibres" is continued from the latter into the middle portion of the former; and hence he considered the two muscles as a musc. biventer. This condition was corroborated by *Rebsamen*. The author found the two muscles frequently connected in the cadaver, but this condition is not constant. *Toynbee* describes the sheath of mucous membrane on the tendon under the name of "tensor ligament of the membrana tympani."[1] He fixes its length at about $\frac{3}{4}'''$, and attaches it on the one side to the processus cochleariformis, and on the other to that portion of the malleus where the long process joins the neck. He attributed to this ligament quite a peculiar functional signification: viz. that during relaxation of the muscle, the membrana tympani is still kept at a certain degree of tension, which however is lost as soon as the ligament is divided, even although the tendon of the tensor tympani muscle remains uninjured. *Sappey* holds a similar opinion concerning this relation between the tendon of the tensor tympani and its sheath; while all other recent anatomists regard this envelope merely as a covering of mucous membrane. The author agrees with the statement of *Henle*, that one is not able to separate artificially the mucous membrane from the tendon at all places.

The sheath of mucous membrane on the tendon was frequently found by the author to be continued as a fold to the antero-external wall, so as to roof over in a manner the most anterior part of the tympanum. This condition is almost constantly found during the first year of childhood.

Erroneous views, as a rule, prevail concerning the insertion of the tendon of the musc. tensor tympani, since it is generally described as being inserted only into the inner border of the handle. That must be regarded as the usual insertion which was first described by the author in his previously quoted work on the tympanic membrane and the auditory ossicles: viz. that the tendon is attached to the inner margin and to the anterior surface of the handle of the malleus. In exceptional cases, a few fibres of the tendon run to the posterior surface of the handle. It follows from this—the normal mode of insertion—that when the muscle contracts, the malleus is not only drawn inwards, but is also rotated more or less around its long axis, so that the posterior surface of its handle is directed somewhat outwards.

Helmholtz describes the action of the m. tensor tympani as follows: "It first of all draws the handle of the malleus, and with it the tympanic membrane, inwards. But at the same time, by its contraction, it acts upon the axis ligament of the malleus, which it draws inwards and puts upon the stretch. Thereby the head of the malleus is farther removed from the inco-tympanal articulation (Amboss-Pankengelenk); and the accessory ligaments of the incus—not only towards the hammer, but also at the apex of its short process—are stretched, the latter being even lifted from the bone. In doing so, the incus comes into the position where the interlocking teeth of the articulation between it and the malleus grip each other most firmly. Finally, its long process is obliged to take part in the inward movement of the handle of the malleus, and thus presses the stapes towards the vestibule."

From this it appears that *Helmholtz*, like the author, considers that when the tensor tympani contracts, the hammer is not only drawn inwards, but is also caused to make a slight rotation round its long axis, and that the incidental observation made by the author, to the effect that when the m. tensor tympani contracts it is able to act on the other ossicles, is well founded.[2]

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[1] "Diseases of the Ear," p. 133.

[2] Vergl. *Jos. Gruber*, "Anatomisch-Physiologische Studien über das Trommelfell und die Gehörknöchelchen," S. 53, u. ff.

(*b*) *The musculus stapedius.*—The stapedius muscle lies in that cana which is found in the substance of the pars petrosa, internal to the descending part of the can. Fallop., and opening into the tympanum by the narrow aperture on the eminentia pyramidalis. *Bonnafont* correctly names it *m. pyramido-stapéale.* It is about *7 mm.* long, quite fills the canal just mentioned, and sends its delicate tendon into the tympanum through the aperture in the eminentia pyramidalis, to be inserted into the head of the stapes, and according to *Rüdinger* into the lower extremity of the descending process of the incus. An accessory fold of mucous membrane is not unfrequently seen on its tendon, similar to that on the tendon of the tensor tympani. This may abnormally unite it to the inner wall of the tympanic cavity at its lower part. This fold of mucous membrane has the same significance as that on the tendon of the tensor tympani. The chief action of the muscle, when it contracts, is to raise the anterior part of the foot of the stapes out of the oval fenestra.

2. *External Muscles of the Middle Ear.*

We must include here all those muscles of the palate and pharynx which stand in direct relation to the tuba Eustachii. As such are to be particularly considered :—

(*a*) *The musculus spheno-salpingo-staphylinus, s. circumflexus palati, s. tensor palati mollis,* which has been classified by anatomists amongst the muscles of the palate, but which all recent investigators unanimously admit has little or nothing to do with the movement of the soft palate, but almost exclusively controls the movements of particular portions of the tube. We shall therefore describe it, according to *Rüdinger,* as *abductor tubæ.* It was named by *V. Tröltsch* also *dilatator tubæ.*

(*b*) *The musculus palato-pharyngeus* (also *pharyngo-staphylinus, s. levator pharyngis internus*).

(*c*) *The musculus levator palati mollis, s. petro-salpingo-staphylinus.*

(*a*) *M. abductor tubæ* (*m. tensor palati mollis*) arises by a short tendon from the inner aspect of the spina angularis of the sphenoid bone, from the under surface of the posterior part of its great wing, and from the inner surface of the processus pterygoideus, on the posterior margin of which the origin of the muscle can be followed for some distance. The cartilaginous part of the tuba Eustachii therefore lies immediately behind its origin. The muscle increases in size through the addition of fibres which arise from the wider border of the outer plate of the cartilaginous part of the tube, and occasionally by some fibres which may arise from its membranous part.

The flattened belly of the muscle lies upon the inner aspect of the musculus pterygoideus internus, and its fibres in their further course

downwards gradually end in a flattened tendon which turns round the hamulus pterygoideus in order to be inserted into the fibrous membrane of the palate and into the fibrous margin, which according to *Henle* is attached to the posterior border of the hard palate. A small bursa mucosa intervenes between the tendon of the muscle and the hamular process.

From the course of this muscle, it must evidently have a greater action upon the tuba Eustachii than upon the soft palate; and when it contracts, the cartilaginous hook and the membranous part of the tube will be drawn downwards and forwards, and in this way the lumen of the tube is widened.

(*b*) *M. palato-pharyngeus.* The action of this muscle is not exclusively limited to moving the different parts of the tube; but since a few of its fasciculi are attached to the lowest part of the cartilaginous tube, it has on this account great functional significance. It springs from the septum of the velum palati; from the fibrous border on the posterior margin of the hard palate; and a little farther away from the median plate, as well as, by means of a few fibres, directly from the membranous tube (*Rebsamen, Henle*). Its fibres partly intermingle with those of the musculus petro-staphylinus and of the superior constrictor of the pharynx. The more laterally situated fibres of the muscle pass to the middle line of the pharynx posteriorly, and are there inserted; while some of them pass across to the opposite side. Its most external fibres are inserted, according to *Henle*, into a strip of elastic tissue which passes from the postero-median line of the pharynx to the inferior cornu of the thyroid cartilage. Those which arise from the velum palati pass to the outer surface of the thyroid cartilage; while some are also said to reach over the edge of this cartilage to the interior of the larynx. According to *Rebsamen*—with whom the author, from researches of his own, agrees—those fibres which spring from the tuba Eust. "draw the inner cartilaginous plate of the tube backwards and inwards," when the point of application of the muscle is removed to the tube. By this means the angle which the outer plate forms with the inner is somewhat increased, and the membranous part of the tube is at the same time "stretched backwards and outwards" by the contraction of those fibres which are attached to it. If one causes the m. palato-pharyngeus to act simultaneously with the levator palati, which is found in its immediate vicinity, and with which it is to some extent united, one sees "the normal lumen of the tube to be considerably enlarged."

Rebsamen, on good grounds, proposes the name *retrahens tubæ* for those fibres of the m. palato-pharyngeus which are attached to the inner plate of the cartilage.

(*c*) *The Musculus levator palati mollis* (*m. petro-salpingo-staphylinus*) springs from the under surface of the petrous part of the temporal bone,

close to the entrance of the carotid canal, and from the lower margin of the posterior part of the tube. It passes downwards and forwards, lying behind the abductor tubæ, from which it is separated by adipose tissue. In its further course the muscle becomes flattened, and is inserted by a broad fanlike tendon, partly into the fibrous margin of the hard palate, and partly into the velum palati. Some of its fibres intermingle with those of the opposite muscle, and some are inserted into the fibrous raphé of the soft palate.

When the m. levator palati mollis contracts, it produces an elevation of the floor of the lowest part of the tube (*Zaufal*), and thus it appears as if the lumen of the tube were momentarily narrowed; this however is not the case.

Although our knowledge regarding the actions of the various palatal muscles and of their relations to the tuba Eustachii has been greatly extended by recent careful researches, yet in this direction there still remains a considerable field for future observers. The attachments of the pharyngeal fascia, and its intimate connection with the different muscles, as well as its relation to the different parts of the tube, appear to be of especial importance. *Rüdinger* was not able to confirm the existence of the *fascia salpingo-pharyngea* described by *V. Tröltsch*.

Blood and Lymph-Vessels of the Middle Ear.

The middle ear receives its blood supply from the external and internal carotid arteries. The branches specially distributed to it are:—

(*a*) *Small branches from the art. pharyngea ascendens* supply the tuba Eustachii and its muscles, and some penetrate the mucous membrane of the tympanum to supply it.

(*b*) *The art. stylo-mastoidea*, a branch of the *art. auric. post.*, in its passage through the canalis Fallopii, gives off small branches which enter the tympanic cavity through its posterior wall. It also supplies twigs to the mucous membrane of the mastoid cells and to the m. stapedius.

(*c*) *The art. meningea media* of the *art. maxillaris interna*, before entering the cranial cavity, sends small branches to the tuba Eustachii; while after it has reached the interior of the skull it gives off a *ramus petrosus superficialis*, which passes into the hiatus canalis Fallopii to anastomose with the art. stylo-mastoidea. Small branches of the art. mening. media also enter the roof of the tympanum in the neighbourhood of the fissura petro-squamosa. The *art. mening. med. accessoria*, according to *Hyrtl*, sends a twig through the floor of the tympanum to the promontory. A small branch is said to take its course between the crura of the stapes.

Zuckerkandl[1] found that a small branch of the *art. stylo-mastoidea* passes out constantly from the middle part of the Fallopian canal, as the *arteria stapedia*. It supplies the stapes and the membrana obturatoria, and then passes over the promontory to anastomose with the artery to the nerv. Jacobsonii.

[1] "Ueber die Art. stapedia des Menschen." Monatsschrift für Ohrenheilkunde, 1873, Nr. 1.

The anastomosis between the art. stylo-mastoidea and the ram. petrosus superficialis is said to have given rise to the supposition of an anastomosis between the n. petrosus superficialis minor and the ganglion geniculi. This is however believed by *Breschet*,[1] and more recently by *Beck*[2] and *Bischoff*,[3] to be non-existent. *Krause* on the other hand states that one can easily demonstrate with the microscope a connecting branch between the n. petrosus superficialis minor and the ganglion geniculi. According to this author, the connecting branch between the two is said to have been frequently overlooked, since it is often buried in the ganglion geniculi in company with the n. petrosus superficialis major. *Krause* says that some individual nerve fibres, with a double contour, branch off from the ganglion geniculi, and also run into the hiatus canalis Fallopii. On examining with a lens of 150 diameters, they are found to end in the Pacinian corpuscles, which are situated under the dura mater, close to the n. petros. superfic. major.

(*d*) *Small branches of the arteria temporalis* pass through the Glaserian fissure into the tympanic cavity. The small twigs which are distributed to the tympanum from the carotis interna have already been mentioned.

The *venous blood* is drained away by veins which accompany these arteries, and which pour it into the venous plexuses near the temporo-maxillary joint, into the veins of the pharynx, and also into the middle meningeal veins.

According to *Prussak*,[4] the arteries in the mucous membrane of the tympanic cavity have an extensive course, without however anastomosing with one another. They divide at acute angles into branches, the calibre of which is large in comparison with that of the parent trunk. These branches pass almost at once into the small veins, the intervening capillaries in many parts being quite absent. The veins of the tympanum form a free anastomosis with each other, so that the blood can readily flow away in various directions. This method of circulation should render difficult the possibility of exudation.

The *lymphatic vessels* of the middle ear are brought into connection with the *glandulæ auriculares anteriores and posteriores*, but more especially with the lymphatic glands of the pharynx.

Nerves of the Middle Ear.

The *middle ear* receives its nervous supply from the fifth, seventh, and ninth cranial nerves, as well as from the sympathetic; thus the tuba Eustachii and the musc. tensor. tympani receive their nerves from the ganglion oticum; the musc. stapedius from the nervus facialis; whilst the mucous membrane of the tympanum is supplied from the glosso-pharyngeal, which gives off the *ramus tympanicus, s. Jacobsonii*, from its ganglion petrosum.

[1] Répert. génér. d'anat. et de physiol. pathol. vol. ii. 1826.
[2] Das VII. und IX. Hirnnervenpaar, 1847, S. 41.
[3] *Dr. Ernst Ph. Ed. Bischoff*, "Mikroskopische Analyse der Anastomosen der Kopfnerven," München, 1865, S. 39, 10.
[4] "Zur Physiologie und Anatomie des Blutstromes in der Trommelhöhle." Berichte der königlich sächsischen Gesellschaft der Wissenschaft. 1868.

The *plexus tympanicus* (*Jacobson's plexus*) is, according to *Bischoff*, a true anastomosis or plexus between the ganglion oticum, the ganglion petrosum, and the plexus caroticus internus. The nerves from this plexus to the tuba Eustachii take their origin from the ram. tympanicus, n. petrosus superficialis minor, and n. sympatheticus. A small microscopical ganglion is found as a rule on the filament going to the oval fenestra.

W. Krause[1] subjected the n. tympanicus to a minute examination, and he found in many places ganglionic cells—it might be singly, or in smaller or larger groups. These send out processes which may be followed into the nerve fibres. Most of the cells were however uni- or bi-polar; and as many as twenty or forty were sometimes seen in a group. According to this author, the nerves from the plexus tympanicus to the mucous membrane of the tuba Eustachii are microscopical filaments, while a larger branch can be followed to the cartilaginous portion of the tube. The mucous membrane of the whole tube is very rich in nerves, on which *Rüdinger* has lately described microscopical ganglia. Moreover, he associates the same with the acinous glands of the tube, and considers them analogous to the ganglia existing in the salivary glands. *Pappenheim* and *Kölliker* have confirmed the presence of ganglia on the n. tympanicus.

The n. tympanicus passes through the floor of the tympanum to the promontory, on which it anastomoses with the branches of the sympathetic to form the *tympanic plexus* (*plexus Jacobsonii*). The n. sympatheticus sends filaments from its plexus caroticus through the posterior wall of the carotid canal to anastomose with the twigs of the glosso-pharyngeus and trigeminus, in order to form with them the plexus. The musc. stapedius receives its branch from the descending portion of the n. facialis.

The *chorda tympani*, as has already been stated, passes through the tympanic cavity in close relation to the inner aspect of the tympanic membrane. It has an oblique direction from the posterior wall to the fissura Glaseri, and leaves the tympanic cavity through the canal of Huguier. At its place of exit from the tympanum it gives off, in most cases, a filament to the facialis itself, the origin of which is most probably to be sought in the ganglion oticum, since from this ganglion fibres run both centrally and peripherally into the chorda tympani.

According to *Bischoff's* latest investigations, the greater part of the fibres of the chorda tympani come from the central portion of the n. facialis.

III. Internal Portion of the Ear.

This, the most important part of the auditory organ, since it contains the structures which are affected by the sound-waves, lies most internally, and is enclosed in a special osseous chamber, which on account of its

[1] "Zeitschrift für Rationelle Medicin." 3 Reihe, Bd. 28, 1866.

peculiar structure is distinctly differentiated from the bony substance surrounding it.

The older anatomists, who as regards thoroughness of study are not to be considered inferior to the inquirers of to-day, have investigated with the most wonderful success the macroscopical anatomy of this part of the ear. We are however chiefly indebted to the researches of more recent times for the knowledge we possess concerning the minute structure of the labyrinth.

The work of *Corti*[1] on the lamina spiralis, which appeared towards the end of the first half of the present century, marks a new epoch in these investigations. Along with it must be placed in the highest rank the distinguished works of *Reissner*,[2] *O. Deiters*,[3] *A. Kölliker*,[4] *Claudius*,[5] *Boettcher*,[6] *Nuel*,[7] *M. Schultze*,[8] *F. E. Schultze*,[9] *Voltolini*,[10] *Hensen*,[11] *Reichert*,[12] *Rüdinger*,[13] *Ibsen*,[14] *Kuhn*,[15] *Schwalbe*,[16] *Löwenberg*,[17] *Henle*,[18] *Hasse*,[19]

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[1] *A. Corti*, "Recherches sur l'organe de l'ouie des mammifères." Zeitschrift für Wissenschaftliche Zoologie, iii., S. 109.

[2] De auris internæ formatione, Dorp., 1851.—"Zur Kenntniss der Schnecke im Gehörorgan der Säugethiere und des Menschen," *Müller's* Archiv, 1854.

[3] Untersuchungen über die Lamina Spiralis Membranacea, Bonn, 1860. Ferner, *Virchow's* Archiv, xix., S. 445; sodann, *Müller's* Archiv, 1862, S. 405, und 1862, S. 262.

[4] Dessen Gewebelehre; ferner, Würzburger Naturwissenschaftliche Zeitschrift, ii., S. 1; ferner, Ueber die letzten Endigungen des Nerv. Cochleæ und die Function der Schnecke, Würzburg, 1854; dann dessen Entwicklungsgeschichte.

[5] "Bemerkungen über den Bau der häutigen Spiralleiste der Schnecke." Zeitschrift für wissenschaftliche Zoologie, vii., S. 154.

[6] Obs. micr. de rat. qua nervus cochleæ terminatur. Dorp., 1856; ferner, *Virchow's* Archiv xvii., S. 243, und xix., S. 224 und 450.

[7] "Beitrag zur Kenntniss der Säugethierschnecke." Archiv für Mikroskopische Anatomie, Bd. viii.—Recherches microsc. sur l'anat. du limaçon des mammifères, Bruxelles, 1878.

[8] "Ueber die Endigungsweise des Hörnerven im Labyrinth." *Müller's* Archiv, 1858, S. 372.

[9] "Zur Kenntniss der Endigungsweise der Hörnerven bei Fischen und Amphibien." Archiv von *Reichert* und *du Bois-Reymond*, 1862.

[10] "Zerlegung und Untersuchung des Gehörorganes an der Leiche," Breslau, 1862; und in *Virchow's* Archiv, xxviii., S. 227.

[11] "Zur Morphologie der Schnecke des Menschen und der Säugethiere." Zeitschrift für wissenschaftliche Zoologie, xiii., S. 319.—"Ueber *Boettcher's* Entwickelung und Bau des Gehörlabyrinths nach eigenen Untersuchungen." Archiv für Ohrenheilkunde, vi., 1871.—"Bemerkungen gegen die Cupola terminalis." Archiv für Anatomie und Entwicklungsgeschichte, 1878.

[12] Beitrag zur Feineren Anatomie des Gehörschnecke des Menschen und der Säugethiere, 1864.

[13] "Ueber das häutige Labyrinth im menschlichen Ohre." Aerztliches Intelligenzblatt, 1866.—"Ueber die Zotten in den häutigen halbkreisförmigen Canälchen des menschlichen Labyrinthes." Archiv für Ohrenheilkunde, ii., 1867.—"Vergleichende anatomische Studien über das häutige Labyrinth." Monatsschrift für Ohrenheilkunde, 1867.—Beiträge zur Histologie des Gehörorganes, München, 1870.—"Ueber den Aquæductus Vestibuli des Menschen und des Phyllodactylus Europæus." Zeitschrift für Anatomie und Entwicklungsgeschichte, ii. 1877; sodann dessen Atlas des menschlichen Gehörorganes, München, 1866; und die Abhandlung über das häutige Labyrinth in *Stricker's* Handbuch der Lehre von den Geweben, ii., 1872.

[14] Atlas anatomicus auris internæ, 1846.

[15] "Untersuchungen über das häutige Labyrinth der Knochenfische." Archiv für Mikroskopiche Anatomie, xiv., 1877.—Das häutige Labyrinth der Amphibien, 1880.—"Ueber das häutige Labyrinth der Reptilien." Archiv für mikroskopische Anatomie, xx., 1881.

[16] Lehrbuch der Anatomie der Sinnesorgane. Erlangen, 1886.

[17] "Beiträge zur Anatomie der Schnecke." Archiv für Ohrenheilkunde, i., S. 175.

[18] Handbuch der systematischen Anatomie, ii., 1873.

[19] *C. Hasse*, "Die Lymphbahnen des inneren Ohres der Wirbelthiere." Anatomische

Waldeyer,[1] *Gottstein*,[2] *Axel Key*,[3] *Weber-Liel*,[4] *Steinbrügge*,[5] and, at a recent date, the admirable studies of *Gustav Retzius*.[6] All these investigators took as the starting-point of their observations the researches of Corti, and have either confirmed or amplified them; the result being that we are now so well acquainted with the minute anatomy of the labyrinth that little remains unknown on this subject. It is only to be hoped that physiological investigations may soon be crowned with a similar success.

Position of the Membranous Structures of the Labyrinth in relation to the Osseous Capsule of the Labyrinth.—Peri- and Endo-lymphatic Spaces.

That the membranous structures of the labyrinth do not fill up the cavities of the osseous labyrinth, is a fact that was known to the older anatomists. They also had a knowledge of the fluid filling the remaining portions of these spaces, and in a certain sense traversing these structures. This fluid they named *perilymph*, in contradistinction to the term *endolymph*, which they applied to the fluid contained within the membranous labyrinth. The arrangement of the membranous structures of the labyrinth in their corresponding spaces is peculiar, in so far that they are all situated parietally or eccentrically. This has long been known with regard to the sacculi of the vestibule and the membranous cochlea; while more recently *Rüdinger* has made us acquainted with the eccentric position of the membranous semicircular canals.[7]

In the vestibule, the *perilymphatic space* (*cysterna perilymphatica* of *Retzius*; *sinus perilymphaticus* of *Odenius*) is comparatively large. It measures, according to *Retzius*, about 3 *mm.* from the base of the stapes to the inner wall on which the sacculi are attached, and about 3·5 *mm.*

Studien, iv. Heft, Leipzig, 1873.—Die vergleichende Morphologie und Histologie des häutigen Gehörorganes der Wirbelthiere, Leipzig, 1873.—"Bemerkungen über die Lymphbahnen des inneren Ohres." Archiv für Ohrenheilkunde, xvii., 1881. Ueber die Gefässe der Lamina spir. membran. des Gehörorgans der Wirbelthiere. An. Anz. 4, 1886.

[1] Hörnerv und Schnecke. *Stricker's*, Handbuch der Lehre von den Geweben, ii., 1872.

[2] Ueber den Feineren Bau und die Entwicklung der Gehörschnecke beim Menschen und den Säugethieren, Breslau, 1871.

[3] *A. Key* und *G. Retzius*, Studien in der Anatomie des Nervensystems und des Bindegewebes, i., Stockholm, 1875.

[4] "Ueber den Zusammenhang des Arachnoidalraumes mit dem Labyrinth." Monatsschrift für Ohrenheilkunde, iii. Jahrgang, 1869.—"Die Aquæductus des Labyrinthes." Medicinisches Centralblatt, 1876.—"Der Aquæd. Cochleæ beim Menschen." Monatsschrift für Ohrenheilkunde, 1879.—Experimenteller Nachweis einer freien Communication der endolymphatischen und perilymphatischen Räume des menschlichen Ohr-Labyrinthes mit extralabyrinthischen intracraniellen Räumen," *Virchow's* Archiv, lxxvii., 1879.

[5] "Ein Beitrag zur Topographie der menschlichen Vorhofsgebilde." Zeitschrift für Ohrenheilkunde, x., 1881.—"Ueber die zelligen Gebilde des Corti'schen Organs." Zeitschrift für Ohrenheilkunde, xii., 1883.—"Ueber die Cupola-Formation im menschlichen Labyrinth." Zeitschrift für Ohrenheilkunde, xv., 1885.

[6] *Gustav Retzius*, Das Gehörorgan der Wirbelthiere. Morphologisch-histologische Studien, Stockholm, 1884.

[7] *N. Rüdinger*, "Ueber die häutigen Labyrinthgebilde im menschlichen Ohre." Bayerisches ärztliches Intelligenzblatt, 1886, Nr. 25. Ferner, "Ueber die Lage des häutigen Labyrinthes bei der Ratte." Monatsschrift für Ohrenheilkunde, iii. Jahrgang, 1869, Nr. 8.

from before backwards. That it is continued backwards into the semicircular canals, and forwards into the scala vestibuli of the cochlea, is sufficiently evident from what has been stated in the description of the osseous cochlea. The perilymphatic space, at the apex of the cochlea, is continued through the aperture of communication (*helicotrema*) existing there, into the lower scala (tympani), and terminates in a kind of blind pouch at the lower end of this scala at the round fenestra. It happens in this way that the *membranous cochlear canal* (*ductus cochlearis membranaceus*) is enveloped both above and below by perilymph.

Through the *aquæductus cochleæ*, which leaves the scala tympani near its lower end, the perilymphatic space of the labyrinth communicates, as has been proved by the important investigations of *Weber-Liel*,[1] *Schwalbe*,[2] and others, with the sub-arachnoidal space; whilst the endolymphatic space, as we shall see later, is by means of the ductus endolymphaticus, which passes through the aquæductus vestibuli of the petrous bone, brought into communication with the *recessus Cotugnii*, *s. saccus endolymphaticus*, found in the dura mater.

1. *Membranous Structures of the Vestibule.*—In the vestibule, two small membranous sacs are found: viz., (*a*) *the sacculus hemisphæricus*, or more briefly, the *sacculus*; and (*b*) *the sacculus hemi-ellipticus*, or *utriculus* (Fig. 44). The former is intimately related to the membranous part of the cochlea, the latter to the membranous semicircular canals.

(*a*) The *sacculus hemisphæricus* (Fig. 44, *s.*) has the form of an oval vesicle, somewhat flattened from without inwards. It measures 3—3·5 *mm.* in length, and scarcely 2 *mm.* in breadth; its longest diameter is directed from above, downwards and outwards.

The upper bulging part of the sacculus is so placed in the recessus hemisphæricus that it lies above and in front of the utriculus, and indeed at one spot the walls of the two appear fused. The sacculus is drawn out at its lower part, near the cochlea, into a short canal (*csc*) (*canalis reuniens*, *Hensen*), which joins the ductus cochlearis almost at a right angle. This small tube has a length of 0·7 *mm.*, and a diameter of 0·22 *mm.* at its narrowest part, while the thickness of its walls amounts to 0·015 *mm.*

The inner wall of the sacculus adheres closely to the inner wall of the recessus hemisphæricus, the union being maintained by reticular connective tissue and by the ramulus sacculi of the auditory nerve (*rs*). The nerve-filaments enter the vestibule through the lamina cribrosa superior, and terminate on the *macula acustica sacculi* (*ms*). This macula is somewhat oval in form, measuring 2·5—3 *mm.* in height, and 1·5 *mm.* in breadth. It is hollowed out in a cup-like manner, and is covered by a disc of loosely

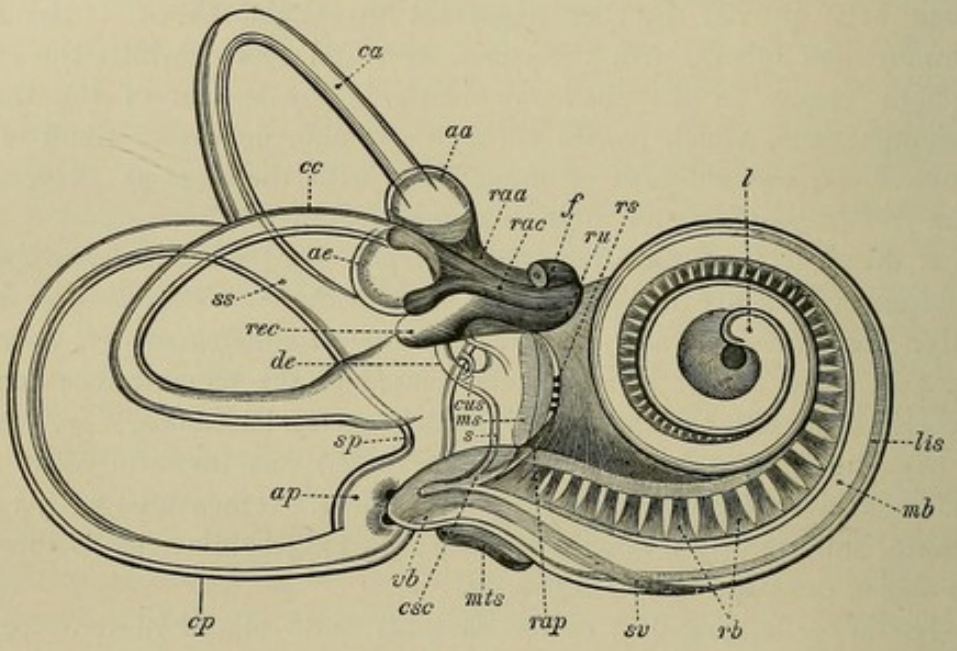
[1] *Weber-Liel*, "Der Aquæductus Cochleæ beim Menschen." Monatsschrift für Ohrenheilkunde, xiii. Jahrgang, Nr. 3.

[2] Centralblatt für die medicinische Wissenschaft, 1869, Nr. 30.

connected otolith crystals. The outer wall of the sacculus is much thinner than the inner, and is also concave outwards. Superiorly it adheres to the under surface of the *recessus utriculi* (*rec*), close to its passage into the utriculus, for which purpose it presents a diverticulum (*sinus utricularis sacculi, Retzius*) running in a curved direction, backwards and outwards. The outer wall gradually rises above and behind, in order to form the ductus endolymphaticus (*de*) discovered by *Boettcher*. Somewhat funnel-

Fig. 44.

Membranous labyrinth of a man twenty-five years of age, seen from the outer and anterior aspect—five times enlarged. Osmic acid preparation (*Retzius*).



Passing from right to left one notices: *lis*, ligamentum spirale; *mb*, membrana basilaris; *l*, lagena; *rb*, ramulus basilaris; *sv*, atria vascularis; *rap*, ramulus ampullæ posterioris; *rs*, ramulus sacculi; *ru*, ramulus recessus utriculi; *f*, nervus facialis; *mts*, membrana tympani secundaria; *csc*, canalis reuniens Henseni as inferior extremity of the sacculus *s*; *ms*, macula acustica sacculi; *cus*, canalis utriculo-saccularis; *de*, ductus endolymphaticus; *sp*, sinus utric. poster.; *rec*, recessus utriculi; *raa*, ramulus ampullæ anterioris; *rac*, ramulus ampullæ externæ; *aa*, ampulla anterior; *ae*, ampulla externa; *ap*, ampulla posterior; *vb*, cæcum vestibuli; *ca*, canalis semicircularis anterior; *cc*, canalis semicircularis externus; *cp*, canalis semicircularis posterior; *ss*, common limb of the anterior and external semicircular canals (sinus utriculi superior, *Retzius*).

shaped at its orifice, this duct soon exhibits a necklike constriction, beyond which it becomes dilated, and passes upwards and outwards on the inner side of the utriculus. Again narrowing itself, it communicates with the *canalis utriculo-saccularis* (*cus*), which opens from the posterior aspect of the utriculus. Behind the sinus superior utriculi, the ductus endolymphaticus enters the aquæductus vestibuli. Passing outwards, downwards, and backwards, it gives off several lateral branches from its posterior part, and opens into the *recessus Cotugnii* through the apertura

aquæductus vestibuli on the inner surface of the petrous part of the temporal bone.

The *recessus Cotugnii, s. saccus endolymphaticus*, was already known to *Cotugnius*; but was subsequently forgotten until *Boettcher*[1] once more called attention to it. It has been carefully studied by *Axel Key*, *Retzius*, *Zuckerkandl*, and *Rüdinger*, who describe it as a pouchlike dilatation between the two layers of the dura mater, situated below and behind the opening of the aquæductus vestibuli, where its position is indicated by the lighter colour of the dura mater at this spot. In the adult, a depression exists for it on the petrous part of the temporal bone.

This, like the sac itself, varies much in different cases.

(*b*) The *sacculus hemi-ellipticus, s. utriculus proprius, s. utriculus*, communicates, as has been already stated, with the semicircular canals. It is elliptical in shape, measuring 3 *mm.* in length and 1·5—2 *mm.* in width, and has its long axis directed downwards and backwards. Its antero-superior extremity is somewhat expanded, and forms the *recessus utriculi* (*rec. Retzius*). Its postero-superior extremity (*sinus superior, ss*) is also expanded, and is lodged in the canalis communis of the anterior and posterior bony semicircular canals, where it receives the common tube of the corresponding membranous canals. The postero-inferior extremity of the utriculus consists of a cylindrical tube about 1 *mm.* wide and 1 *mm.* long, which is described by *Retzius* as the *sinus posterior utriculi*, and receives the posterior ampulla (*sp*).

The anterior (*aa*) and external (*ae*) ampullæ open at the antero-superior part of the recessus utriculi; while on its inner side is the macula acustica (Fig. 45, *mu*) of the utriculus, with an otolith disc similar to that found on the macula acustica of the sacculus. This is, as *Odenius* has shown, closely united with the posterior wall of the recessus to the extent of about 1 *mm.* Almost immediately below this, the *canalis utriculo-sacccularis* (Fig. 44, *cus*, and Fig. 45, between *de* and *mu* is observed on the utriculus as a delicate membranous tube, which forms the communication between the utriculus and the ductus endolymphaticus sacculi.

2. *The Semicircular Canals.*—The membranous semicircular canals have the same external configuration as the osseous canals by which their shape is determined; and just as the osseous canals open into the posterior part of the vestibule, so the membranous canals communicate with the sacculus hemi-ellipticus (utriculus) situated there. Each is united along its convex margin to the corresponding osseous wall, the wide remaining space being filled by perilymph. The union along their

[1] *A. Boettcher*, "Ueber den Aquæductus vestibuli bei Katzen und Menschen." Archiv von *Reichert* und *du Bois-Reymond*, 1869.

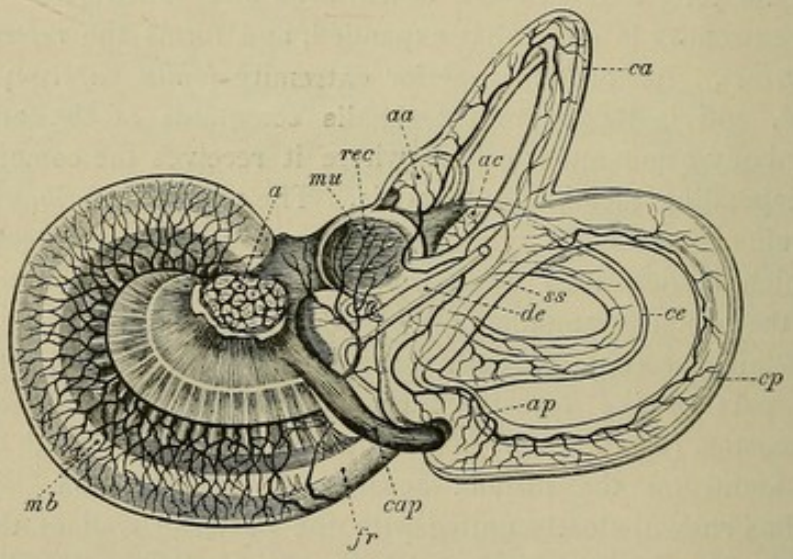
convex border is effected by dense connective tissue; while in addition, they are here and there attached to the opposite wall of the bony canal by bundles of fibrous tissue containing blood-vessels (*ligamenta canaliculorum* of *Rüdinger*).

Like the osseous canals, each has an *ampulla* at one extremity, and the non-ampullated ends of the anterior (superior) and posterior canals open into a common tube (Figs. 44 and 45, *ss*) which communicates with the postero-superior part (sinus superior) of the sacculus hemi-ellipticus.

Whilst the ampullæ of the membranous canals almost completely fill the corresponding parts of the osseous tubes, the lumen of the remaining

Fig. 45.

Membranous labyrinth of a human fœtus at the fifth month, surrounded by its perilymphatic tissue. Seen from its posterior and internal aspect, five times enlarged. (Osmic acid and Carmine prep., *Retzius.*)



ca, Canalis semicircularis anterior; *cp*, can. sem. post.; *ce*, can. sem. ext.; *aa*, ampulla anterior; *ac*, ampulla ext.; *ap*, ampulla post.; *ss*, common crus of the anterior and posterior semicircular canals; *de*, ductus endolymphaticus; *rec*, recessus utriculi; *mu*, macula acustica recessus utriculi; *a*, nervus acusticus; *cap*, ramulus ampullæ posterioris; *fr*, position of fenestra rotunda; *mb*, membrana basilaris.

parts is much smaller than that of the bony canals. The ampullary expansion is especially developed towards the concavity of the arch, its greatest diameter being 2—2·5 *mm.*, and its least 0·57 *mm.* In their further course, the greatest diameter of the membranous canals is 0·5—0·58 *mm.*, and the least 0·3—0·4 *mm.*

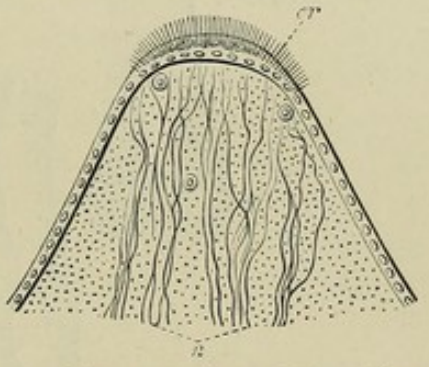
The posterior ampulla (*ap*) differs in shape slightly from the anterior and external (*aa* and *ae*), which are, on the other hand, almost identical in form. The two latter meet close to the recessus utriculi, and open in common into it; the posterior ampulla opens, as has already been described, into the sinus posterior utriculi. We distinguish as the

floor of the ampulla, that wall which serves for the entrance and expansion of the nerve, and where, as a consequence, the macula acustica is found; whilst the wall immediately opposite is regarded as its *roof*. The roof of the anterior ampulla looks upwards and backwards; that of the external, downwards, outwards, and backwards; and that of the posterior, backwards, upwards, and outwards.

A ridge—the *septum transversum* (seen near *aa* and *ap*, Fig. 44)—passes transversely across the floor of the ampulla, and looks as if it were an invagination of the floor produced by the nerve entering it. Looked at from the roof of the ampulla, it is seen to be surmounted by the *crista acustica* (*i.e.* the nerve terminations covered with epithelium), and has the form of "a small biscuit with only a shallow and deeply descending central contraction, and with rounded ends which pass up on the lateral walls of the ampulla." Around these ends the epithelium has an indistinct half-moon-like arrangement (*planum semilunatum*, distinctly seen in the ampulla, *ap* of Fig. 44). On the roof of the ampulla, a streak passes transversely across it, and is described as the *raphé*.

Fig. 46.

Vertical section of the septum transversum, with the crista acustica of the external ampulla (*Retzius*).



cr, Crista acustica with auditory hairs; *n*, nerve fibres, between which are seen sections of blood-vessels.

Regarding the more minute structure of the sacculi and semicircular canals, these have much in common; while the membranous cochlea is distinguished by its more complicated form, and by the greater differentiation of its histological structures.

The membranous wall of the sacculi and the semicircular canals is very delicate, but where the nerves enter—*i.e.* at the septa of the ampullæ, and the maculæ acusticæ of the sacculi—it is somewhat thicker. It is as a whole homogeneous, but at some places exhibits striæ; whilst in its thickest parts cells are found embedded.

In the membranous canals are also found the so-called *papillæ of the semicircular canals*,[1] first seen by *Voltolini* and *Lucæ*, and regarded by them as pathological structures; but considered by *Rüdinger*, on the other hand, as normal. They appear singly or in groups, and exhibit a concentric striation. *Rüdinger* says the wall of the membranous canal which is attached to the bone is free from them; while *Retzius*, with whom the author agrees, states that some are also found in this position. They are most numerous at the junction of the attached and

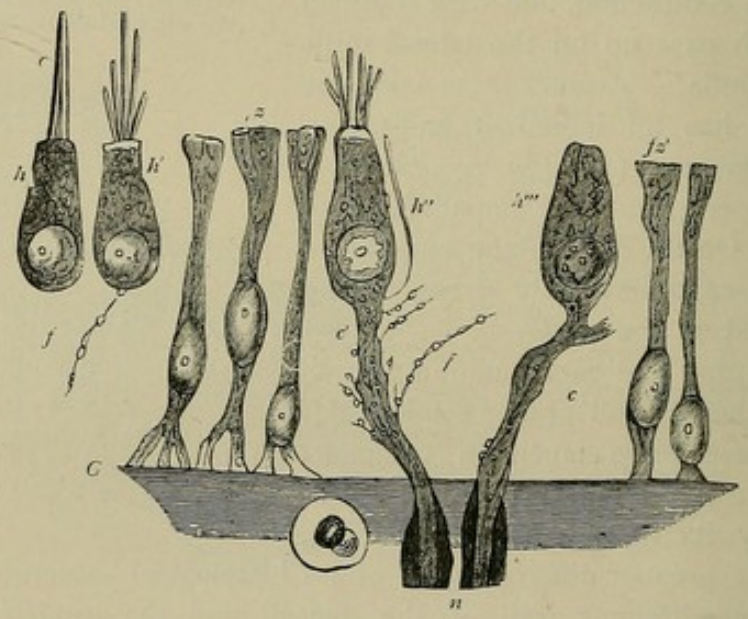
[1] Monatsschrift für Ohrenheilkunde, i. Jahrgang, Nr. 2.

free portions of the canal; and are constantly present in the adult, but only occasionally seen in the infant. Externally they are continuous with the perilymphatic tissue, while internally they are covered by a single layer of epithelium; which on the maculæ and cristæ acusticæ, is replaced by the nerve epithelium. The epithelium is polygonal, varying in diameter from 0·012 *mm.* to 0·021 *mm.*, while in the immediate neighbourhood of the maculæ acusticæ it becomes columnar. The epithelial cells lining all these membranous structures contain brownish-yellow pigment, which increases in quantity as age advances (*Retzius*).

The *nerve epithelium of the maculæ and cristæ acusticæ* appears elevated as compared with that in the vicinity. On the macula acustica

Fig. 47.

Epithelial cells of the macula acustica recessus utriculi of a newly born child (*Retzius*).



G, Limit of the connective tissue next the acoustic epithelium; *b*, blood-vessel in the connective tissue; *n*, medullated nerve fibres which enter the epithelium, the axis cylinder of which there divides into fibrillæ (*c*, *c'*) which pass to end in the hair-cells; *f*, *f'*, nerve fibrillæ with varicose dilatations; *fz*, *fz'*, filiform cells; *h*, *h'*, *h''*, *h'''*, hair-cells with cuticular border and tufts of auditory hairs; at *a*, the filaments of the acoustic hairs are still agglutinated together—in the others they are isolated; in the cell, *h'''*, the hair has been lost in the process of preparation.

utriculi and sacculi it measures, according to *Retzius*, 0·036—0·040 *mm.* in height, and on the cristæ acusticæ of the ampullæ, 0·045—0·054 *mm.* It consists of *filiform cells* and *hair-cells*, which are placed on an extremely thin structureless basal membrane (*G*), and between which the nerve filaments run. The *filiform cells* are finely granular, and project almost perpendicularly from the basal membrane to end in blunt extremities (*fz*, *fz'*); while the nucleus is placed close to the somewhat expanded and often subdivided base of the cell. The so-called *hair- or rod-cells* (*h*, *h'*, *h''*, *h'''*) are found between the filiform cells, and end

peripherally on the same level with them; but only reach about half-way towards the basement membrane. Their outer extremities are rounded or oval, and their lower ends contain each a large round nucleus. From the free extremity of each hair-cell there projects *a rod or hair* (*a*), having a somewhat broad base and gradually tapering to a point, and which, on the macula, measures 0·02—0·025 *mm.*, on the crista 0·025 *mm.*, in height. In the fresh condition the hairs appear translucent, but after hardening they become finely granular, break readily, and often split up into filaments. The substance of the hair-cells also appears translucent when fresh, but on hardening it assumes a finely granular condition. These hair-cells are connected with the nerve fibres; and according to *Retzius* the following condition is found: the nerve fibres (*f*, *f'*), on passing through the basement membrane, lose their medullary sheaths; while the axis cylinders enter the epithelial layer and pass out between the filiform cells, in order to come into direct contact with the lower ends of the hair-cells (*f'*); or they may push outwards along the sides of the hair-cells, on which they terminate (*n*). The nerve fibre either divides so as to send a branch to the lower end of each hair-cell, or it spreads out without dividing so as surround the extremities of two or three hair-cells. "The substance of the nerve fibres forms a sort of cup, in which the hair-cell is implanted; and from which it may fall out, leaving the cup-like formation empty." Whether the nerves really terminate in this structure is, according to *Schwalbe*, not yet fully determined.

The bony walls of the vestibule and semicircular canals are lined by a very delicate periosteum, which reminds one of the internal elastic lamina of the blood-vessels (*Henle*). According to *Kölliker*, it consists of a firm, finely fibrillated connective tissue, destitute of elastic fibres, but containing numerous nuclei. It adheres everywhere so closely to the bone, that one can scarcely obtain even a small piece for examination without some particles of bone which have become detached with it. A simple pavement epithelium covers it. The existence of this epithelium is denied by *Henle*, who adds that the nuclei which are found in the periosteum have led many observers to suppose that it is covered by epithelium.

The periosteum contains blood-vessels and nerves, which in part pass from it to the membranous structures of the labyrinth. The vessels are most numerous on the inner wall of the vestibule.

The position of the *otoliths* on the maculæ acusticæ of the sacculi is recognised by a more or less circumscribed chalky white spot. They appear as rounded or elongated crystals, or in the form of six-sided prisms with blunt extremities. They consist of carbonate of lime; and are loosely connected together by a soft, almost gelatinous, substance. Their manner of attachment is as yet not known. Many believe that they are only kept in position by the gelatinous substance; while others represent

them as being retained by means of a cuticular membrane, with which the hairs from the macula acustica are fused (*Hensen*).

Schwalbe observed in the centre of all the larger crystals a small globule, which produced the appearance of a small vacuole.

3. *The Cochlea.* As has already been shown in the description of the osseous shell of the labyrinth, this spirally running canal is divided by the lamina spiralis ossea into two scalæ, situated the one above the other—viz. *scala vestibuli* and *scala tympani*; but since this lamina does not reach as far as the wall of the cochlea opposite to the modiolus, the two scalæ must communicate with each other in the macerated bone. In the recent bone, however, the partition between them is completed by the *lamina spiralis membranacea* of the earlier authors; and which we now know, after the important discoveries of *Reichert* and *Reissner*, to represent no simple membrane, but *a membranous canal*, to which the name *ductus membranaceus cochleæ* has been applied.

Fig. 48.
Otoliths.



Before describing more minutely the membranous structures of the cochlea, it is necessary to look closely at the recess of the round fenestra, and the relation which it bears to the cochlea and vestibule.

As Fig. 49 shows, these relations are not so simple as are generally described. First of all, there is seen in the macerated bone, close to the upper margin of the recess (below *t*), a fissure (*F*) running from below and behind, upwards and forwards, through which the tympanic cavity communicates directly with the vestibule. On studying this fissure more closely, one soon recognises that the lamina which limits it internally (mesially) is the lamina spiralis ossea, while externally it is bounded by that portion of bone which is continued on the outer wall of the cochlear tube as the lamina spiralis ossea accessoria. This fissure, which the author would designate as the *fissura vestibuli*, is open towards the recess of the round fenestra, and thus places the vestibule in direct communication with this recess—*i.e.* with the tympanic cavity.

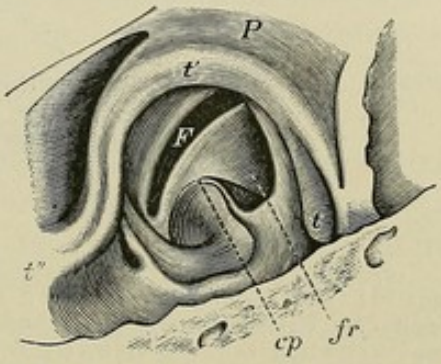
The portion of the recess situated below the fissura vestibuli is divided into two parts, or *recesses*, by an undulating ridge of bone. The anterior part of this ridge—well marked, and known as the *crista Reissneri*—is concave upwards, while its posterior part is convex. In the anterior recess, the *fenestra rotunda* is found as the entrance to the scala tympani, while the posterior recess is of practical importance in otology.

The *membranous cochlear canal* commences in a blind extremity at the antero-inferior part of the vestibule (Fig. 44, from *vb* to *l*), where the

lamina spiralis membranacea is stretched to the margins of the fissura vestibuli, just described. Shortly afterwards it receives on its upper and inner aspect the canalis reuniens (*csc*) of the saccule; and then passing into the true cochlear canal, it runs in a direction similar to the lamina spiralis, forming nearly three spiral turns situated one above another, and stretching between the lamina spiralis ossea and the outer wall of the cochlear tube. The part which lies in the vestibule is generally named the *pars vestibularis*, and the extremity at the apex of the cochlea, the *lagena*, or *blind sac of the cupola* (*Reichert*). The coil which reaches from the entrance of the canalis reuniens to the upper border of the sacculus hemisphæricus is distinguished by *Retzius* as the *basal coil* (first turn); the one immediately following upon it, the *central coil* (second turn); and the most superior, the *apex coil*, or, on account of the singular form of the end of the ductus cochlearis, the *lagena coil* (third turn). This last generally represents from three-fourths to four-fifths of a complete turn. The length of the whole ductus cochlearis is about 36 *mm*.

Fig. 49.

Recess of round fenestra, fifty times enlarged.



P, Posterior part of the promontorium; *t*, *t'*, *t''*, margin of the recess of round fenestra; *F*, fissura vestibuli; *fr*, recessus anterior, with the foramen rotundum; *cp*, posterior part of the undulating margin, below which is the recessus posterior.

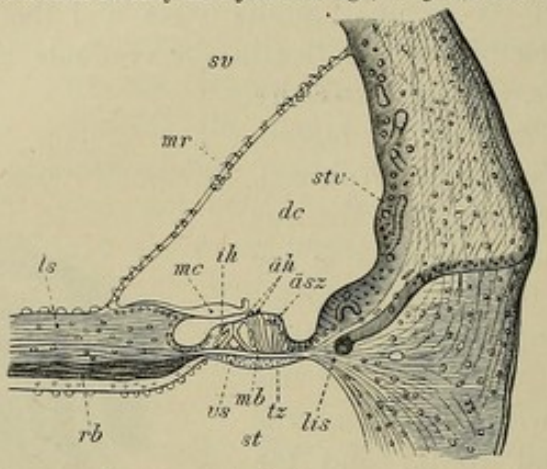
Of the walls of the ductus cochlearis the inferior is distinguished, on account of its relation to the scala tympani, as *the tympanic wall* (*zona Valsalvæ*, *lamina spiralis membranacea*, *membrana basilaris*); the superior, which separates the ductus cochlearis from the scala vestibuli, is named *the vestibular wall*, or, after its discoverer, *the membrana Reissneri*, while the outer wall is formed by the periosteal lining of the bony canal of the cochlea. A transverse section of the ductus cochlearis has been shown by *Löwenberg* to vary in shape at different parts; thus, in the basal coil it is triangular (Fig. 50), while towards the apex it is more or less elliptical.

According to *Retzius*, the tympanic and vestibular walls are somewhat bulged outwards near the lagena, so that in this neighbourhood the ductus cochlearis is wider. The lagena (Fig. 51, *L*) is situated at the apex, between the contracted scalæ of the cochlea, where its tympanal surface rests partly on the end of the *modiolus* (*lamina modioli* of *Henle*, *Lm*), which passes into the osseous partition of the cochlea. The *helicotrema* (*He*) is completed through the connection of the *hamulus Scarpæ* (*H*) of the lagena (*L*) with the lamina modioli (*Lm*), already alluded to in

the description of the bony cochlea. Through the helicotrema the communication between the two scalæ of the cochlea is established.

Fig. 50.

Transverse section of the ductus m. cochlearis at the commencement of the basal coil. From a man twenty-five years of age, × 50 (*Retzius*).

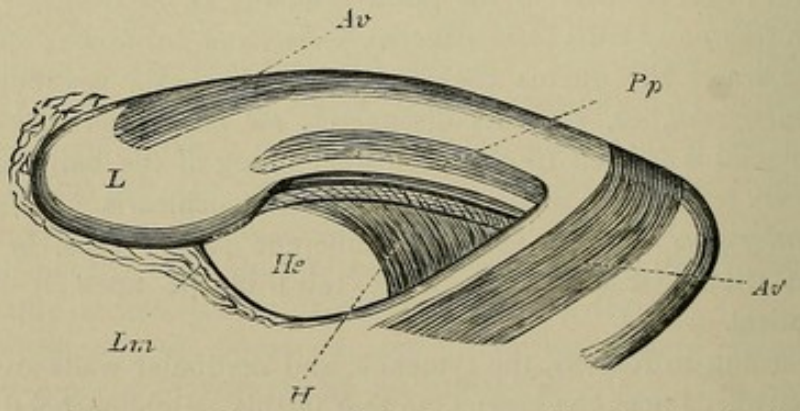


sv, Scala vestibuli; *st*, scala tympani; *dc*, lumen of the ductus cochlearis; *ls*, lamina spiralis; *mb*, membrana basilaris; *lis*, ligamentum spirale; *stv*, stria vascularis; *mr*, membrana Reissneri; *mc*, membrana tectoria; *ih*, inner hair-cells; *äh*, outer hair-cells; *äsz*, supporting cells of Hensen; *tz*, covering of the basilar membrane next the scala tympani; *vs*, vas spirale; *rb*, ramulus basilaris.

In order to understand more thoroughly the relations of the different walls of the ductus cochlearis and the structures found in them, it is necessary to study carefully the lamina spiralis ossea.

Fig. 51.

Upper end of the cochlea with the helicotrema.



L, Lagena (cul de sac at the apex of the ductus cochlearis); *Lm*, lamina modioli; *H*, hamulus scarpæ; *Av*, *Av'*, stria vascularis; *Pp*, papilla acustica (*Corti's* organ).

On microscopic examination of its vestibular surface, there is seen running along its whole length a ridge (*crista Reissneri*—Fig. 50, at the lower end of *mr*), which serves for the attachment of the *membrana Reissneri*. The free edge of the lamina spiralis ossea (*ls*) appears very

unevenly serrated, and grooved in its entire length. This groove (*sulcus spiralis*, below *mc*) is bounded by two edges or lips, the upper of which is called the *vestibular lip* (*labium vestibulare*), the lower the *tympanic lip* (*labium tympanicum*); the latter projecting farthest towards the outer wall of the cochlea. Along the whole sulcus spiralis is found a soft substance pierced by numerous capillaries, and consisting of connective tissue which contains many fusiform and branching cells. In the fresh cochlea this mass of tissue extends outwards towards the lumen of the ductus cochlearis, and was appropriately called by *Henle*, the *limbus laminæ spiralis*. This limbus is especially well developed on the labium vestibulare of the sulcus spiralis, but gradually decreases in breadth and height as we pass from the base towards the apex of the cochlea; so that although still distinctly visible near the latter, its width is reduced by fully one-half.

In addition to the limbus spiralis at the inner angle, a fibrous formation is seen at the superior external and inferior external angles of the ductus cochlearis. This formation is especially well marked at the inferior external angle, and forms the *ligamentum spirale* of *Kölliker* (*lis*).

The tympanal wall of the ductus cochlearis consequently extends from the crista Reissneri to the outer wall of the cochlea; so that one distinguishes in it an *inner part*, consisting of the limbus spiralis and a portion of the lam. spir. ossea, and an *outer part*, the true membrana basilaris (*mb*). The entire length of the tympanal wall is about 33·5 *mm.*, according to *Retzius*; and it increases in breadth as we pass from the base towards the apex of the cochlea, where its width is almost doubled. On the vestibular surface of the limbus a series of peculiar structures is found. These constitute the so-called *auditory teeth* of *Huschke*, and on the inner part of the limbus form rounded or nipple-like projections, while on its outer part they are more elongated. Between these projections are seen furrows of various shapes, which are filled up with nucleated cells. These cells spread out over the upper surface of the limbus, and form polygonal fields when treated with silver nitrate, as *Retzius* has demonstrated. When macerated in water or a weak solution of chromate of potash, they separate from the tissue of the limbus, and fall out of the furrows; thus showing that they are not connected with the processes of the limbus. The auditory teeth are most strongly developed in the basal coil, and according to *Retzius* their total number may reach 7000. Below their outer free extremity the sulcus spiralis internus is found, the labium tympanicum of which gradually becomes more and more attenuated. In this one recognises, even with a low power, the radiating medullated nerve fibres as they pass in bundles to the outer part of the tympanal wall of the ductus cochlearis through the foramina of the *habenula perforata*.

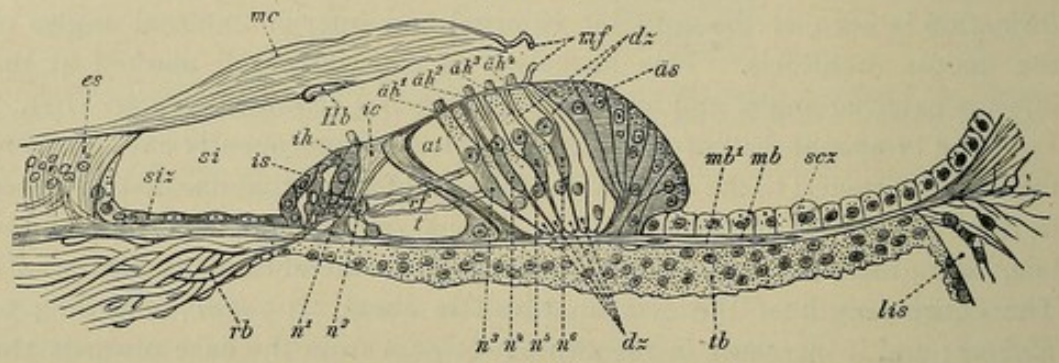
This *habenula perforata* is situated internally to the inner attachment

of the membrana basilaris, and exhibits foramina, or channels, in spirally running lines, which pass obliquely upwards and outwards (distinctly seen in Fig. 44), and through which the nerve fibres are transmitted. The number of the canals in the habenula perforata is, according to *Retzius*, about 4000. In the basal turn they are less numerous than in the upper turns; while, according to *Deiters*, they are entirely absent in the neighbourhood of the hamulus. Externally to the canals the tympanal wall becomes perceptibly thinner, and extends outwards to the ligamentum spirale.

The description of the membrana basilaris is rendered easier, if one divides it into an *inner* and an *outer* zone (Fig. 52). The inner zone (*habenula tecta, Kölliker*) extends from the habenula perforata to the

Fig. 52.

Transverse vertical section of the papilla acustica basilaris of a man aged twenty-nine years, (*Retzius*).



es, Limbus laminæ spiralis; *mc*, membrana tectoria (*s*, M. Corti); *Hb*, Hensen's striæ; *mf*, fibres of attachment to the basilar membrane; *si*, sulcus spiralis internus; *siz*, epithelium of the sulcus spiralis internus; *is*, inner epithelial cells (inner supporting cells); *ic*, inner rod-cells in connection with the outer rod-cells, between which is seen the tunnel of Corti, *t*; *ih*, inner hair-cells; *äh*¹—*äh*⁴, outer hair-cells; *dz*, Deiters' cells; *äs*, Hensen's supporting cells; *rb*, nerve fibres of the ramulus basilaris; n^1—n^6, outer bundles of the spiral nerve fibres; *rf*, radiating tunnel fibres; *at*, inner part of Nuel's space; *mb*, upper layer of the memb. basilaris; *mb*¹, lower layer of the memb. basilaris; *tb*, layer covering the tympanal surface of the m. basilaris; *lis*, ligamentum spirale.

point of insertion of the outer rod cell of the papilla acustica; the outer zone (*zona pectinata* of *Todd* and *Bowman; zona pectinata, Corti; habenula pectinata* of *Hensen*) extends from this point to the ligamentum spirale. It is thicker than the inner part, but, like it, is radially striated.

According to *Retzius*, the structure of the zona pectinata can be well studied, if the membrane is treated with rosaniline or acetate of potash. "One then sees that the fibres run alternately, singly, or joined into bundles," so as to give the membrane a ribbed appearance. Both on its upper and under surfaces the membrane has a covering of protoplasmic cells. On the zona interna, below the tunnel of Corti, one meets with the *vas spirale* in this cellular layer.

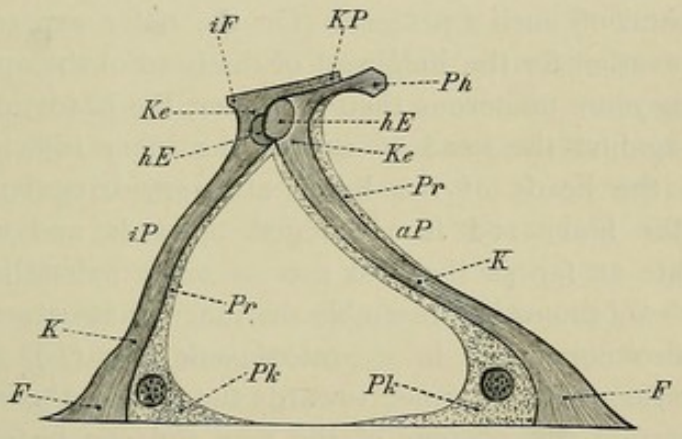
The *epithelium of the tympanal wall of the ductus cochlearis* consists of—(1) that of the proper *papilla acustica basilaris*, and (2) the *epithelium which*

covers the sulcus spiralis internus and the outer part of the membrana basilaris. The epithelium of the sulc. spir. int. (*siz*) is similar to that on the limbus spiralis. The cells cover the outer extremities of the auditory teeth, and line the sulc. spir. int. Immediately on the inner side of the habenula perforata it is somewhat raised, and at this spot the papilla acustica basilaris commences.

The *stria acustica, s. papilla acustica basilaris* (*Retzius*), or the *organ of Corti*, consists of an epithelial eminence running along the whole length of the ductus cochlearis, and which "ascends somewhat from within outwards, and then falls quickly away at its external boundary." It consists of cells and nerve fibres without any trace of connective tissue. The cells consist of: (1) the *rod-cells*, or *Corti's fibres*, (2) *Deiters' cells*, (3) *hair-cells*, and (4) the *external supporting cells of Hensen.*

Fig. 53.

Arch of Corti's rods, consisting of an inner rod (*iP*) and an outer rod (*aP*).



Both rods show: *F*, foot; *Pk*, protoplasm with nucleus; *Pr*, remains of protoplasm on Corti's fibres; *Ke*, head of rod; *hE*, homogeneous deposit in the same; *iF*, inner process of head; *KP*, head plate of inner rod; *Ph*, phalangeal process of outer rod (*Schwalbe*).

The *rod-cells* or *fibres* of *Corti* (Fig. 53) consist of an *inner* (*iP*) and an *outer* (*aP*) series, so arranged that the upper extremities of the inner and outer rods come in contact, and in this way bound a triangular space, the so-called *arch* of Corti's rods. Since these arches are arranged close to each other along the whole basilar membrane, they form a *tunnel*, which extends from the base to the apex of the cochlea (*Corti's tunnel*, Fig. 52, *t*).

Each rod (*Corti's fibre*) retains the condition of a cell, not only in the embryo, but also in the adult. A part of the protoplasm has become modified to form the rod, but the remainder (*Pk, Pr*) surrounds the rod lengthwise. The rod itself exhibits a finely fibrous structure. *Lavdowsky* considers them as contractile structures, the contraction of which can be demonstrated by the electric current. The heads of the inner rods are placed close to each other, side by side, while small fissures are found

between the bodies. Through these fissures the nerve fibres pass in order to reach the tunnel of the papilla acustica.

The *inner rods* commence immediately external to the habenula perforata in an irregular *foot plate* (*F*), which extends for a short distance outwards on the tunnel floor, and which contains the nucleus. Internally from the latter one can recognise the attachment of the rod as the glistening, highly refractile portion. From this attachment each rod becomes slightly attenuated, and passes upwards and outwards, forming a somewhat feeble S-shaped curve reversed. The angle which it makes with the basilar membrane is, according to *Middendorp*, about 60°. The *upper end* or *head* (*Ke*) broadens out, and is peculiarly shaped. Thus, its inner surface, which is turned towards the modiolus, is concave from above downwards for the lodgment of the inner hair-cells. Each of the rods does not, however, receive a hair-cell, since one hair-cell is usually supported by two or, it may be, three rods. Between every two hair-cells, a *process* projects inwards from a rod; and hence it follows that each rod does not send off such a process. On the outer aspect of the head, there is an excavation for the lodgment of the head of the outer rod. The outer rods being more numerous than the inner, the heads of two or three of them rest against the head of one of the inner rods; and thus the concavities on the heads of the latter are very irregular. The upper extremity of the inner rod is prolonged upwards and outwards as a rectangular plate as far as the first row of outer hair-cells.

The *outer rods* somewhat resemble the inner in structure and appearance. They also commence in a protoplasmic foot (*F*), which extends inwards on the floor of the tunnel towards the foot of the inner rod (*Pk*). In this basal portion the contour of the true rod can be seen, while the nucleus and protoplasmic part of the cell have an arrangement similar to that found in the inner rods. Tolerably wide fissures exist between the outer rods, the bodies of which are curved in a somewhat S-shaped manner, and pass upwards and inwards so as to reach the upper extremities of the inner rods. They form with the basilar membrane an angle of about 40° (*Middendorp*), and each ends superiorly in a four-sided *head*. Of its four sides the lateral are in apposition with the heads of adjacent rods; the inner is convex, and fits into the concavity on the head of the inner rod; while the outer is concave from above downwards. The upper surface of the head is overlapped by the thin plate of that of the inner rod, and the two project outwards and slightly upwards. A small process (*Ph*) projects from the external margin of the head of the outer rod, and gives attachment to the *first segment* (*phalanx*) of the *lamina reticularis*, which will be subsequently described. It spreads out in a tongue-like manner between the hair-cells of the first row, and ends externally at the second row of hair-cells.

The rods in the basal coil are shorter than those nearer the apex of the cochlea, and hence the intervening tunnel increases in height as we pass from below upwards. They are dissolved by dilute solutions of caustic soda or potash, and also by tolerably weak hydrochloric acid; whilst they shrivel up in ether, alcohol, chromic acid, saturated solution of hydrochloric acid, or a solution of sugar (*Kölliker*).

Deiters' cells (Fig. 52, *dz*) are so named after their discoverer. They alternate with the outer hair-cells; forming four, sometimes three, rows situated externally to, and some little distance from, the outer rods, with the heads of which, as we shall see, they are to some extent connected. They are more or less spindle-shaped, and one distinguishes in each a foot-piece attached to the basilar membrane, a body or central portion containing the nucleus, and an upper extremity or head, the most external process of which contributes to the formation of the membrana reticularis. Extending from the lower to the upper end of the cell is seen a bright, shining, thread-like structure ("supporting fibre"), which lies close to the inner side of the cell. At the lower extremity of the cell this fibre is attached by a three-cornered base to the membrana basilaris, and is here surrounded by the protoplasm of the cell; so that the lower extremity is in this way considerably enlarged, and comes to have a somewhat polygonal appearance. A spherical nucleus appears in the spindle-shaped body of the cell, while out of the body—which contains some yellow pigment—the fibre is prolonged upwards, to end in a flat process resembling a phalanx of the thumb, and is therefore called the *phalangeal process*. These processes consist of thin plates, each surrounded by a clear margin. They are not always shaped like a phalanx, but are sometimes irregular in form, depending on the arrangement of the outer hair-cells. The adjacent edges of the phalanges partly coalesce; and form, together with the processes which have been described as existing on the heads of the outer auditory rods, a lattice-work named the *lamina reticularis*. The upper extremities of the outer hair-cells are fixed into the meshes of this network.

The *outer hair-cells* ($äh^1$, $äh^2$, $äh^3$, $äh^4$) form three or it may be four rows, and each is placed somewhat obliquely on the inner side of the body of a Deiters' cell. They do not touch the membrana basilaris with their lower extremities, nor have they any organic connection with Deiters' cells; but their upper ends are fixed into, and fill up, the foramina of the lamina reticularis. *Retzius* says "the entire cell is surrounded by a thin structureless membrane, internal to which lie rounded granules separated by interstices." The contents of the cell (Fig. 47) appear transparent; a roundish nucleus occupies a position near the centre of the cell; while towards the upper extremity there is indistinctly seen a rounded or oval body (*Hensen*), the nature of which has not yet been determined. The hair-cells are not always regularly cylindrical, nor are they all of the same size. From their rounded free extremities, stiff glossy rods or hairs of equal

length project towards the lumen of the membranous cochlear canal. Each cell carries about twenty hairs, and these are placed on the extremity of the cell in the form of a crescent with its convexity outwards; the hairs are, according to *Hensen*, cylindrical, and of the finest calibre. In the basal coil three rows of outer hair-cells are usually present; but a fourth is added in the central coil (*Retzius*), and formed either by a series of additional cells, or by the displacement outwards of a large number of cells from the third row. The same occurs in the apex coil, and thus the membrana reticularis has an irregular appearance, due to displacement and adhesion of the phalanges.

The inner hair-cells form only a single row, and are situated internally to the inner rods, by which they are supported. In shape and structure they are similar to the outer hair-cells.

The outer limit of the papilla acustica is formed by what are known as the *outer supporting cells* (Fig. 52), or, as they are called after their discoverer, *Hensen's cells*. These are attached by their slender lower ends to the basilar membrane, and end superiorly in polygonal extremities on the superior surface of the papilla acustica. They are stained somewhat dark by osmic acid, and contain yellowish pigment granules near their upper extremities, while a spherical nucleus is found in the upper half of each cell. These limit the papilla acustica externally, and as they increase in circumference from below upwards they form a wall on the membrana basilaris, which it is evident must project strongly outwards. This wall is very distinctly seen on transverse sections of the membrana basilaris, and is best marked in the apex coil. External to it the membrana basilaris is covered by a much lower form of cylindrical epithelium, which contains yellowish pigment granules and spherical nuclei. The upper ends of these cells are polygonal.

Just as through the arrangement of the auditory rods a tunnel space is formed between them, so also a space is found between the outer rods and the neighbouring cells of the papilla acustica. To this *Nuel* called attention, and hence it is named *Nuel's space*. It is well developed in man; communicates internally with the tunnel space through the fissures which exist between the outer rods; and extends externally between the outer hair-cells and the phalangeal processes of Deiters' cells, as far as Hensen's supporting cells. Both the tunnel space and Nuel's space are closed on the outer and inner extremities of the papilla acustica, and *Retzius* says that they do not communicate with the endolymphatic space through the lamina reticularis.

The papilla acustica is covered along its entire length by the *membrana tectoria*, or *memb. Corti* (*mc*); a somewhat elastic membrane which increases in breadth in the middle and apex coils. It is attached internally almost mid-way between the *membrana Reissneri* and the *labium vestibulare* of the lamina spiralis ossea, and reaches to the outermost row of hair-cells. One distinguishes in it an inner and an outer zone. The former is very

thin, and adheres to the epithelium of the limbus spiralis; while the latter projects outwards and upwards over the sulcus spiralis internus and the papilla acustica. It appears somewhat thicker in the middle, and ends in a free margin externally. In the basal coil this free margin consists of a glistening border; while in the central coil it exists as a thick, and in the apex coil as a thin, fibrous reticulum, the fibres of which project outwards over the most external hair-cells (*Retzius*). Almost in the middle of the lower surface of the membrane one meets with *Hensen's stripe* (*Hb*), consisting of a glistening flat band. The membrana tectoria is composed of fine fibrillæ, which withstand the action of acetic acid.

Regarding *the distribution of the fibres of the nervus acusticus*, *Axel Key* and *Retzius* have shown that, at their exit from the medulla, all possess a myelin sheath and a sheath of Schwann. They have also shown that all the cells found in the branches of the nervus acusticus are bi-polar. The nerve fibres lose both their sheaths below the maculæ and cristæ acusticæ, and enter the epithelium as naked axis-cylinders, where they are connected with the lower ends of the hair-cells. The fibres which are distributed to the membrana basilaris run in bundles between the lamellæ of the lam. spir. ossea; and, after forming sundry anastomoses, pass through the labium tympanicum to the habenula perforata. They are less crowded towards the apex of the cochlea, and appear, on emerging from the upper openings of the canals of the habenula perforata, as naked axis-cylinders, which pass upwards and outwards, and become divided into fine varicose fibrillæ. Here they turn in a spiral manner, and form the *inner* or *first spiral fasciculus* (n^1, n^2); from which fibrillæ ascend to the lower ends of the inner hair-cells, where they form a network, and then end in the cells themselves. Other fibrillæ pass outwards between the inner rods into the tunnel space, and at the lower extremities of these rods they form a *second spiral* or *tunnel fasciculus*. From this, thicker and thinner bundles radiate in a somewhat upward direction (*rf*) towards the outer auditory rods, between which they pass into Nuel's space. Traversing this, they reach as far as the inner side of the first row of *Deiters' cells*, where they are united with the *outer spiral fasciculus* (n^3, n^6) of the nerve. A similar outer spiral fasciculus is found on the inner side of each row of *Deiters' cells*, and from these the nerve fibrillæ pass to the lower extremities of the outer hair-cells, where their mode of termination is still involved in some obscurity.

The *vestibular wall* of the ductus cochlearis (*membrana Reissneri*, Fig. 50, *mr*) commences at the limbus laminæ spiralis osseæ, and terminates at the upper part of the outer wall of the ductus cochlearis. "It consists of an extremely thin structureless, or here and there slightly striated, connective-tissue layer, the vestibular surface of which is covered by a single layer of endothelium, the cells being spindle-shaped and sometimes

containing pigment. The tympanal surface of the membrane is directed towards the lumen of the membranous cochlear canal, and is covered by a polygonal pavement epithelium." The cells of this epithelium are, according to *Retzius*, normally grouped together in many places, "forming racemose projections towards the lumen of the canal."

According to *Steinbrügge*, the *membrana Reissneri* is arched towards the scala vestibuli—a condition which he associates with the unequal pressure exerted on the upper and lower walls of the ductus cochlearis. The pressure upon the lower wall can be more easily balanced through the aquæductus cochlea, and for this reason it is less stretched.

The *outer wall* of the membranous cochlear canal is so intimately connected with the periosteum of the osseous canal that it is impossible to define an accurate boundary between them. It consists of connective tissue containing many connective-tissue corpuscles and blood-vessels. This tissue is thickest in the basal coil, and gradually thins off towards the apex. It is especially thick in the region of the external attachment of the lower wall of the ductus cochlearis (Fig. 50), forming here a somewhat triangular projection—the *ligamentum spirale* (*lis*). Above the lig. spirale a crest is seen, which runs from the base to the apex of the cochlea, and represents the *crista ligamenti spiralis* of *Boettcher*. Between this crista and the lig. spirale is the *sulcus ligamenti spiralis*; while above the crista, and extending to Reissner's membrane, is found the so-called *stria vascularis* (*stv*), which exhibits irregular elevations and depressions towards the lumen of the ductus. The tissue is here traversed by many vessels; while the epithelium is polygonal, and contains numerous pigment granules. It is supposed that the stria vascularis serves for the secretion of the endolymph.

Concerning *the position and structure of the membrana tympani secundaria* (*accessory tympanic membrane*), which closes the round fenestra, we are indebted to *Weber-Liel*[1] for the greater part of our knowledge. Its outer surface looks backwards, and is somewhat concave. When viewed from the scala tympani it appears angularly bent, with the angle projecting towards this space. Through this curvature it is divided into a larger inferior, and a smaller superior segment. The latter, constituting about one-third of the entire membrane, lies almost parallel to the lamina spiralis of the cochlea; while the lower segment is placed almost transverse to the long axis of the scala tympani. According to *Weber-Liel*, the chief constituent of this membrane consists of a kind of membrana propria, made up of fibrous connective tissue, the bundles of which run from the position of the angular bending towards the periphery of the membrane. Externally it is covered by thin mucous membrane, with

[1] "Die Membrana tymp. secundaria," Monatsschrift für Ohrenheilkunde, x. Jahrg., Nr. 1, 4, 5.

a single layer of epithelium; internally by the endothelium of the perilymphatic space. The mucous membrane is strengthened and stretched by somewhat strong fibres which pass to it from the fossula rotunda, and which radiate towards the line of angular bending. Through these the outer surface appears more concave.

Blood-Vessels of the Internal Ear.

The blood reaches the *internal ear* through the *art. auditiva interna*, a branch of the art. basilaris. Entering the internal auditory meatus with the n. acusticus and facialis, it divides into the *a. vestibuli* and *a. cochleæ*. The latter subdivides into numerous branches, which pass through the foramina of the tractus spiralis foraminulentus into the modiolus; and then running between the two layers of the lamina spiralis are distributed to the soft structures and to the walls of the cochlea. In its course over the lamina spiralis it gives off branches to both sides, and these—as *Breschet* has pointed out—form sinuous anastomoses, the fine terminal branches of which are, according to *Huschke*, spread out in a radiating manner. The largest branch of the art. cochleæ runs in the canalis centralis cochleæ.

The *a. vestibuli* breaks up into small branches, which pass through the posterior wall of the vestibule to its soft tissues and to the semicircular canals. On each canal two arterial branches ascend—one on the ampullary, and the other on the non-ampullary limb—in order to anastomose on the central part of the arch.

The *a. stylo-mastoidea* is also said to give off several fine twigs to the labyrinth.

Veins.

The *venous blood* from the *internal ear* is collected partly by the veins of the cochlea and vestibule, and partly by the vein situated at the circumference of the outer wall of the ductus cochlearis. The *venæ cochleæ* and *venæ vestibuli*—the latter having received the blood from the semicircular canals—are united at the bottom of the internal auditory canal to form the *v. auditiva interna*, which terminates in the superior petrosal sinus.

The existence of those veins which are said to pass through the aq. vestibuli and aq. cochleæ is, by recent observers, being more and more questioned. According to *Weber-Liel*,[1] a small vein passes from the bulbus venæ jug. towards the aq. cochleæ; but it enters a special canal of its own 1 *mm.* distant from the aqueduct, and passes through it to the scala tympani. According to *Hyrtl*, small veins run through both aqueducts. He says the vein of the aq. cochleæ

[1] "Der Aquæductus cochleæ beim Menschen." Monatsschrift für Ohrenheilkunde xiii. Jahrgang, Nr. 3.

receives its blood from the cochlea, whilst the smaller vein of the aq. vestibuli receives its blood from the semicircular canals.

Concerning the *lymph-vessels* of the *internal ear*, nothing definite is known.

Triquet,[1] in a work which is chiefly devoted to the subject of tinnitus aurium, describes some anomalies in the auditory vessels which may be shortly referred to here. He says that the *art. mastoidea* passes through the foramen mastoideum to the mastoid cells only in exceptional cases. As the result of a number of special injections, he finds that it most frequently enters the cranium through the foramen lacerum posterius, or through the foramen occipitale, and only rarely through the foramen mastoideum. Only in exceptional cases does it give a branch to the mastoid cells, which as a rule receive their blood from the art. stylo-mastoidea. This latter arises more frequently from the art. occipitalis than from the auricularis posterior. It gives *several branches to the meatus auditorius externus; a branch to the tympanic membrane;* while during its course through the canalis Fallopii it sends *twigs to the tympanic mucous membrane, mastoid cells, semicircular canals, and cochlea.* In several instances he saw a minute branch of the *tympanica* pass through a small foramen on the margin of the round fenestra to the middle scala of the cochlea.

Smaller branches are said to enter the tympanum through minute foramina found on the bony wall of the canal for the tensor tympani muscle.

Sinuses of the Dura Mater which are in close relation to the Auditory Organ.

These are:--

1. The *lateral sinus* (*sinus transversus*), which begins at the protuberantia occipitalis interna, and passes transversely outwards in the sulcus transversus. It then forms an S-shaped bend (*sinus sigmoideus*) on the mastoid angle of the parietal bone, on the inner surface of the pars mastoidea of the temporal bone, and on the pars condyloidea of the occipital bone, and empties itself into the bulbus venæ jugularis. It is therefore found in the immediate vicinity of the mastoid cells, a relationship to which attention has already been directed. Two *emissaria Santorini* pass from the sinus sigmoideus to the outer surface of the cranium—one through the foramen mastoideum, and the other through the foramen condyloideum posticum. Minute vessels also pass from the mastoid cells to open into this sinus.

2. The *superior petrosal sinus* (*sinus petrosus superficialis major*) runs from the sinus cavernosus, backwards along the posterior superior border of the pars petrosa—on which its course is indicated by a slight groove—to open into the sinus sigmoideus.

3. The *inferior petrosal sinus* (*sinus petrosus inferior*) lies in the shallow furrow between the clivus and the pars petrosa, and opens into the bulbus venæ jugularis.

[1] "Mémoire sur une variété pas encore décrite de bourdonnements de l'oreille et les moyens d'en obtenir la guérison." Arch. gén. 5, s. xix., p. 418, Avril 1862.

Nerves of the Internal Ear.

The *internal ear* serves as the place of distribution of the nerve of hearing, or *nervus acusticus*. Certain fine filaments also pass from the adjoining nerves of the tympanum towards the structures of the fenestra, and ramify on the walls of the labyrinth.

The *nervus acusticus* springs from the medulla oblongata by two roots —*anterior* and *posterior*—which are separated from each other only by a slight furrow. The nerve makes its appearance between the crus cerebelli ad pontem and the olive, and passes in a sheath formed by the arachnoid and pia mater through the meatus auditorius internus to the labyrinth. In the meatus, the n. facialis lies in a groove on its anterior surface; and here is seen that apparent union between the two nerves which is described as the *inner connection*. Fibres may be seen passing from the n. acusticus to the n. facialis, and *vice versâ*. Those nerve fibres which are described as the *n. intermedius, s. Wrisbergii*, are however separated again in their further course, and re-enter the nerve which they left, so that the connection is only apparent, since these migratory fibres belong entirely to the n. facialis.

The n. acusticus is divided into three branches as it passes through the meat. aud. int. The part which in the natural position of the nerve lies posteriorly and superiorly (Fig. 54, *Rs*), is already separated from the trunk of the nerve at the commencement of the auditory canal. It enters the vestibule through the macula cribrosa superior, and forms the *ramus anterior* of *Retzius*, or *ramus vestibularis, s. posterior superior* of *Schwalbe*. During its course through the auditory canal it swells out somewhat, forming the *intumescentia ganglioformis* of *Scarpa* (*Ig*).[1] It divides in the vestibule, and sends one branch (*Rm*) to the macula acustica utriculi, a second to the ampulla of the anterior, and a third to the ampulla of the external canal. The remainder of the auditory nerve is divided into two branches; of which the *posterior* (*Rm*, at the lower part of the figure), constituting the *ramus medius* of *Schwalbe*, or the *ramus posterius* of *Retzius*, is again subdivided into two parts (*Ms* and *Ap*), which enter the vestibule through the macula cribrosa and canalis singulare, in order to supply the sacculus sphæricus and the ampulla of the posterior canal; while the *anterior* (*Nc'*, *Nc*), as *r. inferior n. acustici*, or *nervus cochleæ* (*ramus posterior*, *Retzius*), is intended for the supply of the cochlea, to which it passes through the tractus spiralis foraminulentus.

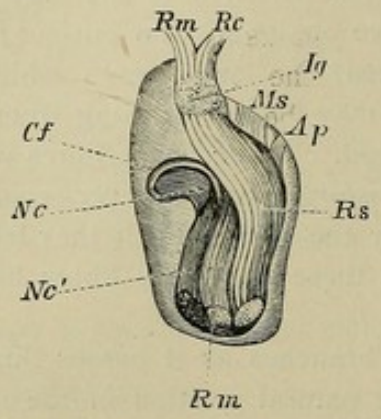
The *n. cochleæ* first gives off a twig to the vestibular extremity of the

[1] According to *Arnold*, the n. facialis sends filaments from its geniculate ganglion to the intumescentia ganglioformis. The further course of these fibres is unknown.

ductus cochlearis, which passes through the macula cribrosa quarta to the soft structures of the vestibule. The trunk of the n. cochleæ then sends a number of small branches through the tractus spiralis foraminulentus to the lamina spiralis. The remainder of the nerve enters the modiolus, and is divided into smaller filaments, which pass through the small canals running at acute angles to the axis of the modiolus, in order to reach the canalis spiralis modioli. Here they are strengthened by the deposition of the ganglion cells, and finally enter the lamina spiralis ossea, through which they take their course in the manner already indicated in the description of the soft tissues of the labyrinth. In the canalis spiralis modioli the ganglion cells are very numerous, and are connected with each other, forming the *ganglion spirale*, or *habenula ganglionaris* of *Corti*. Besides the bundles of the n. cochleæ, which run perpendicularly to the long axis of the lamina spiralis ossea, others are seen running parallel to the long axis of the canal. spir. modioli. These are crossed at right angles by the bundles already described.

Fig. 54.

Nervus acusticus of the right side in the internal auditory canal, after removal of the n. facialis and intermedium—seen from above.



The left side of the figure corresponds to the anterior, the right side to the posterior wall of the meatus auditorius internus. *Rs*, ramus superior (anterior) ; *Rm*, its branch to the macula of the recessus utriculi; *Rc*, its branch to the ampullæ of the anterior and external semicircular canals; *Ig*, intumescentia ganglioformis of the ramus superior; *Rm*, ramus medius; *Ms*, its branch to the macula of the sacculus; *Ap*, its branch which passes through the foramen singulare to the ampulla post.; *Nc*, *Nc'*, ramus inferior (n. cochleæ); *Cf.* crista falciformis of the internal auditory canal.

The course and subdivision of the three portions of the auditory nerve during their passage through the meatus auditorius internus are by no means so simple as they at first sight appear to be. As *Boettcher* has pointed out, these complicated relations are dependent on the method of development of the labyrinth. In the higher vertebrata, and especially in the higher mammalia, including man, a change in the position of the labyrinthine structures takes place during development; so that the cochlea, which at first lies below and behind the sacculus vestibuli and semicircular canals, passes by degrees forward beneath these structures. That branch of the nerve which goes to the cochlea was at first therefore the posterior branch of the n. acusticus, and becomes somewhat later the antero-inferior; while the branch which was originally anterior in position now becomes posterior. In this way it can be explained why the fibres of the individual branches (Fig. 54) have not a straight course, but make curvatures, so that many bundles are twisted on their long axis. The ramus posterior superior makes the greatest bend, with its convexity backwards, while at the same time the nerve is twisted on its long axis. The ramus medius, which passes to the sacculus sphæricus and to the posterior

ampulla, also makes a curve. At first it lies on the dorsal aspect of the ramus anterior inferior. Its fasciculi are then collected into a trunk, which is flattened from above downwards, and which passes backwards and outwards beneath the ramus posterior, to be then divided into the n. saccularis and the n. ampullæ posterioris. Lastly, the n. cochlearis makes a well-marked curve with its concavity forwards before it enters the tractus foraminulentus.

The n. acusticus also possesses fibres which arise from the ganglion cells found in the course of the nerve itself. The ramus superior and ramus medius exhibit ganglionic enlargements during their course through the internal auditory canal (*intumescentia ganglioformis Scarpæ*), whilst the n. cochlearis has its ganglion in the lamina spiralis ossea (*ganglion spirale*). The ganglionic mass of the ramus superior lies on the crista falciformis, close to the macula cribrosa superior; that of the ramus medius is placed somewhat farther back; and these two ganglia are connected with each other. The branch destined for the posterior ampulla shows two small ganglia shortly before its exit from the canalis singulare (*Corti*). The ganglion cells are bi-polar, their two medullated nerve fibres passing out from the opposite poles, while the cells are enveloped by an endothelial nucleated membrane.

The *origin* and *central connections* of the *n. acusticus* are as yet not quite accurately determined. According to *S. Freud*,[1] who made his observations in the human fœtus of the 6th—7th lunar month, the n. acusticus, "or at least the groundwork of its fibres," springs from three distinct grey nuclei, which are all situated in the medulla oblongata. These three nuclei are: (1) the *external acoustic nucleus* (*anterior nucleus of Meynert*); (2) *Deiters' nucleus*; and (3) the *internal acoustic nucleus*. The *external nucleus*—a grey mass situated in the outer part of the medulla—gives fibres to the lowest and most external part of the auditory nerve; in addition transverse bundles pass from it to the root of the fifth nerve, and ventrally below this towards the middle line, where they decussate with the corresponding fibres of the opposite side, forming the corpus trapezoides. On the dorsal aspect of this fasciculus is placed the superior olive, to which some individual fibres of the n. acusticus pass. As a bundle of fibres is directed from the superior olive to the abducens, a connection is thus established between the two nerves, "which may possibly bring about the reflex turning of the eyes in the direction of the source of sound." From the external acoustic nucleus fibres wind round the corp. restiforme, and pass to the internal acoustic nucleus. Those passing laterally from the restiform body probably represent the commencement of the *striæ acusticæ*;

[1] "Ueber den Ursprung des N. acusticus." Monatsschrift für Ohrenheilkunde, xx., Nr. 8 und 9.

the others on the contrary, which are directed partly through the restiform body, partly past it on its inner and outer aspects, represent a second portion of the auditory nerve situated internally to the first, and terminating in the internal nucleus of the n. acusticus. From this second portion fibres also pass in a curved manner to the corpus trapezoides. These fibres pass through the root of the fifth nerve, and are connected with the superior olive.

A third portion of the acustic root arises from *Deiters'* nucleus, which is situated internally to the restiform body; and a fourth portion from the *inner acoustic nucleus*. This last is probably that fasciculus of fibres which first passed round and then through the restiform body, and belongs to the second portion of the n. acusticus. The inner acoustic nucleus is situated on the lateral part of the floor of the fourth ventricle, and has a three-sided form with its base directed towards the ependyma of the ventricle. From its outer corner fibres pass to the abducens; from its deepest part a large number of curved fasciculi pass towards the roof of the fourth ventricle, and are there crossed between the roof nuclei of the cerebellum by the corresponding fibres of the opposite side, and so represent the connection of the n. acusticus with the cerebellum.

According to *Luciani*,[1] the auditory centre is found, not only in the temporal lobe, but also in the cornu ammonis. A large decussated fasciculus and a smaller non-decussated one run in the n. acusticus, and each ear communicates with both auditory centres. The destruction of one auditory centre causes transitory deafness, with persistent incomplete psychic deafness, while bilateral extirpation does not produce complete deafness (cortical deafness). We shall refer again to this important question in the special part of this work.[2]

Physiological Observations.

Although the physiological importance of the *pinna* is by no means so great as one, from its complicated configuration, would be inclined to suppose, yet it cannot be denied that it does play a part in connection with the sense of hearing. It acts not only as a reflector, throwing the sound-waves into the auditory canal, along which they are conducted to the tympanic membrane; but also as a conductor, transmitting the sound-waves to its place of attachment—*i.e.* towards the auditory canal. That the latter takes place, may be proved by the following simple experiment: Hold a vibrating tuning-fork in front of the ear until the sound produced by it is no longer heard; then place the tuning-fork immediately on the

[1] "Ueber die sensoriellen Localisationen in der Hirnrinde." Centralblatt für die medicinische Wissenschaft, 1884, Nr. 44.

[2] For further information on this subject, the reader may be referred to *Schwalbe's* excellent treatise, "Lehrbuch der Anatomie der Sinnesorgane," von *Prof. Dr. G. Schwalbe*. Erlangen, 1866, S. 547—559.

upper part of the auricle, and the sound will once more become audible. *Voltolini* says the pinna conducts the sound-waves received by it directly to the bottom of the auditory canal. Yet in people in whom the pinna is completely wanting, there is apparently no perceptible diminution in their power of hearing, if the remaining structures of the auditory organ are normally developed.

The muscles of the pinna are certainly of no great physiological importance, since it is only in exceptional cases that they are under the control of the will.

Vierordt[1] supposes that the presence of the auricular muscles is of some importance, since the auditory perception might gain in intensity and distinctness if greater attention were directed to it in consequence of movements at the entrance of the organ of sense.

According to *Ed. Weber* the pinna is of use in distinguishing whether the sound comes from the front or from behind. He thinks this is demonstrated by the following experiment: The ears are pressed flat against the sides of the head; and a screen taking the place of the auricles is made with the hands in front of the auditory canals. The sound now appears to come in the opposite direction from that in which it really originates; so that when the eyes are closed, a sound coming from the front appears to be directed from behind; one from above appears to come from below; and *vice versâ*. How far these statements agree with the conditions found in disease we shall subsequently consider. This much is certain: that we judge of the direction of a sound according to the intensity of the perception of that sound; since we if possible move the head towards that side from which the sound appears louder. If throughout this movement the sound preserves a constant intensity; then this act which we instinctively follow is useful in ascertaining its direction.

According to *J. Kessel*,[2] an equally strong stimulation of both ears, giving rise to a single auditory perception, only takes place when the sound proceeds from the mesial plane. If the stimulation of the two ears is unequally powerful, only one auditory perception is said likewise to take place; but this time on the side of the more strongly stimulated ear. The best binaural audition is produced when the sound proceeds from the mesial plane anteriorly; the best monaural audition, on the other hand, when the sound-waves are transmitted directly in the axis of the auditory canal. According to this observer, the pinna is divided into five auditory districts, which are sharply defined from each other, and are characterised by the fact that they convey the sound to the ear with a different intensity, according to the direction of the head at rest or during movement. These districts for the perception of sound are: anterior, posterior, inferior, superior, and central or direct. The different auditory districts are brought into use by means of suitable movements of the head; and in association with the sense of sight the direction from which the sound proceeds is ascertained. The sound-waves are transmitted by the *external auditory canal* to the tympanic membrane. This membrane, which is not tightly stretched, carries with it in its movements the handle of the malleus. Since the malleus forms with the other auditory ossicles a continuous chain, these also must to some extent share in the movements of the membrane; and, as the opposite end of the chain consists of the foot of the stapes, movably attached in the oval fenestra, it follows that the movement of the tympanic membrane must exercise an influence on the terminations of the n. acusticus.

It is remarkable to what an extent the external auditory canal may be narrowed, if only the other relations of the ear are normal, without the sense of hearing being

[1] Grundriss der Physiologie des Menschen. Tübingen, 1860.

[2] "Ueber die Function der Ohrmuschel bei den Raumwahrnehmungen." Archiv für Ohrenheilkunde, xviii. Bd., 3 Heft.

impaired. Frequently it is almost quite closed by foreign substances, and still the patient enjoys good hearing. Many are of opinion that this is associated with the short distance which the sound has to travel in the external auditory canal; but it seems to the author to depend upon peculiar anatomical conditions, both in the auditory canal itself, and also in the other sound-conducting structures.

E. H. Weber concluded from his experiments that it is the tympanic membrane which first of all informs us whether a sound is produced outside or inside the body. If the membrane is prevented from vibrating by filling the external auditory canal with water, the sound seems to proceed from the interior of the head; but if the canal is filled with air, so that the membrane can vibrate freely, then the sound seems to come from the outside. According to *A. Fick*, this depends on the tactile perception of the tympanic membrane, which is richly supplied with nerves, as well as upon stimulation of the auditory nerve. A means would thus be given also by which to distinguish whether the sound proceeded from the right or left side: in the former, the stimulation of the right membrane must be stronger, in the latter, that of the left.

According to *Steinbach*,[1] there can be distinguished, both in monaural and binaural hearing; *direct*, *indirect*, and *mixed hearing*. In the direct, the sound-waves reach the ear directly; in the indirect, only after one or more reflections; and in the mixed, both with and without reflections. In binaural audition both ears may be struck by the direct or by the indirect, or the one by direct and the other by indirect sound-waves. The intensity of the perception of hearing depends upon the sum of the sound-waves which are reflected from the auricle into the auditory canal; the size of the reflecting surface of the pinna, on account of its complicated form, being almost the same for the different directions of the sound-waves. The distance of the origin of the sound is determined from the relative intensity of the sound perception which one compares with what he, according to experience, knows would result from the production of a sound in the immediate neighbourhood. The direction of the sound one estimates by the difference of intensity with which it is perceived by the two ears. If the source of the sound is in the district of direct audition, then its direction can be defined with tolerable certainty: nevertheless, each individual has for this judgment his own standard, which depends upon the angle which the two auricular surfaces make with each other: the smaller the angle the more certain the judgment. The best binaural audition takes place, according to *Steinbach*, when the sound proceeds from the front, in the visual direction; and hence one involuntarily turns the face to the person speaking, whilst a person deaf on one side turns the best ear to the speaker. The best monaural hearing takes place when the sound-waves strike the surface of the auricle perpendicularly. If the angle which the two auricles form is less than 60°—and this is usually the case in most individuals—one hears with one ear better than with two, and therefore the listener turns one ear towards the source of sound. Changes of place in the origin of the sound in direct audition are generally estimated by the altered intensity of the sound-perception. In indirect hearing other circumstances also assist. Judgment, together with the assistance of auditory impressions which are from experience familiar, play a principal part. In the mixed binaural audition, in which direct waves of sound only reach one ear, whilst both ears can be struck by indirect sound-waves, one can only vaguely determine the direction of the sound; and its origin is placed in the district of that ear which is struck by the direct sound-waves. If we wish to define more accurately the direction of the sound in indirect or mixed binaural audition, we are assisted if we turn our head so that the sound is received from the district of direct binaural audition, or from the boundary

[1] "Die Theorie des binauricularen Hörens." Wien, 1877.

of two adjacent auditory districts, or from the direction of the best monaural hearing. Daily experience teaches us that secondary conditions enable us to assist our power of localisation.

Le Roux[1] found from his experiments on binaural hearing that the distinction is very marked between audition with one and audition with both ears. He made a tuning-fork vibrate in front of one ear, and he found, on bringing another tuning-fork vibrating with the same pitch and intensity in front of the other ear, that the sound of the first appeared disproportionately louder—in fact, far more than twice as loud. He also observed that when the sound of the tuning-fork is almost lost by the one ear, it is heard again distinctly if one brings a sounding tuning-fork having a similar number of vibrations in front of the other ear. According to *Urbantschitsch*,[2] a feeble tone striking one ear is in many persons distinctly augmented, even if the tone adjusted to the other ear is not in unison with the first; a similar increase is also observed with regard to noises. The increased faculty of perception outlasts the second sound in many individuals for a varying length of time; sometimes for several seconds. Cases do occur however in which a second auditory stimulus lowers the perceptive capacity of the other ear.

Weber's observation is only partly confirmed clinically. There is no doubt that the normal ear receives information through the auricle and tympanic membrane concerning the direction and origin of the sound; and that our conceptions of the latter are determined by the activity of these organs, so long as they are normal. But this result is not exclusively dependent on these structures. If it were so, then in those persons who have no auricle, or in whom the membrana tympani is deficient, the consciousness of the origin and direction of the sound would be absent; but this is not the case. It is true that some people, if their tympanic membrane be suddenly damaged, have for a longer or shorter time no certain judgment concerning the origin and direction of the sound; but even if the membrane be completely destroyed they soon acquire through practice the capacity of quick localisation; and they are also soon able to recognise correctly the direction and place of origin of the sound. From this it follows that the function of the auricle and tympanic membrane in this respect can be compensated by other structures. *Fick's* view with regard to the sense of touch of the tympanic membrane finds its realisation here, and may even have a still greater value in reference to the structures on the inner wall of the tympanum. According to *Rauleigh*,[3] the nature of the sound greatly influences the recognition of its direction. Thus one easily recognises the direction of the human voice, while other sounds are only determined with certainty in the lateral direction, and not in front or behind. *Gellé*[4] observed that a patient in *Charcot's* clinique had absolute insensibility of the two tympanic membranes and auditory canals. When his eyes were closed he could not state the direction of the sound of a watch, although he heard it distinctly. In persons suffering from anæsthesia, who were able without hesitation to recognise the direction of a sound, the sensibility of the tympanic membrane was found to be preserved.

Since stretched membranes are well adapted for the transmission of sound-waves, we have in the tympanic membrane a structure most suitable for this purpose. But every stretched membrane has its own fundamental tone, which is produced in this way—viz. when the membrane is struck, it must return to its

[1] Gaz. hebdom. 1875, 19.

[2] "Ueber die Wechselwirkung der innerhalb eines Sinnesgebietes gesetzten Erregungen." Separatabdruck aus Pflüger's Archiv, xxxi., 1883.

[3] Monatsschrift für Ohrenheilkunde, x., Bd. 11.

[4] "Rôle de la sensibilité du tympan dans l'orientation du bruit." La Semaine Méd., 1886, Nr. 42.

position of equilibrium, and, before permanently regaining this position, it must vibrate to and fro, these vibrations having a certain rapidity. It is easy therefore to understand that disturbance of the membrane would necessarily occur if it were struck by a column of sound-waves the number of vibrations of which was equal to that of the fundamental tone of the membrane. The membrane would then vibrate more strongly for this tone than for others, and this might be in the highest degree disturbing. Even if vibrations corresponding to its own proper tone are left out of consideration, disturbances would always occur in the function of the tympanic membrane if it could vibrate freely. If a new column of sound-waves struck the still vibrating membrane, conditions would arise which would interfere with the conveyance of the sound-waves to the deeper structures.

From this it appears that the tympanic membrane can best perform its functions when it is so circumstanced that the vibrations producing its own fundamental tone must quickly cease, and the waves striking it are most perfectly transmitted to the deeper structures. It is muffled, so that its own fundamental vibrations, as well as those of the sound-waves striking it, may cease as quickly as possible, and the membrane may be thus in a condition to receive a new impulse: that is to say, it is connected with a chain of solid auditory ossicles, to which it transfers the vibrations, and by this means comes to rest. It is in this manner set free to receive a new impulse, and so can continue to act without interruption.

The oblique direction of the tympanic membrane, as well as its concavity outwards, play an important part in this function. The concavity is according to *Helmholtz* of great importance, because such membranes when struck by the sound-waves convey, with proportionately little amplitude, much active force to the auditory ossicles, which in turn is by these communicated to the deeper structures. *A Fick*,[1] *Helmholtz*,[2] and others are of the opinion that it is not necessary that much active force be conveyed by the auditory ossicles to the terminations of the n. acusticus; but only that a modicum of the active force of all kinds of vibrations be transmitted. The locked-teeth arrangement described by *Helmholtz* as existing in the articulation between the malleus and incus, also prevents the auditory ossicles from being pressed too strongly inwards towards the oval fenestra.

The movements which the tympanic membrane and auditory ossicles make while transmitting the sound-waves are graphically represented by *Politzer*, *Lucæ*, and others.

Regarding the functions of the *m. tensor tympani* and *m. stapedius*, much difference of opinion exists. The view of *Joh. Müller* that they represent an accommodation apparatus for the ear is contradicted by others, who entirely deny to muscles inclosed in osseous canals the power of strong contraction. They recognise in the auditory ossicles and their muscles only an apparatus which serves as a damper to the tympanic membrane. As the researches of *Zuckerkandl*[3] taught, and which the author from his own observations is able to confirm, only a part of the muscular fibres is firmly fixed to the walls of the osseous canals, so that the remainder is free to contract. The effect of electrical stimulation also supports this view, as under it the muscle distinctly contracts. The author thinks that these muscles certainly perform the part of an accommodation apparatus; not however to the extent supposed by *Joh. Müller*, but with the limitation described by *Mach*.[4] According to this observer, the muscles, during attentive audition, are always in a

[1] "Lehrbuch der Anatomie und Physiologie der Sinnesorgane," 1864, S. 134.
[2] "Die Lehre von den Tonempfindungen." Wien, 1863.
[3] "Zur Morphologie des Musc. tens. tymp." Archiv für Ohrenheilkunde, xx. Bd.
[4] "Zur Theorie des Gehörorgans." Sitzungsbericht der k. k. Akademie der Wissenschaften in Wien, 1863.

condition of vicarious activity. By them we fix and follow the tones, so that the attention of the ear is connected with the tension of the auditory muscles. The tensor, during an accommodation of this kind, acts not only on the tympanic membrane, but also indirectly upon the other structures as far inwards as the labyrinth; and the author is inclined to recognise in this a support for the doctrine that the fibres of the muscles are unable all to contract equally easily. Those fibres which contract with the greatest difficulty will require a stronger nerve impulse than the others, and the degree of this effort may be of the greatest influence upon our perception. This view can also be made to harmonise with the highly interesting results which have already been obtained by *Hensen*[1] and *Bockendahl*,[2] and more recently by *J. Pollak*,[3] in their experimental researches concerning the function of the tensor tympani muscle. According to these observers, this muscle, in the living animal, not only responds to each tone-stimulation by a distinctly visible contraction, which is stronger for the higher tones than for the lower; but besides, as *Bockendahl* showed, in continued tone-stimulation a tetanus of the muscle occurs.

Through the researches of *Pollak* in *Stricker's* laboratory, it was proved that these contractions cease entirely after destruction of the cochlea in the living animal, so that the muscular contraction can be brought about reflexly after the auditory perception has taken place. It is easy to conceive that these facts can be turned to account in connection with the ingenious theory of *Stricker*, according to which we attain to the perception of the tones by this means: viz. that the acoustic impression immediately produces an innervation of the muscle, and that the remembrance of that which was heard is likewise followed by such a muscular innervation.

The transmission of the sound-waves through the bones of the skull takes place according to the same physical laws by which sound-waves are as a rule transmitted through solid bodies—*i.e.* by waves of condensation.

The waves which are transmitted to the labyrinth will put in movement the fluid of the labyrinth, and these movements will stimulate mechanically the terminations of the auditory nerve, and produce in the brain the sensation of sound. The auditory perception lasts just as long as the external stimulation—no perceptible after-sensation takes place; and in this respect the sense of hearing is essentially distinguished from the sense of sight. Concerning the further events which take place in the labyrinth, and especially concerning the functions of its different structures, we are still little informed. According to the view of *Helmholtz*, which was previously advanced by *Simon Ohm*, and which was experimentally demonstrated by *Helmholtz*, each periodical sound-movement in the labyrinth is broken up into simple pendulum-like oscillations, each of which is for itself perceived, but only together produce the sound-conception.

According to *Dennert*,[4] the faculty must also be attributed to the auditory organ of perceiving as tones movements which are not simply pendulum-like. This occurs in the perception of combination tones. *Helmholtz* was formerly of the opinion that the fibres of *Corti* play the chief part in the perception of tones. This theory he afterwards abandoned, for it has been proved that although

[1] "Beobachtungen über die Thätigkeit des Trommelfellspanners." Archiv für Physiologie, 1878.

[2] "Ueber die Bewegungen des M. tensor tymp., etc." Archiv für Ohrenheilkunde, xvi. Bd.

[3] "Ueber die Function des M. tensor. tymp." Jahrbücher der k. k. Gesellschaft der Aerzte in Wien, 1886.

[4] "Acustisch-physiologische Untersuchungen mit Demonstration." Vortrag, gehalten in der otiatrischen Section der Naturforscherversammlung in Berlin, 1886. Monatsschrift für Ohrenheilkunde, 1886, 10.

birds have a good musical ear, yet in them there is a complete absence of structures resembling *Corti's* fibres. *Helmholtz* now claims for the radially striated membrana basilaris the function which he formerly attributed to the fibres of *Corti*. In the radiate fibrous arrangement of this membrane, he recognises a system of cords of different tension and length, which would be able to perform the function previously ascribed to *Corti's* fibres.

Hensen[1] and *Hasse*[2] are of opinion that the division of the different parts of the m. basilaris for certain tones is connected with the breadth of the membrane, which increases as we proceed towards the apex of the cochlea, so that its lower part is intended for the higher, and its upper part for the lower, tones. *Hensen* found in crabs that only a certain number of the auditory cilia vibrated to certain tones, while others remained at rest. *Helmholtz* has given up his former opinion that the sound of regular periodic vibrations (tones) is always received by the cochlea; while the perception of short, temporary, irregular vibrations (noises) is brought about by the saccules of the vestibule and the ampullæ of the semicircular canals, since *Exner*[3] demonstrated that a tone-pitch is also perceived in noises. *Brücke*[4] is of the opinion that the cochlea may suffice for the perception of noises. He says that tones are produced if certain groups of nerve fibres are continuously stimulated, and noises if the same nerves are only stimulated for a very short time; or if the stimulation passes over irregularly and quickly from one group of nerves to another; or if so many nerve fibres are struck at the same time, or so quickly one after the other, or with such an alternation that it is not possible to hear, out of the whole impression, a tone of a definite pitch. *Hensen*[5] cannot agree with this theory. Experimental researches, no less than clinical observations, to which we shall refer later, point by no means to a strict anatomical localisation of the auditory perceptions.[6]

The literature concerning the physiological significance of the *semicircular canals* has increased to an unusual extent, but the question is not yet quite settled. *Fluorens*[7] has demonstrated in the case of pigeons that, if one cuts through their anterior (superior) or their posterior membranous semicircular canals, they move the head from before backwards, and at the same time are inclined to fall forwards if the anterior, and to tilt backwards if the posterior, canal is divided. If the external (horizontal) canal is cut, nystagmus occurs; the animal moves the head from side to side, and makes efforts to turn itself round its long axis. If several of the canals are divided at one time, there appear complicated disturbances of movement. These experiments, which were often repeated, show that in the semicircular canals we have the peripheral organs for the maintenance of equilibrium—*i.e.* the organs intended to bring about the knowledge concerning our position in space. But experiments on animals alone cannot answer this question in a satisfactory manner. From the delicate structure of the semicircular canals one can readily conclude with probability that these structures are concerned, not only in the function already mentioned, but that they play a part in the act of audition. We shall refer again to this question.[8]

[1] Zeitschrift fur wissenschaftliche Zoologie, 1863, xiii. Bd., S. 398.
[2] De cochlea avium. Kiel, 1866.
[3] Archiv für Physik, xiii. Bd., S. 228.
[4] Sitzungsbericht der k.k. Akademie der Wissenschaften, xciii. Wien, 1884.
[5] "Untersuchungen über Wahrnehmung der Geräusche." Archiv für Ohrenheilkunde, xxiii. Bd., S. 69.
[6] *Prof. Rutherford* has originated a new theory of hearing under the name of "the telephone theory." His arguments in support of it will be found in the Journal of Anatomy and Physiology, vol. xxi., p. 166.—Eds.
[7] Compt. Rend. 1828; Recherch. Expér. etc. 1842.
[8] For further particulars regarding the functions of the semicircular canals, see *McKendrick's* "Special Physiology," chap. viii., p. 694.—Eds.

The stimulation of the auditory nerve, from its position concealed deeply in the bone, can only take place by mechanical concussion, or by electrical stimulation. *Volta* heard a noise when he conducted an electric current through the ear. *Ritter* considers that he has produced even musical perceptions of tone by means of electricity; while *Ed. Weber* could obtain no such effect. It is indisputable that even a strong electric current may be applied in many persons with normal hearing, without the perception of sound being produced; while in others, the least electric irritation produces even troublesome noises in the ear. This will again be referred to more in detail.

The auditory nerve is of course most frequently stimulated by oscillations of sound which are produced in the outer world. These probably strike both auditory organs at the same time, or with only an extremely short interval between the two impulses. That they are perceived by us as one sensation, notwithstanding that both nervi acustici are stimulated, is a matter of cultivation, according to which we acquire in time the capacity to leave the perceptions aside and to retain firmly only the conception of their cause (*Ludwig*).

GENERAL PART.

CHAPTER I.

EXAMINATION OF PATIENTS.

General Symptoms—Subjective Symptoms.

JUST as derangements of individual organs may affect the health of the body as a whole by reason of the intimate connection of its different parts, so on the other hand, so-called general disorders and morbid states of vital structures, particularly of the nervous system, may evoke not only slight disturbances in the organs of special sense, but may also influence in a marked degree the course of affections primarily originating in these. The close relations existing between the various parts of the body necessitate therefore the investigation, not only of the state of the organs of hearing, but also of the general condition of the patient in its widest sense.

It is advisable to direct attention in the first place to the general organism, and afterwards to the ear, as in this way certain particulars may be brought out which otherwise might remain unnoticed. With reference to the general examination, it is to be observed that special attention should be paid to the condition of those parts which stand in close anatomical or physiological relationship to the ear. A neighbouring new formation, for instance, may induce important disturbances by pressure on vessels, or by modifying the relations of the different auditory cavities, without any associated morbid change in the auditory structures themselves. Again, various affections of the circulatory system, or of the central nervous system, may superinduce subjective symptoms in the ear without any structural disease being necessarily present.

The general examination being completed, the state of the auditory organs must be investigated on a definite plan. It is usually better to begin with the subjective symptoms; allowing the patient, or should this be impracticable, one of his friends, to relate the history of the case; taking care meanwhile to avoid putting leading questions. It is, as suggested, desirable to carry out the inquiry in a definite order. The following is that adopted by the author.

(*a*) Age, occupation, and mode of life of patient.

(*b*) Family history—especially as regards ear disease.

(*c*) Duration and previous course of the disease.

(*d*) Nature of previous treatment.

(*e*) Other diseases from which the patient has suffered, with their treatment.

(*f*) The effect of various circumstances upon the ear affection: *e.g.* weather changes, alterations in personal habits, etc.

(*g*) Subjective symptoms, not only aural, but general; and amongst the latter, the patient's psychological condition.

(*h*) Special examination of the hearing power.

With regard to the duration of the ear disease, the statements of the patient or his friends should be received with much reservation. Most aural affections begin without pain or conspicuous derangements of function; the failure often creeping on unperceived, and thus being easily overlooked at its commencement. Especially is this the case when one ear alone is affected, or the other but very slightly disordered in function. The comparatively healthy ear may tolerably well meet the hearing necessities of the patient, and only when an increased failure occurs does it become perceptible either to himself or to others. Or among the less intelligent and careful class of patients, their deficiency may be brought home to them only by disinclination for their society shown by their friends, or perhaps by the supervention of noises in the ear as well. In this way secondary changes, such as extensive opacities of the drum-membrane, contraction of the tubes, or atrophy of various structures which may have taken years to develope, are often found in patients who consider their malady to be one of days only.

With respect to the inquiry as to the occurrence of other diseases, past or present, special attention is necessary concerning such as may injuriously affect the ear, and particular care in assisting the recollection of the patient may be needed to elucidate this matter. Unimportant affections of the mucous membrane, common enough in the naso-pharyngeal region, frequently remain unnoticed by the patient. Such conditions are among the most common causes of ear disease. Years may have elapsed between the disappearance of such ailments and the establishment of any conspicuous auditory derangement; the patient only remembering what he had regarded as unimportant after it has been recalled to his recollection by direct inquiry.

Serious ailments even, particularly those of less evident connection with disease of the ear, are frequently ignored for the same reason; and it is therefore advisable to make definite inquiry regarding all such affections as are liable to be followed by ear trouble.

It is useful to discover any conditions which may possibly exist influencing for better or worse the special disorder under investigation; and in this connection passing reference may be made to the influence of

changes in the weather upon that commonest of ear affections, middle ear catarrh.

In reference to *subjective aural phenomena;* in the first place those of the nerves of common sensation, and afterwards those exhibited by the auditory nerve, will demand consideration. Regarding the former, it should be noted whether the patient has pain in the ear, and whether such pain is restricted to it, or is felt also in other parts of the head; or perhaps whether it may be quite limited to some part of the head. Other parts of the body, particularly the structures of the naso-pharyngeal region or the different parts of the throat, may also be or may have been the seat of pain.

If pain exists, its nature should be inquired into: whether it be constant or periodical only; and in the latter case perhaps appearing only at night-time; whether the pain is increased by pressure upon any structures, and if so, which; etc.

Attention must also be directed to the occurrence of abnormal sensations in connection with certain functions—*e.g.* swallowing, blowing the nose, or sneezing.

In regard to the elucidation of phenomena in connection with the central nervous system, various points may require investigation. Thus the existence of fever, and the nature of such fever, must be determined. Then as to giddiness; whether this, if present, is constant or only occasional; and whether apparently due to any definite cause; as well as the manner in which the attacks come on, and whether they be accompanied or not by vomiting.

Psychical disturbances may also manifest themselves; as in the form of defective comprehension, weakness of memory, absence of mind, depression reaching even to melancholy, and so on.

Respecting the *function of the auditory nerve,* derangements may exhibit themselves in two ways. First, in either absolute or partial failure to represent to the brain, as sound, an external auditory stimulus. When the loss of function is not complete, it may be manifested in either a quantitative or a qualitative direction. Secondly, auditory sensations may be present for which no corresponding external auditory stimulus exists. These *subjective auditory sensations* (*noises in the head*) may differ greatly in different ear affections.

While in regard to subjective auditory sensations, we are entirely dependent upon the statements of the patient; the examination of the hearing in response to external stimulation is, on the other hand, of a more objective character; although even here the results cannot be adopted with the certainty of scientific exactitude, especially when we are concerned with only one ear.

Respecting these *subjective sensations,* inquiry is to be made as to their nature, duration, and locality.

They are described by patients in various ways. Sometimes they are spoken of as simple tones, such as the striking of a clock, singing of a bird, whistling of a locomotive,—sometimes as like other common noises, as the bubbling of water, blowing of the wind, or perhaps as a hissing noise. Sometimes different sounds are heard by the same patient, either at the same or at different times. In some cases again, melodies and even harmonies are heard, and these may perhaps change. And in certain rare cases, in which no mental disturbance is present, even words or sentences are stated to have been heard; though in such patients mental derangement does come on later almost without exception.

With regard to the duration of these noises in the head, it should be noted whether they are *constantly* present, or *occasionally* only. Inquiry must also be made as to the duration of the intermissions, and whether the noise changes from time to time; whether it becomes more or less loud in different positions of the body or of the head, or by pressure on the vessels of the neck or on the mastoid process; whether or not it disturbs the patient's rest, and whether it has existed from the commencement of the affection, or only appeared during its course; whether too, it has since its onset increased or decreased in intensity; and whether perhaps improvement has followed on any particular treatment.

Attention must be directed to the part of the head in which the sound is said in some instances to be perceived, and also the direction from which in others it seems to have proceeded. In the majority of cases the noises seem to be in the ear itself. In some however, they are stated to be present in the whole of the head, or perhaps in particular regions, generally the back part. Other patients again, refer the sound to some place outside the body, and this locality itself may appear to change during the course of the disease. Sometimes the apparent place of origin of the noise moves from the cranium towards the ear, and even farther outwards; while at others the reverse is the case; the first mentioned being of more favourable prognosis than the latter.

Difficult as it may be with our present physiological knowledge to comprehend the differences of these various noises in the head; it is nevertheless, as experience shows, important to note them, if only from their bearing on the prognosis of the affection.

The investigation of these subjective auditory sensations should not be concluded without establishing the fact whether or not they cannot *also* be heard by the *observer*. Such *objectively-perceptible subjective sounds* (so called) have frequently been observed by the author after even years of previous treatment. When present, they may sometimes be perceived by the unaided ear, when brought close enough to that of the patient; while in others, the otoscope may be needed for their recognition. Inasmuch as noises of this nature may be *intermittent*, it is obvious that frequent

examination should be made during the course of the affection in order to determine their existence. Further details on this subject will be given later on.

Testing the Hearing Power.

The estimation of the hearing power admits of much greater precision than that of the subjective symptoms, as already noticed. But even here absolute exactitude cannot be arrived at, inasmuch as external auditory stimuli affect both ears, so that in testing the condition of one, being unable to entirely exclude the activity of the other, we are again dependent to a certain extent on the patient's account of his sensations.

The following experiment was made by *Dennert*,[1] in order to determine whether it be possible wholly to suspend the receptive function of one ear while estimating the hearing power of the other. In a girl seven years of age, who after scarlet fever had lost by necrosis the entire labyrinth on the left side, the right external auditory canal was filled up to the tympanic membrane with damp lint and cotton-wool. The auricle also was similarly filled, and over this some thick moistened pasteboard discs were fastened by a bandage, a wet cloth being finally bound over the ear. Tuning-forks for deep tones (to C^1) were not heard in the neighbourhood of the affected ear, but higher tones (C^2, C^3, C^4) were perceived, and equally loudly whether the ear was closed or not. Quickly whispered words, words easily understood, and ordinary conversation were for the most part also heard; but low whispering was not. From this experiment *Dennert* concluded that in testing the hearing power of a dull or deaf ear, the perceptive capacity of the other healthy ear could not be eliminated.

As a rule, it is well to test the hearing repeatedly and under similar conditions with the same test-apparatus, basing conclusions upon the accumulated results of the examinations. The methods which are in ordinary use comprise *the watch, the tuning-fork or other sounding instruments, and speech.*

1. *Testing with the Watch.*

Of all hitherto known methods this is the most constant; but as it only estimates the capacity for the perception of two weak, undefined, sounds (tick-tack), the examination is an imperfect one. Nevertheless it is first used, both from its convenience and from its constancy in respect of the intensity of the sounds produced. As a matter of course, the same watch must be used in the same case throughout; and it is advisable that it should emit as little accessory noise as possible besides the two sounds.

Before using a given watch, it is necessary to fix the normal hearing distance with it for the healthy ear in as many cases as possible. It is

[1] "Zur Gehörprüfung auf Grund einer Beobachtung von Nekrose des Vorhofes, der halbzirkelförmigen Gänge und der Schnecke." Archiv für Ohrenheilkunde xiii. Bd., Seite 19.

advantageous too, to have watches which emit sounds of different degrees of loudness, so that the louder one may be used for very deaf persons. Stop-watches are sometimes used; but they are expensive, easily damaged, and not really necessary.

The examination is to be carried out in the following way. The patient having closed his eyes, and also with his finger the ear not being tested, the watch is brought towards the ear from a distance at which it is not heard to a point at which the sounds are just perceived. This should be repeated to insure accuracy, and the patient's eyes should be kept closed throughout, otherwise the result cannot be depended upon. As a control test, the watch may be approximated to and removed from the ear from the point at which it was first heard, when it should of course be heard respectively more and less distinctly.

It is best to bring the watch, as described, from a distance, until a point is reached at which it is just heard, rather than remove it from the ear to that point. The auditory nerve, once stimulated by a given sound, is for a short time afterwards more sensitive than it otherwise would have been. On this account, the greatest hearing distance for a given watch when gradually withdrawn from the ear is greater than when it is gradually brought near from a distance at which it is not heard.

Whether the watch can be heard or not at any distance from the ear, it is always well to examine also with it the *sound-conducting power through the cranial bones*. The watch should be brought into contact with the head; and if heard, it should be noted whether this is only on firm pressure or on mere contact. The positions usually selected are the base of the zygoma and the mastoid process. If the results be negative, other points should be tried, as it sometimes happens that sound can be communicated from some other point, but not from one of those named.

The conducting power of the cranial bones diminishes with advancing age; and instances are not rare where at sixty and upwards they fail to conduct sound, even when it is heard in the ordinary way through the air. It is, however, not in accordance with the author's experience that such incapacity is at all common in persons under sixty whose hearing is otherwise good.

In denoting the hearing power, it is customary to use as a symbol a fraction, the numerator of which represents the hearing distance in the given case, and the denominator the normal hearing distance for the same watch.[1] Thus, if a watch can be heard at a distance of 100 *cm.* by a healthy ear, and is heard only at a distance of 5 *cm.* in the case under examination, the hearing distance is written $\frac{5}{100}$. If the watch is heard only on contact with the external ear, this may be denoted "*a*" (auricula); if on contact with the zygoma, "*z*"; and when pressed on the mastoid process, "*m.*" Other points on the head at which the watch is heard may be similarly described. If the watch is not heard at all this may be signified by "0."

[1] *Knapp*, "Eine systematische Methode zur Bestimmung und Aufzeichnung der Hörschärfe." Archiv für Augen- und Ohrenheilkunde, iii. Bd., i. Abth., S. 186 u. ff.—*J. S. Prout*, "Boston Med. and Surgical Journ. (29 Feb., 1872).

In testing the hearing by the watch, as well as in those methods described further on, the following points must also be considered :—

(α) The interval of time which elapses before the sound is perceived.

(β) The place at which the patient perceives the auditory sensation.

(γ) Whether or not sounds are appreciated, *as regards their character and duration*, in the same manner by the affected as by the healthy ear.

The auditory nerve sometimes exhibits a tardiness in its functional activity, whereby the sound is heard on the affected side only after the expiration of a certain interval of time. If this interval is considerable, then as a rule there exists an erroneous belief on the part of the patient as to his hearing capacity. Many, especially very deaf persons, are very imaginative. After listening for a time in the expectation of hearing a sound, they come at last to persuade themselves that they really do perceive it. The error becomes at once evident however, if the watch be moved nearer to and farther from the ear while the eyes are shut ; for the answers received will not correspond with what they ought to do. With children especially, extra care is needed in estimating the value of their statements, as they usually answer readily in the affirmative, whether they hear the sound or not.

It should not be forgotten to determine whether sounds are really perceived by the ear under examination or by the other ear, and also whether the direction of the sound is correctly appreciated or not.

It ought likewise to be remembered that the sounds of the watch are heard better with the glass turned towards than away from the ear. Lastly, the hearing power varies somewhat with variations in external conditions, such as in larger or smaller rooms. These circumstances must therefore be taken into consideration in estimating the result.

2. *Investigation of the Capacity for Perception of Tone.*

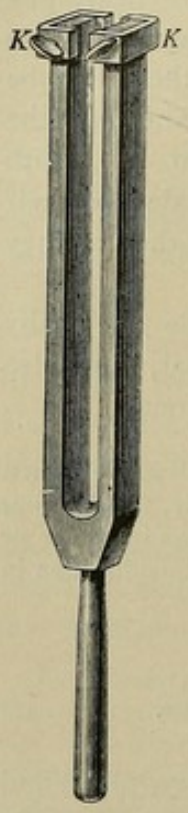
For this purpose sounding instruments of varying intensity, pitch, and character are used, and the examination is made in the same way as in testing with the watch. Ordinarily, differently toned tuning-forks are employed, the sound being conducted either through the air or through the cranial bones ; the tuning-fork in the latter case being placed on the crown of the head or some other point. Tones of varying pitch and intensity are produced by the use of tuning-forks of different sizes. According to *Politzer*,[1] those with rounded branches give out fewer overtones or harmonics than those with square ends. The same tuning-fork may be made to produce different tones by providing it with movable metal clamps (*König*)

[1] "Neue Untersuchungen über die Anwendung von Stimmgabeln zu diagnostischen Zwecken bei Krankheiten des Gehörorganes." Wiener medicinische Wochenschrift, 1868.

(Fig. 55, *K*). The higher up the clamp is fixed on the branch, the deeper is the tone. According to *Kiesselbach*, the weight of the clamp deepens the tone, the highest note being emitted by the simple tuning-fork without the clamps. *Bing* has therefore recommended the use of short pieces of india-rubber tubing instead of the clamps. They may be drawn down the branches of the tuning-fork, and if not at hand may be replaced by pieces of ordinary bandage.

Magnus[1] uses a tuning-fork marked with lines corresponding to the tones produced by adjusting movable metal rings at those points. According to him the effect of tones can be less easily limited to one ear alone than that of noises.

Fig. 55.
Tuning-fork with movable clamps.



Oscar Wolf makes use of rodlike tuning-forks, some being tuned to C° and others to A'. The C° fork can be heard only at a distance of a few inches from the ear, and is therefore very suitable for testing one ear alone: it must not, however, be struck too strongly, as the harmonics may then be produced, and perceived by the other ear.

For aërial conduction *Lucæ* recommends forks emitting tones of very different pitch—*e.g.* C and C''. In testing bone conduction, on the other hand, tuning-forks of lower pitch, with few harmonics, are best (C and C'). The harmonics may be avoided by grasping the roots of the prongs firmly, and after striking letting them go. In order to make the tones also of high-pitched tuning-forks distinctly perceptible in bone conduction, *Lucæ* recommends the use of a short steel cylinder. This is placed on the mastoid process or in the auditory canal, and the stem of a strongly vibrating tuning-fork is to be then brought into gentle contact with the cylinder.

Helmholtz[2] has constructed an *electro-magnetic tuning-fork*, with the view of producing an equable and constant tone. It is fastened upon a small board covered with indiarubber, to prevent conduction of vibration; and the prongs of the fork placed between the poles of an electro-magnet. The rapidity of the constantly changing currents in the coils of the electro-magnet is arranged so as to be in correspondence with the rapidity of vibration of the branches of the tuning-fork. *Lucæ*[3] has modified the apparatus by the addition of screws, by which the branches of the electro-magnet may be moved nearer to or farther from those of the tuning-fork.

For the examination of patients so deaf that they cannot hear the sound produced by simply striking the fork, as well as to prolong the perception of the tone, the author uses an apparatus fitted with *Helmholtz's* resonator (Fig. 57). The resonator consists of a hollow ball of glass or metal with two openings, one of which is prolonged like a funnel, the other cut off sharply.[4] It is made so as

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[1] "Ein Fall von partieller Lähmung des Corti'schen Organes." Archiv für Ohrenheilkunde, ii. Bd., 4 Heft, S. 271.—Bericht über den internationalen medicinischen Congress in Amsterdam, 1879.

[2] *Helmholtz*, "Die Lehre von den Tonempfindungen." Braunschweig, 1863, S. 184, u. ff.

[3] Centralblatt für die medicinische Wissenschaft, 1863, S. 625.

[4] *Helmholtz*, "Die Lehre von den Tonempfindungen," S. 73, u. ff.

to correspond to the tone of the tuning-fork, and fastened upon a board (*B*), so that the sharply cut-off opening is opposite the branches of the tuning-fork. The other opening carries an indiarubber tube with its end, or nozzle, adapted to fit the ear. The metal rod which supports the resonator is provided with a hinge (*C*), by means of which the resonator may be turned away from the tuning-fork, and allow the latter to be used without it. The under surface of the board is covered with indiarubber to prevent the conveyance of vibrations. Both tuning-fork and resonator may be changed at will. The apparatus is very useful for physiological experiments and for demonstrations. *König's*[1] so-called sounding-rods are but little used. They are steel cylinders 20 *mm.* in diameter, and of different lengths; and when struck with a hammer, nodes are formed at one-fifth of the length from each end, the rods being suspended at these points. Ten rods are used, the lowest making 4096, and the highest 32,768 vibrations per minute.

Fig. 56.



Fig. 56 represents a small tuning-fork used by the author for the production of feeble tones. It is particularly suitable for examination of one ear alone, as it can be more easily put into vibration without the knowledge of the patient. The tone is brought out by drawing the ends of the branches suddenly together with the fingers.

In investigating sound-conduction through the bones with the tuning-fork, it should be noted that the patient may fancy he hears the sound, when in reality he has only perceived the mechanical concussion of the vibrations: it is therefore always well to allow him to describe his sensations. If he has really heard the tone, this is correctly described; perhaps even sung afterwards. He should also be asked to indicate the locality of his sensations; and it should not be forgotten that this depends partly upon the pitch of the tuning-fork, as well as that a perfectly constant perception for the same tone does not invariably exist, even with quite healthy organs. The examination should therefore be repeated at different times, at different parts of the cranium, and with tuning-forks of different pitch.[2]

If a vibrating tuning-fork is held in such a way that an edge of one of its branches is just opposite the external auditory meatus, the sound becomes for the moment extinguished. If the tuning-fork is turned round on its longitudinal axis opposite the auditory canal, the same thing happens four times in succession;[3] and *Urbantschitsch*[4] found that it also occurred when it is brought opposite the meatus from before backwards, or from above downwards. These phenomena are due to interference of sound-waves. According to the

[1] *Müller-Pouillet's* "Lehrbuch der Physik," 1877, i. Bd., 2 Abth. S. 551.

[2] Compare *Urbantschitsch*, "Ueber die von der Höhe des Stimmgabeltones und von der Applicationsstelle abhängige Schallleitung durch die Kopfknochen." Archiv für Ohrenheilkunde, xii. Bd., S. 207, u. ff.

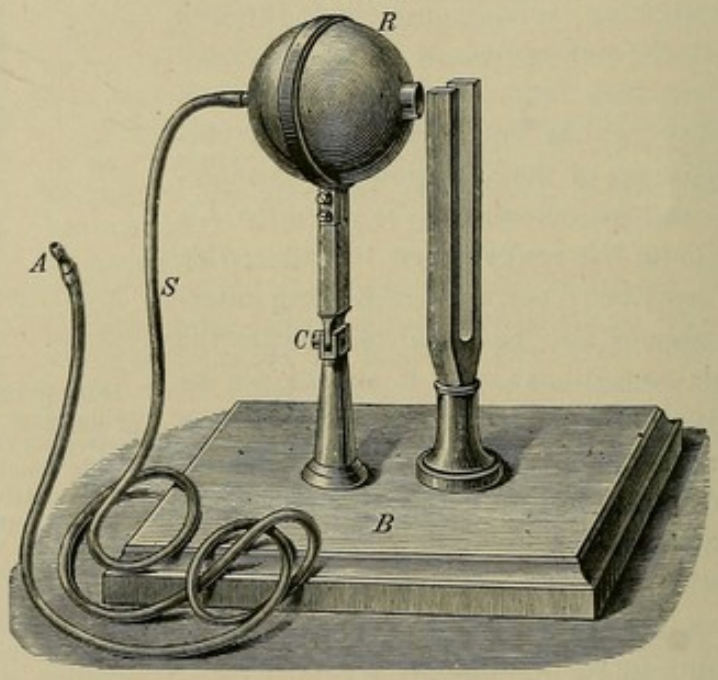
[3] Gebrüder *Weber*, "Die Wellenlehre." Leipzig, 1825, S. 506.

[4] Centralblatt für die medicinische Wissenschaft, 1872, Nr. 8.

author's observations,[1] a difference in the perception of the sound of the tuning-fork occurs when it is held before the external auditory canal, according as the mouth is open or closed: the more it is closed, the louder up to a certain point does the sound appear. If on the other hand it is placed on a tooth of the upper or lower jaw, the sound appears louder the more the mouth is opened, and *vice versâ*. These facts should be borne in mind in testing the hearing.

Amongst patients who are musical, inquiry should be made whether or not they distinguish accurately the pitch of the sound of the tuning-fork. This however can seldom be made out, as the majority of people, even with good hearing, are unable to do it. But inasmuch as deviations of this kind are comparatively common among musicians who have ear affections, the same imperfection is probably not rare among others.

Fig. 57.



In order to compare the hearing power of one ear with that of the other, *Urbantschitsch*[2] recommends the ends of two indiarubber tubes to be placed in the ears, and the two free ends to be then brought near each other. A feebly sounding tuning-fork is now brought in quick succession, first near the end of one tube, and then near that of the other. In this way both quantitative and qualitative differences in perception between the two ears are readily recognised.

Burckhardt-Merian[3] refers to "Galton's pipes" as a valuable aid in the discovery of defective perceptions of tone.

With the view of measuring the acuteness of the hearing, *Von Conta*[4] recom-

[1] *Gruber*, "Ueber das Offenhalten des Mundes bei Schwerhörigen." Monatsschrift für Ohrenheilkunde, etc., xv. Jahrg., Nr. 5.

[2] Lehrbuch der Ohrenheilkunde, ii. Aufl., S. 31.

[3] "Vergleichende Ergebnisse verschiedenartiger Hörprüfungen," Vortrag, gehalten am III., internationalen otologischen Congresse.

[4] "Ein neuer Hörmesser." Archiv für Ohrenheilkunde, i. Bd., S. 107, u. ff.

mends a tube to be used, one end of which is placed in the auditory canal of the person examined, and the other end just in front of a vibrating tuning-fork. The hearing capacity is judged by the length of time during which the sound continues to be heard.

Urbantschitsch uses for this mode of examination a T-shaped tube, one horizontal branch being connected with the ear of the observer, and the other with that of the patient. The tuning-fork is held before the end of the vertical part, and the time in seconds noted during which the normal ear of the observer perceives the tone after it has ceased to be heard by the patient.

The "sonometer" (audiometer) of *Hughes* and *Boudet* serves similarly for testing the acuteness of hearing. *Hughes'* audiometer[1] consists of two *Leclanché* elements, connected by two fixed resistance coils with a microphone rod. Besides this there is an induction coil, the ends of which are connected with a telephone. The induction coil is movable on a graduated rod, and situated between the two fixed coils. If the coil is moved along its rod a sound is produced, the intensity of which increases with the distance through which it is moved, and at its loudest may be heard by any one not absolutely deaf.

Hartmann[2] makes use of a telephone arrangement, by which as weak a sound as may be desired is produced. The receiving telephone is connected with the primary coil, and the delivery telephone with the secondary coil of a *Du Bois-Raymond's* sliding induction apparatus. The feebler one wishes the sound heard in the receiving telephone, the farther must the sliding arrangement be pushed out from the primary coil. *James Blyth*[3] also recommends the use of the telephone in the estimation of the hearing power. He introduces in the course of the conducting apparatus measured resistances of varying degrees, the hearing capacity being in relation to the degree of resistance in the circuit. *Koerting*[4] likewise employs a telephone, the measured resistances of which are obtained by rheochords. *Preyer*[5] uses for this purpose a rheostat through which a constant current is passed.

3. *Estimation of the Hearing Capacity for Speech.*

Oscar Wolf[6] considers this the most perfect method of testing the hearing power, inasmuch as it embodies the most delicate shades in the pitch, intensity, and character of sound. *Hartmann*[7] thinks, on the contrary, that the test is too complicated to insure accuracy. In any case it is indispensable, from the fact that nearly every patient seeks relief from disability in respect of it, and therefore for social intercourse. It is desirable, in estimating the degree of perception for speech, to test first of all both ears simultaneously, even though only one be affected; proceeding afterwards to the examination of each in turn. A separate examination of the hearing power should be made for each ear, even if previous testing by the watch and the tuning-fork has indicated an equally diminished hearing

[1] Wiener medicinische Presse, 1873.

[2] "Eine neue Methode der Hörprüfung mit Hilfe elektrischer Ströme." Archiv für Ohrenheilkunde, xiii. Bd., S. 298.—Vergl. auch *A. Wodtke*, "Ueber Hörprüfung, mit besonderer Berücksichtigung der Methode mit Hilfe elektrischer Ströme." Inaug. Dissert. 1878.

[3] Brit. Med. Journ., 1878.

[4] Deutsche militär-ärztliche Zeitschrift, viii. Bd., S. 337.

[5] Sitzungsbericht der Jena'schen Gesellschaft für Medicin, 1879, 21 Februar.

[6] "Neue Untersuchungen über Hörprüfung und Hörstörungen." Archiv für Augen- und Ohrenheilkunde, iii. Bd., 2 Abth., S. 35, und iv. Bd., 1 Abth., S. 125 u. ff.

[7] Archiv für Augen- und Ohrenheilkunde, vi. Bd., S. 467.

capacity on both sides; since experience shows that the perception for speech is not always deficient in the same measure as that for simple noises and tones. Cases indeed occur in which conversation is best heard on that side on which the watch and tuning-fork are not perceived so well as on the other, and *vice versâ*. The repetition of the test-words gives the best control for the perception of them (*Dennert*).[1]

The method of examination is as follows: In the first place the patient should never see the observer's face. Many patients, especially such as have been deaf a long time, are able to guess the words spoken merely by the movements of the lips, though they may imagine that they really hear them. The patient should hold his head straight and keep his mouth closed, as when the mouth is open the auditory meatus becomes enlarged, admitting thus a greater number of sound-waves, and so invalidating to that extent a comparison when the mouth is closed. The observer then places himself at a certain distance, first behind the patient, afterwards at each side in turn, and requests him to repeat the words spoken.

It is injudicious to commence the examination with questions, because there are some patients who are able to appreciate the cadence of the voice; and hearing some of the words, guess the rest, and reply correctly; especially if they have been previously examined. One therefore should begin with single words; and only after having proved he cannot hear them, go on to enunciate whole sentences and address questions to him, in order to ascertain whether he can still hear speech at all.

The words first chosen as a test should be such as are found from experience to be heard with more difficulty—as those with soft vowels and the less emphasized consonants; taking note at the same time whether the patient can distinguish such sounds as are usually found more difficult in this respect—*e.g.* monosyllabic words beginning with *h*, *b*, *t*, *f*, before the short *i* (*tip*, *fish*).

If such words cannot be heard we may proceed to others; examining both ears in this way simultaneously, as well as each in turn; the ear which is not tested being closed by the patient's finger or in some other way.

The range of sounds in speech is, according to *Wolf*, defined within certain limits; reaching from *R* (lingual) with the deepest tone of sixteen vibrations per second, to *S* with 4032 per second. Musically expressed, the former begins with the subcontra *C.*, i.e. *CCC*, and the latter approaches *c''''''*; embracing thus eight octaves. The tones of vowels and consonants within these limits vary extremely in regard to intensity and quality; from *A* (*ah*) with the loudest and richest, to *H* the weakest and poorest sound. Consonants are usually perceived by the ear with more difficulty than vowels, because the waves of sound associated with the latter are regular and of greater amplitude than those connected with the former; thus approaching

[1] "Zur Gehörprüfung auf Grund einer Beobachtung von Nekrose der Schnecke." Archiv für Ohrenheilkunde, xii. Bd., S. 19.

more nearly in character to pure tones, which as is well known, are more easily heard than other sounds.

Wolf and *Appunn* stood on a calm afternoon in an avenue; one pronounced the single letters as loudly as possible, and the other noted the greatest distance at which each letter could be distinguished as such. The results are contained in the following table.

Letters.	Pitch of Fundamental Tone.	Indications of Tone-intensities. The numbers represent the number of paces (about 28 inches) at which the corresponding letters are heard.
A	*b''*	360
O	*b'*	350
Ei and *Ai*	—	340
E	*b'''*	330
I	*d''''*	300
Eu	—	290
Au	—	285
U	*f*	280
Sch	$f''''' + d'''' + a'''$	200
S	$c'''' - c'''''$	175
G soft and *Ch* soft	*d''''*	130
Ch hard and *R* open	—	90
F (*F* and *V*)	*a'' – a'''*	67
K (*K* and hard *G*)	*d'' – d'''*	63
T (*T* and *D*)	$f''' - f'''''$	63
R lingual (without vocal sound)	$CCC + CC$ $C + c$	41
B (*B* and *P*)	*c'*	18
H (as intensified aspirate)	—	12

Later investigations made by *Wolf* gave similar results. *Hartmann's*[1] examinations confirm *Wolf's* statements.

Note by Editors. The letters and combinations here mentioned have in general a different sound to that of such as correspond to them in English. They may be approximately compared as follows:—

German.	English.	German.	English.
		Eu	*oi* in oil
A	*a* in father	*Au*	*ou* in loud
O	*o* in stone	*U*	*u* in rule
Ei	*i* in mind	*Sch*	*sh* in ship
Ai	*i* in fire	*G* (hard)	*g* in great
E	*e* in end	*V*	*f* in father
I	*i* in milk		

Lucæ[2] has constructed an apparatus which he calls a maximal phonometer. It is intended for observing accurately the intensity of the speaking voice—*i.e.* the intensity of sound associated with each expiration used in uttering any word. One

[1] "Ueber Hörprüfung und über *Politzer's* einheitlichen Hörmesser." Archiv für Augen- und Ohrenheilkunde, vi. Bd., S. 468, u. ff.

[2] "Maximal Phonometer." Archiv für Ohrenheilkunde, vi. Bd., S. 276.

end of a pasteboard tube 190 *mm.* long and 48 *mm.* in diameter is closed by an indiarubber membrane 0·5 *mm.* in thickness. The membrane is not stretched tensely, so as to permit the slightest movement of air in the tube to set it in vibration. A delicate lever which can move round an axis in its course, is affixed to the tube, in such a way that one end touches the centre of the membrane, while the other indicates any movement of the lever on a graduated scale. If a word be spoken into the tube, the corresponding sound-vibrations set the membrane in motion, which is communicated by the lever, and indicated by its farther end on the scale. The hearing acuteness may be estimated by a comparison of the distance at which a sound or word giving a certain deviation on the scale is heard, with the distance at which the same word of the same loudness is heard by the normal ear.

In testing the hearing power for speech, *Clarence Blake*[1] draws attention to the "logographic value" of the various consonants. This intensity-value of each consonant may vary when uttered by different persons, and even in the same person at different times; but the relative intensity-value of the various consonants to one another is tolerably constant. If 100 denote the value of that consonant with the highest logographic value, and other numbers the corresponding values of other consonants, there may be obtained, on *Blake's* view, a table which may serve for material for a list of test-words, in which we depend on the intensity rather than the pitch of the corresponding sounds. Accepting *T* as of the greatest logographic value, the relation would appear as follows:—*T* = 100, *B* = 53, *P* = 58, *D* = 45, *G* = 56, *S* = 40, *Z* = 63, *C* = 62, *F* = 35, *K* = 31, *L* = 21, *N* = 11, and *M* = 9.

Monosyllables are preferable for the purpose of testing. It must however be recollected that the logographic values of those consonants produced in the deeper part of the oral cavity in connection with the deeper vowels, as well as of those formed farther forward in connection with the higher vowels, are greater than those of other combinations. The logographic value of *T* is for instance somewhat greater in "tip" than in "top," and that of *G* greater in "got" than in "get."

In the examination of the hearing power we usually employ whispering; the speech of ordinary conversation; and loud speech. In whispered speech the vowel sounds are weakened; while those of consonants are, on the contrary, little changed in intensity. There is accordingly less difference in the intensity of the various sounds amongst themselves in whispering than in ordinary speech; and the former is therefore eminently suitable for testing the hearing.

It is by no means easy to regulate satisfactorily for the estimation of the hearing power so variable a test as speech. At first it is satisfactory only if employed with considerable care; later after long practice, a certain aptitude in examination may be acquired, whereby the importance of variations of the voice in intensity and pitch at different times is diminished. It is advisable to construct a scale of spoken words of increasing difficulty of perception by the ear, and to use this in the examination. It must not however be forgotten that such a scale is not always applicable to every patient. Sometimes cases are met with in which a certain word is readily understood which is perceived with great difficulty by other patients; although the former may prove with other word-tests much more hard of hearing than the latter. It is well therefore in each case to note such words as are more and less easily perceived, and examine with reference to these in the course of treatment.

[1] "Auswahl von Worten zur Prüfung der Hörschärfe in Bezug auf ihren logographischen Werth." Zeitschrift für Ohrenheilkunde, xi. Bd., 1. Heft.

Indispensably necessary as is the estimation of the capacity of hearing for speech, errors may easily creep in in cases in which one ear is sound; therefore much caution must be exercised. In general it must be admitted that the perception of spoken words in all their phases demands a perfect functional capacity of the auditory organs; and that more simple sounds, and especially pure tones, are often still heard quite well by a patient when his capacity for hearing speech is considerably enfeebled. Too much confidence must not be placed in the statements of patients in this matter, for the reasons already alluded to; and particular care is indicated in regard to little children, whose parents and others are easily deceived in respect of their hearing power. Deaf children will repeat easy words by looking at the speaker's lips without having really heard them. If it should appear on examination that the patient does not understand words at all, he may possibly be able to perceive the sounds without understanding them; and if this should be the case, it should be noted which sounds these may be. If he hear nothing, even though the words are shouted into his ear, an ear-trumpet may be used. It may happen that he hears better, or in some cases, even worse with the ear-trumpet; and this is a point which, as we shall see later, is of diagnostic importance.

Up to the present time no better instruments for estimating the hearing capacity have been invented than those enumerated. The more recently constructed instruments do not meet the demands of this problem much better than the older ones of *Wolcke* and *Itard*. *Wolcke*[1] used as an acoumeter a metal hammer, which struck on a metal piece at a graduated angle. *Itard*[2] allowed a ball to strike against a freely suspended metal ring. *Kessel*[3] employs a "tongue" arrangement, comprising six octaves. The so-called "*Politzer's*[4] Universal Acoumeter" consists of a percussor, which falls from a certain height upon a steel cylinder. *Beerwald*[5] recommends a scale of steel bells (*C* to *C'*), struck by a clapper with variable force.

On some Modern Methods of testing the Hearing Power.

1. *Weber's Method.—E. H. Weber*[6] demonstrated that a vibrating tuning-fork placed against the teeth, or on a point of the cranium, is heard better in a person with normal ears when the external auditory canals are closed than when they are open. If only one ear is closed, the sound appears to move at once towards it. Upon this is based

[1] *Kramer's* Ohrenkrankheiten, 1849, S. 84.
[2] "Traité des mal. de l'or." 1821, T. 2, p. 46.
[3] Sitzungsprotokoll der Section für Ohrenheilkunde auf der Naturforscher-Versammlung in Graz, 1875. Archiv für Ohrenheilkunde, x. Bd., S. 273.
[4] Archiv für Ohrenheilkunde, xiii. Bd., S. 298.
[5] "Ueber einen neuen Hörmesser." Archiv für Ohrenheilkunde, xxiii. Bd., 23 Heft.
[6] "De Pulsu, Auditu et Tactu," Lips., 1834.

Weber's method, which consists in placing a vibrating tuning-fork upon the skull, and observing whether the sound appears more or less loud by the ear under examination when it is stopped by the finger, or in some similar way.

Weber has endeavoured to explain this phenomenon by resonance: "Quod illam explicationem attinet soni vis v. c. per resonantiam forsitan ab aëre in tympano et in meatu auditorio contento profectam, augeri fortasse potest, si auris clausa est." *Rinne* and *Toynbee* are among modern authors accepting the same view. *Mach* again, holds the increased intensity of tone to be due to obstruction of the sound outlet. According to him, some of the sound-waves transmitted from the cranial bones to the labyrinth leave the skull again, under normal conditions, by way of the external auditory canal, and if this emergence be impeded a stronger auditory impulse results. *Politzer* considers that the explanation of the fact demands the admission of both causes—resonance and impeded exit of sound-waves. *Lucæ* on the other hand, completely rejects the latter theory, and explains the matter by the labyrinthine variations which are associated with the confinement of the sound-waves. According to the author's experience, each of the above-mentioned factors may occasion the phenomenon in question; sometimes one, sometimes another, coming into play in a higher degree, in accordance with individual peculiarities. If however the normal ear be closed to the same extent by bodies of different sound-conducting power, no perceptible variation in intensity of tone is to be observed in the different cases, which should apparently occur if impeded exit of sound-waves were alone the cause of the increased sound.

2. *Rinne's Method.—Rinne*[1] observed that when a vibrating tuning-fork held against the incisor teeth has ceased to be heard, the sound at once reappears if it be held in the air close to the ear. Bone-conduction is thus inferior to aërial. Upon this fact the so-called *Rinne's method* is founded, which consists in estimating how long the tuning-fork is heard when brought near the auditory meatus after it has ceased to be perceived when placed on the cranium. If it is heard in this way, the fact is denoted "*Rinne's method positive*" (+ *R*); if it is no longer heard, "*Rinne's method negative*" (— *R*).

Hessler[2] endeavoured to determine some constant relations between the durations during which various tuning-forks may be heard by aërial conduction and the durations during which they are perceived when placed on the cranial bones at various points. He conceived that if such formulæ were constructed for the normal ear, they might be utilised for diagnostic purposes in cases of deafness. It appears however, even in persons with perfectly normal hearing, that the differences in question are very diverse; so that it would seem difficult to arrive at the relations desired.

3. *Gelle's*[3] *Method.*—The aim of this process is the perception of the

[1] "Beiträge zur Physiologie des menschlichen Ohres." Prager Vierteljahrschrift, 1855. i. Bd., S. 71; ii. Bd., S. 45 und 155.

[2] "Beitrag zur Physiologie des Ohres." Zeitschrift für Ohrenheilkunde, xviii. Bd., iv. Heft.

[3] "Précis des maladies de l'oreille." Paris, 1885, S. 339-40.

tone of a vibrating tuning-fork placed upon the head, while at the same time the air is being condensed in the external auditory canal. The condensation of the air in the auditory canal is effected by an air-ball connected with a tube, the end of which is to be fitted into the patient's ear. The tube is provided with a manometer to indicate the degree of condensation. For simultaneous auscultation a three-branched otoscope is employed, the arm intended for the auscultator being shut off from the main tube by a thin membrane, in order that the inflated air may not strike the ear of the observer.

4. *The Author's Method.*[1]—If the end of the finger be inserted in the ear after the sound of a vibrating tuning-fork held before the ear has become completely extinct, and the tuning-fork be then firmly placed upon the finger, a weakened sound becomes again audible, and remains so for some time. The explanation is possibly that the increased tone may be due to the increased atmospheric pressure in the closed canal; perhaps also to the altered relations of tension and pressure in the middle and internal ear; and partly it may be to the conduction of the sound-waves to the bones through the finger. The practical value of all the above expedients for testing the hearing will be referred to in the special part of this work.

Remarks on some of the rarer Anomalies of Hearing.

We may in this place consider some complex phenomena and rare subjective symptoms, which may be associated with the most various morbid processes.

(*a*) *Exaggerated hearing* (*Hyperacusis : Hyperæsthesia acustica*) consists in individual tones or noises, and in general all sounds, being perceived much louder than usual. The hearing may be associated with a most unpleasant, even painful sensation, the latter being more frequently observed in connection with high than with deep tones. The cause of this phenomenon would appear to lie in some condition of irritability of the auditory nerve. To seek the underlying state occasioning the hyperæsthesia outside the auditory nerve or its place of origin seems to the author inadmissible, inasmuch as all such conditions as are cited by way of explanation involve simply by themselves merely a weakening of the hearing capacity, and therefore could not bring about unaided a state of hyperacusis. The condition is probably analogous to that of a sensory nerve in a state of irritability, in which a slight stimulation, such as a healthy nerve would not resent, may occasion violent pain.

(*b*) *Double hearing* (*Paracusis duplicata : Diplacusis*).—This phenomenon

[1] "Zur Hörprüfung." Monatsschrift für Ohrenheilkunde, xix. Jahrg., S. 33.

manifests itself by the occurrence of two distinct auditory sensations, although only one auditory stimulus is given. It is rare for a patient to have double hearing both for speech and tones, though such cases have been observed. Most frequently it occurs in connection with tones, and is confined usually to particular instances of these. The symptom may present itself in very various ways. If it be associated also with speech, the patient generally describes it by saying that besides a distinctly audible word, he also hears another more or less distinctly, and as though it were uttered by a second person. Sometimes only one syllable or sound in the second word is heard, the rest being so confused as to occasion simply an unpleasant auditory sensation, unrecognisable as to its sense. If the peculiarity refers to tones, then in addition to that correctly perceived, another of different quality or pitch is also heard, into which the first becomes merged. Sometimes however the second tone appears like an echo, separated by an interval from the first. The abnormality may occur with all tones, or with one only, the rest being heard in the ordinary way. It may happen too, that the doubling may only appear periodically in the course of the ear-affection, and that the tones in question may be different at different times. The quality and pitch of the second tone (pseudo-tone) may also vary.

Most authors refer the cause of diplacusis to changes in the membrana basilaris of the cochlea. *Knapp*,[1] who examined a case of this abnormality, thinks that possibly the harmonious action of the two cochleæ is deranged; the lamina spiralis of one being attuned for a different tone-scale than that of the other. He does not however, exclude a possible origin in the auditory centres. *Von Wittich* considers "that if the organ of Corti really brings about the perception of a certain tone of a fixed number of vibrations and duration by means of its proper peculiarities of construction, it is conceivable that exudation into the tympanic cavity, which would thereby alter the pressure in the labyrinthine fluid, might through this change of pressure affect the functional integrity of the endings of the nerve-fibres; so that, *e.g.*, fibres attuned for the tone *B* may come into functional activity along with others corresponding to the tone *A*, the *A* fibres being also stimulated by the tone *B*." If *Helmholtz's* theory regarding the physiological significance of the cochlea could be accepted as perfectly correct, we should be compelled to refer the underlying cause of the phenomenon in question entirely to cochlear conditions. There are however many objections to *Helmholtz's* doctrine, so that the above explanation of diplacusis cannot be received as final. Since too, cases of double-hearing have been observed in which the hearing became at once normal after a single application of the air-douche, the influence of the sound-conducting structures can scarcely be ignored. It must also be remarked that the symptom is not always associated with tones alone, but with noises and words also, in which the cause could certainly not be sought exclusively in an affection of the membrana basilaris. Probably in this class of cases, derangements of various kinds may give rise to the symptom. Many instances of diplacusis have been recorded. *Bressler*[2]

[1] "Archiv für Augen- und Ohrenheilkunde," i. Bd., 2. Heft., S. 93.
[2] "Die Krankheiten des Kopfes und der Sinnesorgane." Berlin, 1840, ii. Bd., S. 375.

quotes several relating to this condition, and others have been observed by *Sauvages*, *Itard*, and *Von Gumpert*. In *Sauvages'* case the symptom appeared in the course of a catarrh, and disappeared again with this. *Itard* treated a lady who suffered from intermittent deafness; as often as hearing returned she heard sounds double. *Von Gumpert* observed the phenomenon in himself after an inflammation of the ear. The interval varied between a third, a fourth, and an octave. The deeper tone appeared to be near; the higher at a distance of from two to three yards. Diplacusis of words was also observed. The condition lasted eight days.

Von Wittich[1] relates that four weeks after a severe purulent inflammation of the middle ear, he observed that "the tone of a tuning-fork was heard exactly half a note higher in the affected than in the healthy ear, and the same difference was observed with the middle notes of the scale (once accented octave) when struck on the piano or whistled. The same occurred when the patient's external auditory canal was filled with wadding or water, or if the tympanic membrane was made otherwise tense by inflating the tympanum with air. A tuning-fork placed on the teeth was heard first in its natural pitch, and then in the next half-tone gradually dying away. If placed on the head, the tone was half a note higher than when close to the affected ear. Two tuning-forks, of which the pitch of one was half a note higher than that of the other, appeared to have the same tone, when the higher pitched was struck before the healthy and the lower before the diseased ear. *Moos* recounts similar examples in his "Klinik der Ohrenkrankheiten." An asthmatic patient who inhaled chloroform during an attack became immediately afterwards hard of hearing, with noises in the head, and all the notes of the scale from *A* appeared doubled. In another case[2] he noted the appearance of double-hearing in the course of treatment by iodide of potassium. The patient, a man of forty, who had suffered from asthma for a long period, and took for this more than ninety grains daily, during six weeks, was attacked with severe catarrh, accompanied by loss of appetite and troublesome itching in the arms and legs. Next day numbness of the head, and double-hearing for the notes of the piano appeared, with a difference of half a tone in the double sounds. After the iodide had been suspended for two days, the diplacus ceased, and did not return. *Moos* thinks petechiæ in the cochlea a probable cause of the symptom in this case.

Burnett[3] treated a music teacher aged thirty-nine, who suffered from deafness, noises in the head, giddiness, and headache. After the giddiness had improved, the patient heard an *A* tuning-fork held before the ear, a whole tone higher—*i.e.* as *B* natural. On the lower part of the frontal bone, between the orbital ridges, the sound was heard correctly as *A*, but on the mastoid process as *B* natural. If the patient pressed alternately the right and left ear upon a table while the vibrating tuning-fork was set on it, no difference in tone was perceptible. He heard the contra *A* in the right ear half a note higher; the difference became less with each higher octave, and disappeared altogether in the fifth higher. No difference was noticed with the tones of a violin or with wind instruments. The watch was heard at a distance of 18″ on the left, and 1″ on the right side.

F. A. Spalding,[4] who had suffered for twenty years from middle-ear catarrh,

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[1] "Ein Fall von Doppelhören an sich selbst beobachtet." Königsberg. medicin. Jahrb., iii. Bd., 1861.

[2] "Doppelhören in Folge einer Jodkaliumcur." Zeitschrift für Ohrenheilkunde, xi. Bd., 1. Heft.

[3] "Ein Fall von Diplacusis mit Erläuterungen." Archiv für Augen- und Ohrenheilkunde, vi. Bd., S. 24.

[4] "Diplacusis binauricularis. Eine Selbstbeobachtung." Zeitschrift für Ohrenheilkunde, x. Bd., 2. Heft.

with tingling and humming, happened one day to be for some minutes in a factory in which a machine was working with a loud noise, and suddenly experienced a fulness and tingling in both ears. The tingling noise seemed like the whistle of a distant locomotive, apparently with the pitch of G'. After the use of the air-douche the feeling of fulness disappeared; but the tingling continued in the left ear, whilst in the right it alternated with a buzzing sound. In the evening of the same day, while listening to a tune being whistled, he noticed that in the left ear he heard a second tone accompanying the notes near G'', the tingling noise G' meanwhile still going on. On examination with a flute he found that the notes G', $G\sharp$, A'' and $A\sharp$ were perceived correctly with the right ear, but that on the left they were heard a minor third higher. Some hours later (one o'clock in the morning) the duplicate tone was no longer heard with G'', but was still present with $G''\sharp$, A and $A''\sharp$, and was now observable also with B'' natural. By next morning the duplicate tones had disappeared.

H. Steinbrügge[1] had under his care a man of fifty-two, who was musically cultivated, and had suffered from ear disease since childhood (central perforation on left side, cicatrix and calcareous deposit on right). His hearing was completely lost on the left side, and impaired on the right. One evening while singing, he observed that along with each tone he heard also the major third. He could not say on which side the duplicate note was heard, nor in which octave. This condition continued for a time, and then all music appeared confused to him. He had at the same time tinnitus, giddiness, and a staggering gait. Four weeks afterwards his hearing improved, the giddiness ceased, and he was again capable of appreciating music.

Pomeroy[2] observed double-hearing during a catarrh. Each tone was heard a note higher by the right than by the healthy left ear. The difference became gradually less, and finally quite disappeared. The author has himself treated several patients in whom this phenomenon was present. A professional musician, who was under treatment during four weeks for a bilateral middle-ear catarrh, stated that during the whole time "all tones" seemed double, although the hearing power for the watch was almost normal during the last two weeks. A tone correctly perceived on the left side was mingled with that heard on the right; but he was unable to determine with accuracy the pitch of the latter. Individual words he heard double, whether spoken by himself or others, the word appearing to be mixed up with an indistinct one in the second ear. The symptom vanished suddenly, and never returned. In a colleague of the author's, who after a chill was attacked with slight catarrh of both middle ears, the symptom of diplacusis made its appearance at the beginning, and was experienced with every note of the scale. The patient, who was musical, stated that with each note he heard the major third. In this case also the double-hearing disappeared with the catarrh. In another patient, who also stated that each note was accompanied by the major third, a disease of the labyrinth was diagnosed by the author, who is unaware whether the symptom in question has disappeared or not. Patients sometimes complain of a difficulty in understanding conversation on account of a simultaneous auditory sensation resembling more or less the word spoken. This symptom occurs frequently in catarrh of the middle ear on one side, and even when it is present on both sides. It is thus probable that the phenomenon of double-hearing is not rare, though, as remarked by *Knapp*, very few patients recognise the fact.

(*c*) *Hyperacusis Willisii.*—By this is meant a curious phenomenon consisting in this: that an auditory stimulus is sometimes perceived

[1] "Ein Fall von Diplacusis." Zeitschrift für Ohrenheilkunde, xii. Bd., 10 Heft.
[2] "Otological Contribution." New York Med. Journ., 18 April, 1885.

very much better if it be at the same time accompanied by a loud noise, than if it occurred alone. It is most often experienced by patients when travelling by train or driving in a carriage, under which circumstances they find they hear conversation better than when quiet. The symptom occurs frequently, especially in connection with chronic hyperplastic inflammation in both ears, and has received various explanations. The author has been unable to accept any of the theories hitherto advanced, and he imagines that its cause must be referred to different circumstances, partly pathological, partly physiological, which may happen to co-exist in the ear, and bring about a condition favourable to the better conduction of a powerful auditory stimulus.

Weber-Liel[1] refers the symptom to the effect of strong and repeated impulses upon the tympanic membrane and ossicles, as a result of which the structures too rigidly fixed by retraction of the tendon of the tensor tympani muscle and thickening of the mucous membrane "become somewhat relieved from their over-tension," and are thus better accommodated for conduction; the labyrinthine pressure being at the same time diminished. This view is favoured by the effects of section of the tensor tympani tendon. *Urbantschitsch*[2] looks on Hyperacusis Willisii as a "physiological symptom." The sensitiveness of the auditory nerve being increased with each stimulation, the ear is capable of appreciating impressions of sound which it would be unable to do if they occurred alone. To the author, neither the view of *Weber-Liel* nor that of *Urbantschitsch* recommends itself. Against *Weber-Liel's* explanation it may be objected that the symptom occurs in patients in whom the objective conditions cited are absent; and according to the theory of *Urbantschitsch* it ought to follow that every patient with impaired hearing ought to be subject to this anomalous condition; whereas the proportion of aural patients in whom it is observed is very small.

(*d*) *Paracusis loci* is applied to a condition described by *Politzer* and others, which consists in the inability to determine with accuracy the direction of sounds. The symptom occurs in mon-auricular diseases, especially in those of an acute and severe character; but also in affections of both ears, in which they suffer in different degrees of intensity. In accordance with generally accepted physiological views there is nothing remarkable in the phenomenon, and it usually disappears after a short time.

[1] "Ueber das Wesen und die Heilbarkeit der häufigsten Form progressiver Schwerhörigkeit." Berlin, 1873, S. 136.

[2] Lehrbuch der Ohrenheilkunde, S. 348.

CHAPTER II.

OBJECTIVE EXAMINATION.

The progress of otology, as with medicine in general, has been characterised for the most part by increased objectivity in diagnosis; and from this has followed greater certainty in prognosis, and more rational treatment.

There is no one subjective symptom characteristic of and peculiar to any disease of the ear. It is obvious therefore, that accurate observation of the objective signs of the various morbid conditions is of extreme importance in relation to diagnosis. The accounts which patients give of their ear-affection, of whatever nature it may be, usually differ from one another only in regard to the intensity and the duration of some troublesome symptom or other. Thus it may be seen how unsatisfactory was the state of diagnosis in aural diseases at a time when this was arrived at exclusively from a consideration of the subjective symptoms.

The gradual simplification in the methods of examination, and the disuse of complicated apparatus requiring much time for manipulation, undoubtedly paved the way for considerable improvement in diagnosis; and the measures now employed for this purpose are such that an examination may be made with ease either in the consulting-room or in the patient's own house.

The objective conditions which may be observed in ear diseases are to be recognised by the eye, ear, or touch; and the examination is therefore to be considered in accordance therewith. The sense of smell is of little importance in diagnosis, since a bad odour emanating from the ear gives no positive indication as to its cause. In regard to exudation processes, in which the olfactory sense of the examiner is often exercised, the view has been long abandoned according to which a bad odour was supposed to imply a carious or necrotic bone affection.

A. Ocular Examination.

Examination by the eye in a case of ear-disease should involve not only the ear itself, but all such regions of the head and throat as

have a close connection with it; more particularly the structures adjacent to the auricle, and those of the naso-pharyngeal region. Other parts of the body should however not be neglected, if any suspicion exists of the presence of general disease. The examination is conducted either by means of direct illumination, with or without the aid of instruments, or, as is generally necessary in the examination of the deeper parts of the ear and of the naso-pharyngeal region, by means of reflected light.

(*a*) *Examination of the External Auditory Canal and the Deeper Structures of the Ear.*

The observation of the external auditory canal is in general carried out best by reflected light. By direct illumination it is but seldom possible to obtain a distinct view of the deeper parts of the canal, or anything at all of the tympanic membrane. The meatus is generally much too narrow and its walls too uneven to permit of the incident rays reaching and properly illuminating these structures. Not only this, but the view of the examiner is further impeded by the interposition of his own head between the patient and the source of illumination. Nevertheless, the simplicity of the method, and the possibility of seeing the structures in their natural colour, are a recommendation, and one may therefore make use of it when convenient, proceeding to the examination by reflected light if necessary.

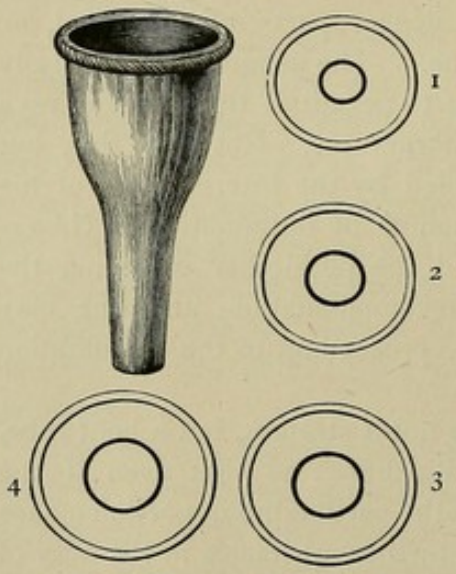
The auditory canal as is well known, is not a straight, but a bent tube, of considerable length in proportion to its calibre; so that even if one succeeds in straightening out the bend which the cartilaginous portion makes with the osseous, its conformation places further obstacles in the way of its illumination, in addition to those already mentioned as to its narrow orifice and uneven walls.

With the object of facilitating the examination, an instrument called an *ear-speculum* is used. The first mention of it is by *Fabricius von Hilden*, in the seventeenth century; and the forceps-shaped instrument still met with, known as *Kramer's* ear-speculum, is a copy of *Hilden's*. These instruments must give way to the simple specula of more recent times first designed by *Dr. Ignaz Gruber*, and brought into use amongst aurists more particularly through *Wilde*. The simple speculum is much better suited for ordinary examination than the bivalved, the supposed advantage to be obtained from the use of the latter—viz. enlargement of the meatus—being entirely erroneous. The intervention of scales, hairs, and other soft structures between the blades of the speculum more than counterbalances any dilatation of the cartilaginous portion of the canal, in which part alone could it possibly be brought about.

The simple specula employed by *Ignaz Gruber* were hollow truncated cones with the inner surface blackened. Since the width of the external auditory canal is different in different persons, the specula are made of different sizes; usually a set of three is employed, the smaller just fitting into the next larger one. These specula have been variously modified; always with the same object of increasing the illumination, and with varying success.

The speculum introduced by the author is flattened from side to side in one direction, and made up, as it were, of two segments of different width, the curvatures of which pass gradually one into the other. A section perpendicular to the longitudinal axis is everywhere conformable to that of the auditory canal—that is to say, elliptical. It is blackened inside, and the edge of the smaller end is well rounded off, the larger end carrying a milled ring on its outer surface to enable the speculum to be handled easily. A set consists of four instead of three specula, and they graduate in size, not only as to width, but length also. The narrowest one is almost 1 *cm.* shorter than the remaining three, which are equally long. Their proportions are represented in the diagram, in which the rings show the actual sizes of the larger and smaller ends. The shortest speculum is employed for young children. The advantages which this form of speculum possesses are that it can, on the one hand, be introduced for some distance (1·5 to 2 *cm.*) into the canal; and on the other hand, the light is admitted freely through the wide external opening.

Fig. 58.
Ear speculum.



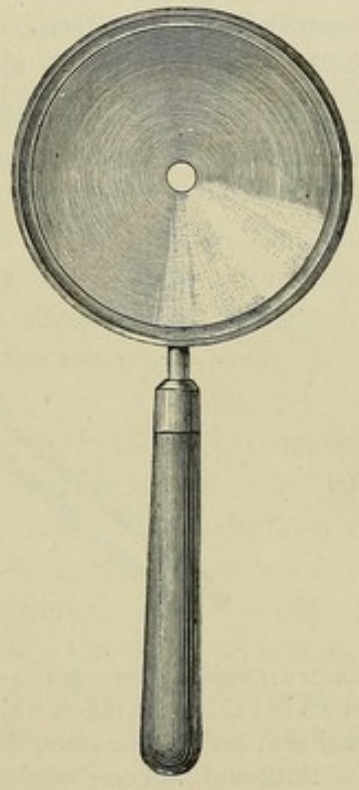
Toynbee and others have endeavoured to attain this by other means. Their instruments have nearly the form of an ordinary funnel, which although allowing plenty of light to enter the large end, have the disadvantage of too sudden a transition of the wide into the narrow part, whereby many rays of light are reflected instead of proceeding down the auditory canal. The prolonged manipulation of the instrument is also apt to cause fatigue of the fingers, whereas in the form of speculum recommended by the author, the fingers rest not only on the margin, but also on its prominent external surface.

Aural specula are made of German silver, or of vulcanite, the latter being convenient when it is desired to apply substances—such as nitrate of silver—which would act upon a metallic instrument. In other cases, the author invariably uses metal specula, because to say nothing of other small

advantages which they possess, they are usually much more durable, and permit of far better illumination than those made of vulcanite.

As already mentioned, it is only on rare occasions that sufficient illumination of the deeper structures can be obtained by means of sunlight or artificial light falling directly upon the ear. A stronger light derived from special apparatus is needful for this purpose. Such arrangements as were formerly employed were all constructed on the principle of passing the light through collecting lenses, and in this way concentrating the rays. In some instances, so-called 'reverberators' were also placed behind the source of light, so as to reflect towards the collecting lenses such of the rays as would have otherwise fallen in other directions. Wax candles or oil lamps were employed, or as a more intense light, a photodyl flame supplied with a continuous stream of oxygen (*Voltolini*[1]). The disadvantages connected with the general use of such apparatus have been already adverted to. At the present day the instrument almost universally employed is that introduced into practice by *Von Tröltsch* in 1855. This consists of a concave mirror, with a focal distance of from 13 to 16 *cm.* and 7 to 8 *cm.* in diameter. It is screwed on to a handle, and the glass pierced in the centre to permit of the examiner looking through it. In those cases in which it is desirable that both hands should be at liberty, it is necessary to use a reflector adapted by a ball-and-socket joint to a plate fixed to a band going round the forehead.

Fig. 59.
Reflector (half ordinary size).



Weber-Liel[2] uses for the same purpose a mirror with a handle which can be held between the teeth. The handle has a hinge to regulate the direction of the mirror. *Delstanche fils* recommends a similar reflector, and *Czermak* at first also employed a mirror movable on a wire handle which was held in the mouth.

In such cases however, the suggestion of *Schwartze* may be adopted. The reflector is held by the thumb and index finger of the left hand, the middle finger used to adjust the speculum, and the auricle drawn aside by the remaining fingers. *Trautmann*[3] suggested an arrangement of a reflector, on the handle of which a

[1] For further information concerning all these obsolete apparatus s. *Lincke*, "Handbuch der Ohrenheilkunde," Leipzig, 1845; as well as *Von Tröltsch*, "Die Untersuchung des Gehörganges und Trommelfelles," Berlin, 1860.

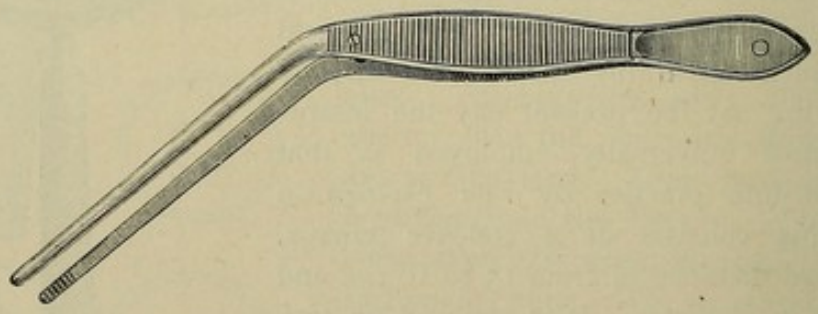
[2] Monatsschrift für Ohrenheilkunde, xii. Bd., S. 2.

[3] Archiv für Ohrenheilkunde, vii. Bd., S. 93.

ring is fixed, through which the thumb may be inserted: all the fingers may then be used for manipulating the ear and speculum. Since electric illumination has come into vogue, various kinds of electric lamps have been invented for aural examination. *Voltolini*[1] is opposed to all apparatus of this kind hitherto constructed, since in his opinion, the small ones give too little light, and the larger ones are very expensive, and the light painful to the eye. *Felix Semon*[2] advocates an electric apparatus made by *Müller* of Hamburg, the accumulator connected with which will supply the small lamp for ten to fourteen days. The same instrument can also be used for laryngoscopy. *Zaufal*[3] speaks highly of the "*Nitze-Leiter electrical otoscope*," and considers *Leiter's* battery best for supplying the current. He thinks it especially adapted for the ear, and refers to the excellent definition of the parts which it permits. It is however, as he admits, too expensive for general use. *Hedinger*[4] used as an illuminator a glowing platinum wire placed in the focus of a polished silver mirror, and supplied by a modified *Bunsen's* battery. He recommends it from the possibility of bringing the source of light very near the object examined. *Fritsche*[5] employs common gas as an illuminant, previously passed, however, through a heated iron bottle containing vapour of naphthaline, with which it becomes mixed before being burnt. The light is

Fig. 60.

Aural forceps.



concentrated by two plano-convex lenses, and falls upon a concave mirror. The flame is said to be much whiter, and from two to four times stronger than an ordinary gaslight, and at the same time to effect a saving of 40 to 45 per cent.

Although acknowledging the various efforts to produce a better light, the author believes the electric light will scarcely come into general use for examination until electric illumination becomes adapted to household use with the ease of gas.

The alteration in appearance produced by artificial light is modified by *Schwartze* by the use of a blue-coloured lamp glass, as in microscopical work (*Schenk*).

The *aural forceps* is an instrument in frequent use in aural practice, and ought to be always at hand. The author employs the simple form represented in the figure (Fig. 60); but others are in use, and may be

[1] "Das elektrische Licht verwendet in unserer Specialität und die Anwendung des Cocain." Monatsschrift für Ohrenheilkunde, xix. Bd., S. 142.

[2] "Electric illumination of the various cavities of the human body, faradisation, galvanisation, and electrolysis by means of pocket accumulators." Lancet, 1885. May.

[3] "Ueber den Werth des *Nitze-Leiter'schen* Endoscops zur Untersuchung des Gehörorganes." Archiv für Ohrenheilkunde, xvi. Bd., 3 Heft.

[4] "Deutsche medicinische Wochenschrift," v. 7, 1879.

[5] "Die Albocarbon-Untersuchungslampe für Nasen- und Kehlkopf." Berlin, Klinische Wochenschrift, 1885, Nr. 5.

serviceable in special cases, *e.g.* instruments with cross blades, or spoon-shaped or hooked ends. The more complicated the forceps, the more training is needful for their manipulation. In examining the external auditory canal, the ensuing method should be adopted.

(*a*) *Examination by Direct Illumination.*

The patient sits or stands in such a way that the light falls upon the ear to be examined,[1] and the observer, placing himself opposite the ear, draws the upper part of the auricle somewhat backwards, upwards, and away from the side of the head with the thumb and first finger. In this way, owing to the connection of the auricle with the cartilaginous portion of the auditory canal, the bend in the latter at the junction of the cartilaginous with the osseous portion becomes more or less straightened out. This being done, the speculum, previously warmed a little, is introduced in the direction of the axis of the canal—that is, inwards, and somewhat forwards and downwards, care being taken not to scratch the walls of the meatus. Attention should also be given that the longer axis of the elliptical diameter of the speculum is directed from above downwards.

In using the speculum, it occasionally happens that an obstruction or difficulty presents itself on account of some peculiarity or other of the canal. To overcome this, however, only calls for a little judicious management, and practice in manipulation. It is advisable to employ as large a speculum as can be conveniently introduced, with the object of obtaining as large a field of view as possible; but care should be taken to avoid undue pressure upon the lining membrane of the canal, which is richly supplied with blood-vessels and nerves, especially in the osseous portion; and is not only very sensitive, but readily excoriated. If therefore the speculum cannot be easily used, a smaller one should be taken. If the patient be instructed to open his mouth, the introduction of the speculum will be facilitated by the widening of the auditory canal which this occasions. This procedure should not be forgotten when examining a case in which much inflammatory swelling is present.

In many patients the most gentle contact with some part of the lining membrane of the canal is sufficient to induce paroxysms of coughing; brought about, it is believed, by the reflex function of the auricular branch of the pneumogastric nerve. The coughing fits soon cease however, and do not further interfere with the examination. An epileptic patient of the author's was once seized with a fit during the introduction of the speculum; and another case will be referred to later on, in

[1] It is desirable to ascertain the condition of the meatus before introducing the speculum. For example, an acute inflammatory swelling will render it temporarily inadmissible, or obviously necessitate the use of a very small instrument.—EDS.

which convulsions supervened upon contact of the instrument with the auditory meatus. Otherwise the author has never observed serious symptoms during the examination. *Schwartze*[1] relates having on several occasions observed epileptic convulsions to come on during the aural examination of patients who were supposed never to suffer from such attacks.

The speculum being introduced, it is held in position by the thumb and index finger; the latter finger also, with the middle finger of the same hand, serving to hold up the auricle. The other hand is now set at liberty, and the light adjusted so that as much as possible falls upon the speculum in the direction of the canal. Should it have proved impracticable to introduce a speculum large enough to view all the deeper structures at once, they must be examined in turn by inclining the speculum first in one direction and then in another. By turning also the patient's head into different positions, one often succeeds in seeing parts which would otherwise have been invisible.

If, after the speculum has been introduced, any small particles, such as epidermic scales, or small pieces of cerumen, should obstruct the view, they may be carefully removed with the aural forceps. Larger and more firmly adherent substances should be removed by syringing out the canal—a process to be described later on. After syringing, the appearance of the tympanic membrane may be considerably altered as a simple result of the process, a fact which should always be borne in mind in respect of diagnosis. The blood-vessels which run along the handle of the malleus are specially apt to become strongly injected, so that the condition might be easily mistaken for an inflammatory hyperæmia.

If the auditory canal should be clear, and no pathological changes present, the tympanic membrane may be seen at its extremity. It appears at the inner end of the auditory canal as a moderately tense membrane, concave outwardly, and usually shining with a dull light. Its colour is not the same throughout, depending as it does not only upon the histological character of the constituent parts of the membrane itself, but also upon the colour of adjacent structures. In general it can only be stated that in the normal condition the tympanic membrane is of a mixed colour, answering to its own proper tint and that of the surrounding parts (Plate I., Figs. 1 and 2). It is usually grey, but with a marked redness of the lining membrane of the external auditory canal, as well as with increased redness of the mucous membrane of the tympanic cavity, it acquires a reddish or somewhat violet appearance. With a yellowish tint of the mucous membrane again, it appears somewhat yellowish. The thicker portions of the membrane are in general lighter in colour than the thinner parts; and the posterior segment, especially at its upper part, is usually lighter than the anterior. The ordinary

[1] "Die chirurgischen Krankheiten des Ohres." S. 11.

whitish-grey colour varies also in accordance with the kind of light employed; and as even the colour of the sun's rays varies, the tint of the membrane may differ at times even with direct illumination by sunlight. The whitish-grey colour seen by reflected sunlight becomes more yellow by gas-light. In the greyish ground of the membrane is seen a tolerably broad ridge, usually of a whitish-yellow colour, extending from the upper part in front, downwards and backwards to somewhere about the middle of the membrane. In this ridge the handle of the malleus may be readily recognised, and also its upper end corresponding to the short process, and appearing as a small protuberance into the canal. The lower extremity of the handle appears rather rounded, and behind and near this an irregular reddish-yellow or whitish-yellow spot may be observed, due to the promontory shining through.

Between the spot just mentioned and the most external border of the membrane (annulus cartilagineus), the colour is generally darker for a variable distance; while the cartilaginous ring itself, so far as it projects between the lips of the sulcus tympanicus, appears on the other hand of a lighter, yellowish tint. The "dendritic" fibrous structure of the membrane may also be sometimes recognised by a pale, cloudy, opaque appearance. When the drum-membrane is very transparent, the lowest portion of the descending process of the incus may be seen through it, even in the normal ear; and in rare cases even the head and posterior crus of the stapes, as well as the tendon of the stapedius muscle, may be visible (Plate I., Fig. 2) in the upper posterior section. The upper parts of the membrane, especially in the posterior region, have a lighter and more opaque appearance than the rest, due to the presence behind of the folds or duplicatures of mucous membrane forming the anterior and posterior pouches. The incident luminous rays, being in fact reflected in greater number by the drum-membrane and folds of the pouches than from the membrane alone, this part must appear lighter in colour. Similarly, since the lower margin of the duplicatures is still further thickened by the presence of the chorda tympani, this nerve may in many cases be perceived simply on external inspection of the tympanic membrane. It then looks like a whitish thread running from behind and below, forwards and upwards, and limiting below the lighter-coloured region just described.

From the lower end of the handle of the malleus, extending forwards and downwards, the "cone of light," first described by *Wilde*, may be observed. It has the appearance of a brightly shining equilateral triangle of from $1\frac{1}{2}$ to 2 *mm.* in height, with the apex directed towards the extremity of the handle of the malleus, and the base forwards and downwards towards the periphery of the membrana tympani. Even in healthy ears however the bright spot varies very much in both form and extent.

According to *Helmholtz*, the "cone of light" is a result of the peculiar position of the drumhead. "The vertical part of the membrane which is turned towards the axis of the auditory canal, and lies as a rule close under the handle of the malleus, reflects light thrown from without into the ear, back again towards the outlet of the canal, and appears therefore as a shining triangular spot."

In the normal membrane two folds or ridges arise from the short process of the malleus, one of which runs forwards and upwards, and the other (much the longer) backwards and downwards. They are due to the fact that the upper end of the handle of the malleus projects outwards towards the external auditory canal, and so makes the membrane prominent in this region. These folds are more distinctly marked, the more concave that part of the membrane below them is, and the more distant they are from the upper part of the inner end of the auditory canal.

That *Von Tröltsch* first described these folds in the normal tympanic membrane, as *Politzer* supposes in his Text-book, is incorrect. In *Von Tröltsch's* Text-book, published in 1862, on page 106, where he describes the appearances in acute catarrh of the membrane, he certainly writes: "In like manner the tympanic membrane as a whole appears abnormally concave; and besides many partial irregularities in its incurvations, a ridge which curves backwards and downwards from the short process of the malleus may in particular be often observed in connection with the inward tension of the membrane." Nowhere however does he speak of an anterior fold, and still less of *the constant presence of an anterior and posterior fold in the normal membrane*. The author had already drawn attention to the fact that these folds are frequently very strongly developed in disease, in his reports of the aural out-patient practice for the year 1861 (first printed, of course, in the Hosp. Summary Reports of 1862). The first account of the presence of an anterior and posterior fold, and that they are developed in a moderate degree in the normal state (of which *Von Tröltsch* had no knowledge), the author has given in his before-mentioned work on the tympanic membrane.

Of the cartilaginous ring, only traces are as a rule seen in the form of curved lines on the periphery of the membrane, since the largest part of it is situated in the sulcus tympanicus itself.

(β) *Examination by Reflected Light.*

In this a reflector is employed, as well as the before-mentioned ear-speculum; the method of examination being as follows: The patient sits or stands (as most convenient) between the source of light and the observer, in such a way that the ear to be examined is turned away from the light, attention being at the same time given that the patient does not obscure it with his own head. To this end he should, after the speculum has been properly introduced, incline his head somewhat towards the opposite shoulder. Whilst the observer now with the fingers of one hand holds the speculum as well as the auricle in the manner previously described, he, with the reflector in the other hand, intercepts the rays of light, and directs them into the auditory canal. To effect this, the reflector must be

turned a little in different directions, until a position is found at which the light-rays are most abundantly thrown into the ear.

Beginners may be recommended to illuminate the meatus before introducing the speculum, as the position of the mirror necessary for good illumination is then more easily determined; otherwise, in searching for the light, the examination may readily become tedious and troublesome.

In examining by this method the observer makes use of both hands. If however, for operating or other purposes he wishes them to be free, this may be effected by using a mirror provided with a band for the forehead, and by introducing the speculum into the meatus far enough for it to maintain itself in position without being held there.

With regard to the source of light, that from white or pale-grey clouds is best for a prolonged examination (*Von Tröltsch*). If therefore the examiner should by chance find himself opposite the sun, the mirror should be turned to one or the other side; the patient of course also changing his position, so that the light-rays may be derived from some sufficiently illuminated object—*e.g.* a white wall.

The objection which has been made to illuminating by reflection, that the colour of the various structures is thereby altered, applies equally to all other modes of artificial illumination, and has really no great weight, inasmuch as reflected light is employed almost exclusively for the purpose of examination, and normal and abnormal structures therefore observed and compared under the same conditions. Though a very strong light, as direct bright sunlight, no doubt enables the structures to be more accurately observed, it is unsuitable for a prolonged examination, on account of the fatigue to the eye which it induces.

The points about which information is to be obtained from the examination are:—the width of the external auditory canal, its possible contents, and the condition of its walls; the extent, colour, position, curvature, and other characters of the tympanic membrane; and the condition of the malleus, the direction of its handle, the situation of its short process, as well as its other relations to the membrane. Then again the state of the folds of the membrane which proceed from the short process of the malleus, the occasional visibility of parts of the other auditory ossicles (incus and stapes), and the condition of the other structures of the tympanum which may be noticeable, should likewise be observed.

For the more accurate observation of the mobility of the membrana tympani, the instrument known as *Siegle's* speculum may be employed. In its original form it consisted of two principal parts—viz. the speculum proper (Fig. 61, *K G A*), and a tube (*S*), which had a mouthpiece at the end (an air-ball in the figure).

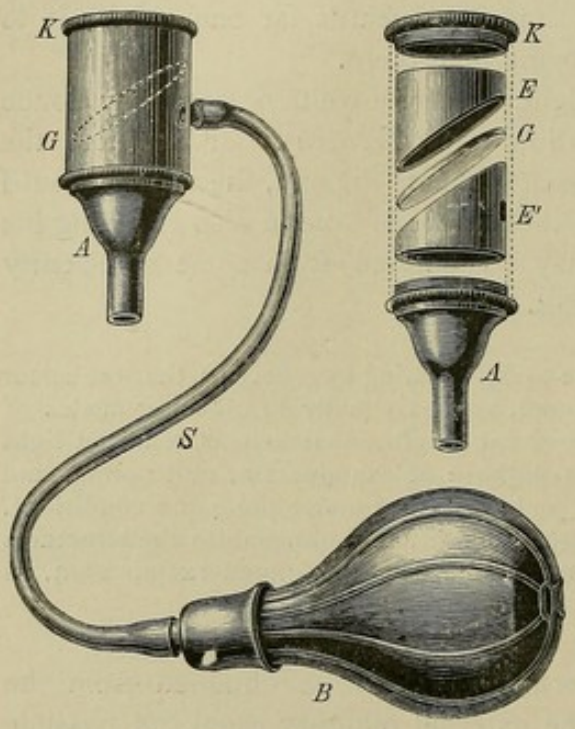
The tube communicates with the speculum by a side opening, to the outer side of which (*i.e.* towards *K*) a glass diaphragm was in the original

speculum fixed almost at right angles, and completely shut off one part of the speculum from the other. The inner part (A) can be screwed off, and replaced by another. The alteration of density of the air in the auditory canal is brought about through the tube, either by means of the mouth or by an air-ball.

This instrument has been modified to some extent by the author. In its original form, the fixity of the glass diaphragm made it difficult to keep it thoroughly clean. Further drawbacks were the reflection of light from the surface of the glass, and the unsuitable form of the ear-piece. In the author's modification the glass diaphragm can be removed. In Fig. 61 the drawing to the right gives a correct idea of the construction. The dotted lines represent the external case of the speculum, into the outer (ocular) end of which the milled ring K can be screwed. The glass diaphragm is placed between the segments E and E', cut at an angle of 45°. The segment E is removable, E' being permanently fixed into the outer case of the instrument. Between the diaphragm and the segment E is a removable elastic ring, which serves to perfect the contact between the diaphragm and the two segments when the ring K is screwed up, and so cut the two chambers completely off from one another. The opening for the lateral nozzle, by which communication is established between the indiarubber tube S and the inner (aural) division of the speculum, is indicated near E'.

Fig. 61.

Modification of *Siegle's* aural speculum (half ordinary size).



$K\,G\,A$, Speculum; G, glass diaphragm, placed obliquely; A, inner portion of speculum; S, ventilation tube; B, air-ball. In the figure on the right, K, external ring; G, glass; E, E', the two oblique tubes between which the diaphragm is fixed by screwing the parts K and A.

Delstanche's[1] "rarefactor," which is worked by an air pump, does not appear to the author to be as practical or simple as *Siegle's* speculum.

Weber-Liel[2] has constructed an "aural microscope," with the object of obtaining a magnified view of the tympanic membrane. With this instrument the

[1] Monatsschrift für Ohrenheilkunde, etc., xx. Jahrg., Nr. 3.
[2] *Ib.*, ix., 10.

membrane may be magnified fifteen times, and even its vibrations observed if it has been previously dusted with powdered starch.

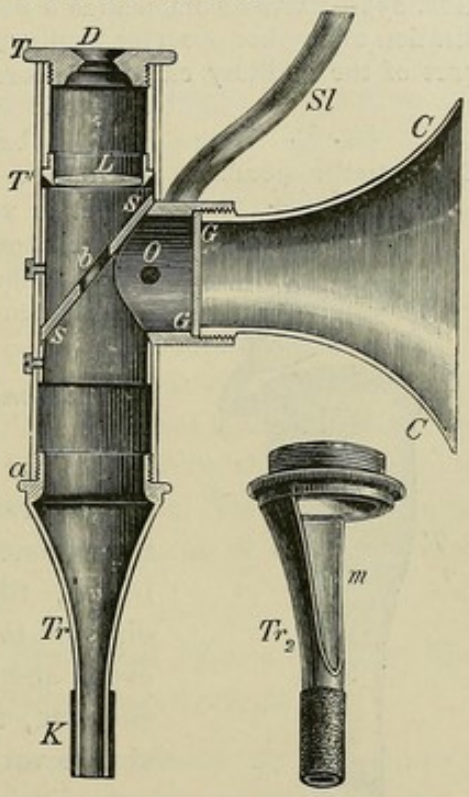
Voltolini's otoscope is more simple, and easier to manipulate. It consists of a *Brunton's* aural speculum, furnished with various glasses which serve partly to magnify, partly for other purposes. A longitudinal section of the instrument is shown in Fig. 62, drawn two-thirds of the actual size. *C C* represents the funnel-shaped part through which the light is admitted into the cylindrical body of the speculum *Ta*, in which is fixed obliquely a plane mirror *S S*, with a central aperture. At *a* the speculum proper *Tr*, of varying width of aperture as needed, is screwed on. The glasses of the instrument are fixed in at *T* and *T*. If specula of different length be employed, the lens *D* must be chosen of a corresponding focal distance. The apparatus is so constructed as to allow movements of the tympanic membrane due to changes in the atmospheric pressure in the auditory canal to be observed. The glass *G G* is fixed air-tight in the funnel *C C*, and farther inwards is an aperture in the connecting tube, which leads at right angles to a narrow nozzle, to which an indiarubber tube *Sl* is attached. A strong light, best of all sunlight, should be used with this instrument.

If it be desired to observe the movements of the drum-head, the air in the auditory canal may be condensed or rarified through the indiarubber tube, either by the mouth or a small air-ball. When the air is condensed the normal membrane will be seen to move inwards, and when rarified, outwards. The end of the speculum may be made to fill the auditory canal, and fit also more closely, by covering it with a short piece of indiarubber tubing, as at *K*.

For the performance of operations, *Voltolini* recommends the use of a speculum with a lateral opening, as shown at *m* (Tr_2), through which the desired instrument may be introduced.

Fig. 62.

Longitudinal section of *Voltolini's* modification of *Brunton's* speculum (two-thirds ordinary size).



C C, Funnel through which the light rays reach the cylindrical tube *Ta*; *S S*, obliquely fixed plane-mirror with central aperture *b*; *Tr*, aural speculum with extremity (*K*) covered with piece of indiarubber tubing; the speculum, changeable at will, is screwed on to the cylindrical tube at *a*; *D* and *L*, lenses; *G G*, glass shutting off the cylindrical part of the instrument from the funnel-shaped part; *O*, opening communicating with the indiarubber tube *Sl*; Tr_2, speculum with a lateral opening, *m*.

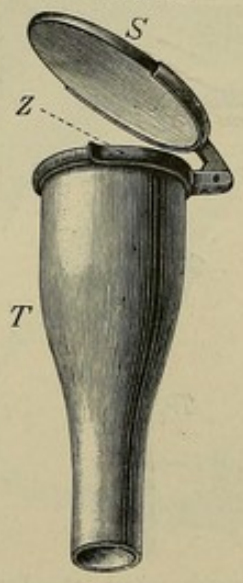
Grünfeld[1] has constructed an apparatus well adapted for purposes of demonstration. A small oval mirror, *S*, of the same size as the outer ocular end of a speculum is attached by a clamp on which it is movable by a hinge-joint. The clamp may be applied to either side, and the mirror turned

[1] "Ein Demonstrationsspiegel in Verbindung mit dem Ohrtrichter." Monatsschrift für Ohrenheilkunde, xv., 4.

thus either to right or left, its angle of inclination being likewise variable by means of the hinge-joint. The observer, looking through the speculum into the auditory canal, sees of course an ordinary direct image, while another person looking at the mirror sees the image reversed—that is to say, the right membrana tympani looks to him like a left one, and *vice versâ*. The image may be magnified by using a concave mirror.

Hinton described his demonstration auriscope in 1868 (Med. Times and Gaz. 25).—*Lucæ* recommended a plane-mirror with a central aperture for demonstration to another observer by direct sunlight, the image of an object in the deeper part of the auditory canal.—According to *Siegle*,[1] an observer may see his own tympanic membrane in a plane-mirror, by placing himself with his back towards the source of light, and holding the mirror at a suitable distance before his ear.

Fig. 63.
Demonstration speculum of *Grünfeld*.



T, Speculum; *S*, mirror; *Z*, clamp.

It is very useful to record diagrammatically the objective conditions found in a patient side by side with the notes of the case, the changes which occur in the course of treatment being thus more easily appreciated.

(*b*) *Examination of the Structures of the Oral Cavity.*

Since investigations in morbid anatomy have demonstrated the connection of many aural affections with abnormal conditions in the naso-pharyngeal region, the attention of aurists has been greatly directed to the latter. The structures of the mouth even should be carefully examined; experience showing, for instance, that carious teeth may occasion severe suffering in the ear, and may thus, if unrecognised, lead to serious errors. The state of the mucous membrane of the oral cavity, of the tongue, and of the hard and soft palate, is to be particularly noted, and any abnormalities should be carefully investigated. The position of the soft palate, its mobility, and its state of tension or curvature, must also be examined. The tonsils too should be carefully inspected, as they are not seldom the sole cause of morbid changes in the Eustachian tubes and the neighbouring structures. If the tonsils are hypertrophied, it should be noticed in which direction they are chiefly enlarged,—whether upwards towards the tubes, and possibly pressing upon them; or whether they perhaps stretch the soft palate and interfere with the function of its muscles, etc.

The best spatula for depressing the tongue is that designed by *Türck* (Fig. 64), with which the teeth are not touched, nor the light interfered with. There are three tongue-pieces of different sizes, which can be fixed on to the handle by a screw.

[1] Berliner Klinische Wochenschrift, 1874.

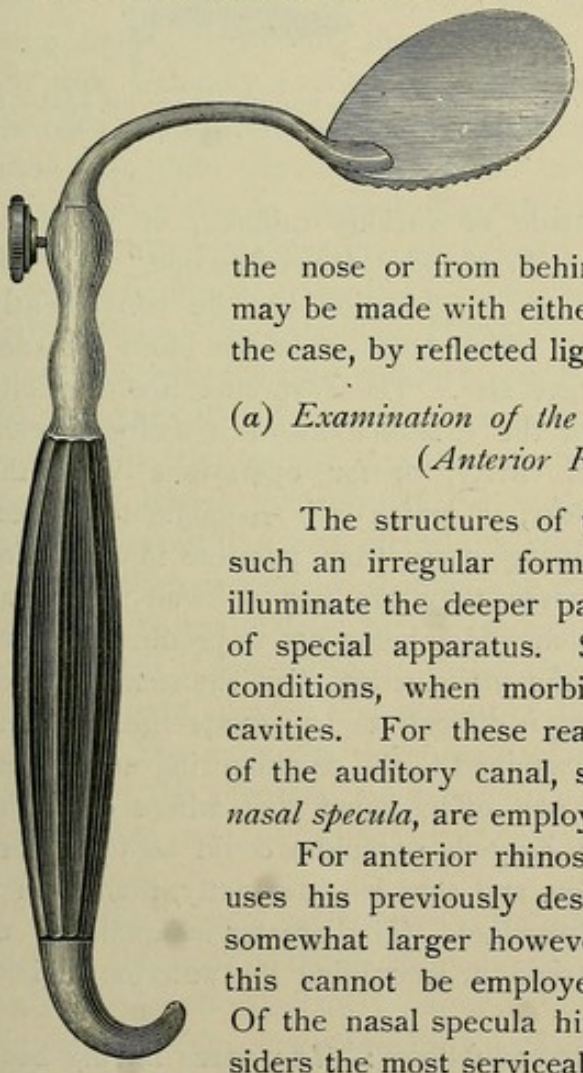
Some individuals cannot tolerate the presence of a tongue depressor in the mouth at all—gagging, and even vomiting, being sometimes induced. Others arch up the tongue towards the hard palate the more one endeavours to depress it with the spatula. In such cases the author has often succeeded by gently using simply the point of an aural catheter, the very small surface of contact being apparently unperceived; and afterwards even this could often be removed, the tongue remaining quiet in the floor of the mouth. In many persons the finger is much more efficacious as a tongue depressor than the spatula.

(*c*) *Examination of the Structures of the Naso-pharyngeal Space* (*Pharyngo Rhinoscopy*).

Aural diseases are found more frequently in intimate association with morbid states of the naso-pharynx than with affections of the mouth. The methods which are serviceable for the investigation of the former will be now shortly described.

Fig. 64.

Türck's Tongue spatula (half ordinary size).



The examination of the post-nasal space may be made either from the front through the nose or from behind from the pharynx; and both may be made with either direct, or, as is more frequently the case, by reflected light.

(*a*) *Examination of the Post-nasal Space from the Front* (*Anterior Rhino-Pharyngoscopy*).

The structures of the nasal fossæ are commonly of such an irregular form that it is seldom possible to illuminate the deeper parts well enough without the use of special apparatus. Still more unfavourable are the conditions, when morbid changes are present in these cavities. For these reasons, and as in the examination of the auditory canal, special instruments, the so-called *nasal specula*, are employed to facilitate the examination.

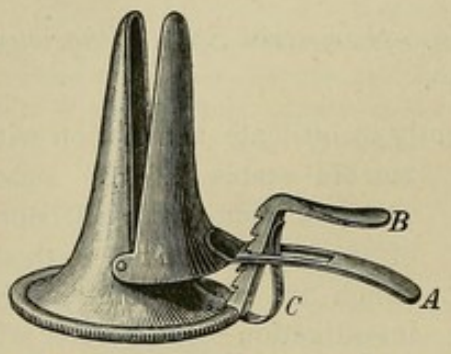
For anterior rhinoscopy the author most frequently uses his previously described aural speculum, of a size somewhat larger however than Nr. 4 of the set. Where this cannot be employed a smaller size may be tried. Of the nasal specula hitherto introduced, the author considers the most serviceable kinds to be: that recommended by *Markusowsky* and modified by *Roth*, which is constructed like the old bivalve aural speculum; the one designed by *Voltolini*,[1]

[1] "Die Rhinoscopie und Pharyngoscopie, etc." Breslau, 1879, S. 65.

modified by *Duplay* (Fig. 65); that represented in Fig. 66, which is *Bresgen's*,[1] modified also by *Duplay*; and the spring speculum of *Bosworth* (Fig. 67). *Zaufal's*[2] naso-pharyngeal speculum (Fig. 68)

Fig. 65.

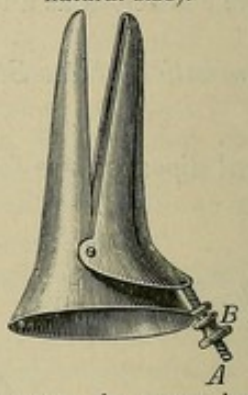
Voltolini's nasal speculum (natural size).



A B C, Catch arrangements for separating and fixing the two halves of the speculum.

Fig. 66.

Bresgen's nasal speculum (two-thirds natural size).

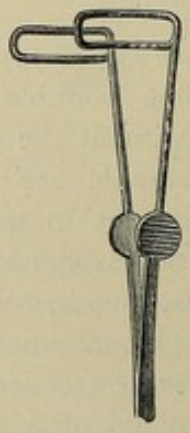


A B represents the screw by means of which the parts are separated from each other.

is about 11 *cm.* long, and is made of various calibres, of metal or vulcanite. This instrument, like *Wertheim's*[3] "conchoscope," may be employed, if its introduction can be conveniently accomplished, which however is not often the case with the larger size. These specula are specially applicable for the examination of a limited region of the nasal cavity, or for operations with the galvano-cautery, in which it is requisite to protect the neighbouring parts from possible injury. For general purposes they are not so well suited as others, the sharp edge being apt to produce excoriation during the introduction, and the small field of vision making it difficult to appreciate the relations of the part examined to the neighbouring structures. The author has often found that where even the largest-sized *Zaufal's* speculum could be used, less could be seen, and that less distinctly, than with a larger ear-speculum. The greater adaptability of the shorter speculum is most marked in examining the anterior regions of the nasal fossæ.

Fig. 67.

Bosworth's spring nasal speculum (half ordinary size).



Anterior rhinoscopy is conducted as follows:—The nares having been

[1] "Der chronische Nasen- und Rachen-Katarrh." Wien und Leipzig, 1883, S. 17.

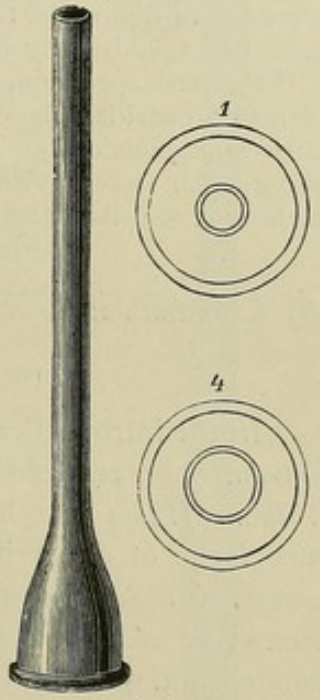
[2] "Ueber die Untersuchung des Nasen-Rachenraumes von der Nase aus, insbesondere mit trichterförmigen Spiegeln." Archiv für Ohrenheilkunde, xii. Bd.

[3] Wiener medicinische Wochenschrift, 1869.

previously freed from any obstructing matter, by washing out if necessary, the patient sits or stands with his face towards the source of light if the examination is by direct illumination, or turned away from it if reflected light be employed, and inclines his head somewhat backwards. With the tip of his left thumb the observer then tilts the end of the nose a little upwards, so that the light may enter the nasal cavity. In this way the structures in the anterior region may be made out for a certain distance but for the examination of the deeper parts, a speculum must be employed. The instrument is to be introduced into the meatus with its outer end somewhat lowered, so as to avoid the sensitive crest-like projection which arises from the floor of the nostril at the entrance into the nasal fossa. This being done, the outer end of the speculum is raised, the instrument being thus brought into the horizontal position, and then carefully pushed forwards towards the posterior wall of the pharynx. During the manipulation any slight impediments which may present themselves are to be avoided by gentle movements of the speculum, as also in a similar way in regard to properly directing the light on to the desired part. Valved specula like *Voltolini's* must be introduced with the blades closed, the latter only being separated afterwards. In most cases a certain dilatation of the meatus may be brought about by lateral pressure of the blades of the speculum upon the soft structures covering the turbinated bones and the septum, and this expansion may be maintained by the screw or spring arrangement of the speculum. *Zaufal's* speculum, which is used almost exclusively for the examination of the most posterior parts of the nasal cavity and the pharynx, must be introduced with the greatest care, as lesions may be easily caused by the sharp edge of its small end.

Fig. 68.

Zaufal's naso-pharyngeal speculum (two-thirds ordinary size).



1, Size of the external and internal openings of the smallest speculum.

4, Size of the external and internal openings of the largest speculum.

If the normal nasal cavity be adequately illuminated, the septum narium, the floor of the nasal fossa, as well as the free borders and varyingly-sized portions of the lower and middle turbinated bodies may be seen, but very seldom any more of the contained structures. The mucous membrane, even when healthy, is from its great vascularity very red—much redder indeed than that of the mouth. The anterior end of the middle turbinated body does not project so far forwards towards the nostril as that of the lower one; but its free border is, on the other hand, nearer to the

septum, so that the central region of the lower turbinated body is often to be recognised with much more difficulty than the corresponding part of the middle turbinated. In the regularly formed nasal cavity one may as a rule see as far back as the posterior pharyngeal wall; the floor of the fossa being usually somewhat deepened in the middle part, and the septum generally deflected towards the left side. In certain cases the protuberance round the mouth of the Eustachian tube may also to a certain extent be recognised, and even the backward and inward movement which the free end of the posterior wall of the tube makes during swallowing may sometimes be likewise observed.

For the purpose of defining the situation of any of the structures, and especially in regard to diagnosis, the careful employment of the probe is indicated. If the nasal passages be very narrow, a gradual dilatation may be attempted by means of the valved speculum, or by some other method. The turbinated bodies will tolerate a considerable degree of pressure without injurious results, if this be carried out judiciously. In malformations of the septum, *Voltolini* recommends a spring-catch forceps with spade-shaped blades: the bent septum is grasped by the blades, and the deflection corrected by regularly applied pressure.

(β) *Examination of the Naso-pharyngeal Space from behind (Posterior Rhino-Pharyngoscopy).*

In the introduction and practical development of posterior rhinoscopy, *Voltolini* has rendered much service, particularly in relation to otology. *William Wilde* had indeed, in his work on the ear, laid stress on the importance of direct inspection of the mouth of the Eustachian tube by means of a small mirror fixed to a wire; besides which *Czermak* and *Semeleder*[1] had, soon after the introduction of laryngoscopy, also recommended and practised rhinoscopy. Still the great value of this mode of examination in relation to ear disease was only thoroughly recognised as a result of the appearance of *Voltolini's*[2] paper, brought forward at the jubilee celebration in the university of Breslau. Since then posterior rhinoscopy has become not only indispensable as an aid to diagnosis, but has also led to many improvements in treatment.[3]

The mode of examination is as follows:—The patient sits or stands with his head a little higher than that of the observer, and opens his mouth widely. The tongue having been sufficiently depressed in the manner before indicated, the rhinoscope (a small laryngeal mirror), previously slightly warmed, is introduced into the mouth so as to reach

[1] "Die Rhinoscopie und ihr Werth für die ärztliche Praxis." Leipzig, 1862.
[2] "Die Rhinoscopie und Pharyngoscopie." Breslau, 1861.
[3] The author in the year 1857, whilst assistant in the wards of *v. Sigmund*, and during *Czermak's* first laryngological demonstration in the presence of *Türck*, maintained *Wilde's* claim to priority in this examination. *Czermak* also makes mention of it in his first treatise on laryngoscopy, which appeared in 1857 in the Wiener medicinischen Wochenschrift.

as far back as possible behind the soft palate, taking care however to avoid contact with the wall of the pharynx, as this is liable to bring on spasmodic movements (gagging). The larger the mirror which can be advantageously used in the particular case, the better will the parts be seen. Many individuals, as *Voltolini* long ago remarked, can be examined without interfering in any way with the soft palate. For the more perfect relaxation of the latter, the patient may be instructed to make a nasal intonation, such as the French "*on*," or he may be requested to sniff. If the inspection does not prove successful at first, the patient may often be made gradually amenable to examination by touching the pharynx from time to time with any body, so as to accustom the parts to tolerate the presence of the mirror. Even with sensitive throats, however, this preparation may be dispensed with by the use of *Voltolini's* palate hook (Fig. 69). With this instrument the soft palate may be sufficiently raised and drawn forwards to allow the greater part of the pharynx and the posterior nares to be seen. If the hook is of metal, it should be warmed before introduction; and if great sensitiveness of the parts should interfere with the examination, they should be accustomed gradually to its presence as before indicated.[1] Cocaine too may of course be advantageously used with this object. The higher in the pharynx the mirror can be introduced and seen, and the better the illumination, the more satisfactory will be the result of the examination.

Fig. 69.

Voltolini's vulcanite palate hook (half ordinary size).



When the mirror is suitably held opposite the posterior nares, the two choanæ separated by the posterior edge of the vomer come into view (Fig. 70). The whole of these structures cannot however always be seen at once. Often only the upper portions can be recognised as two arches curving downwards and outwards on each side of the vomer; but by moving the mirror a little in the proper directions, the lower parts of the choanæ and the posterior border of the hard palate may perhaps also come into the field of vision. Cases do occur however in which with the most judicious management certain portions, especially the lower parts of the choanæ, cannot be seen. The colour of the mucous membrane at the margins of the choanæ is paler than that of the neighbouring

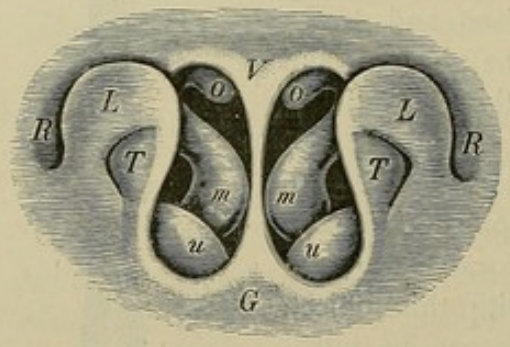
[1] *v. Schrötter* employs a vulcanite hook, the angle of which is somewhat more acute than *Voltolini's*.

parts ; that covering the posterior border of the septum being in particular much paler, and thus easy to recognise.

Within the choanæ are seen the posterior ends of the three turbinated bodies ; the superior being situated more to the side, and close under the upper margin of the choana. It appears as a small irregular body about the size of a pea, generally of a pale yellow colour, and at a variable distance from the nasal septum. At a certain distance below the posterior end of the superior is seen the corresponding part of the middle turbinated body, somewhat larger, and of a bluish-grey colour ; while below this again may be seen the lower turbinated body, generally of a still darker colour. Sometimes the superior turbinated lies so deep that it cannot be seen at all with the rhinoscope. The middle one appears the largest, its posterior "flask-shaped" extremity (*Voltolini*) seeming quite free, and being easily recognised. It sometimes comes close up to the septum and to the floor of the nasal fossa, so that it may touch the inferior turbinated body, and even partly obscure the posterior part of the latter. The lower turbinated looks, as *Voltolini* well described it, "almost like the fruit of the wild plum plant (*Prunus spinosa*) when it has become rather over-ripe and wrinkled." It is situated so low down as to be often invisible. The free spaces between the turbinated bodies on the one hand, and between them and the other structures on the other hand (nasal passages or meatus), appear dark in the mirror.

Fig. 70.

View of the structures in the upper region of the pharynx, as seen by posterior rhinoscopy.



V G, Vomer (posterior border of the septum narium),—the choanæ are seen on both sides of this ; *u* lower, *m*, middle, and *o*, upper turbinated bodies ; from *G* downwards is the posterior surface of the soft palate ; *T*, pharyngeal opening of Eustachian tube ; *L*, cushion round mouth of Eustachian tube ; *R*, *Rosenmüller's* fossa.

Externally to the choanæ may be seen the entrances to the Eustachian tubes—that is to say, their pharyngeal openings bordered by their cartilaginous lips. To bring them well into view, it is advisable to use a mirror which is at an obtuse angle to the stem, and to hold it as much as possible in a position facing the tubes. As seen in the mirror, the relations of the different parts appear of course altered ; those situated behind seeming to be in front, and *vice versâ*. Thus the cartilaginous prominence of the posterior wall of the tube appears to be in front ; and the anterior membranous wall, with the salpingo-palatine fold, is seen behind. So also the long diameter of the pharyngeal opening of the

tube is in reality directed downwards and backwards, though in the mirror its direction appears to be downwards and forwards. *Rosenmüller's* fossa again, which is behind the protuberant lip of the mouth of the tube, seems to be in front of it, appearing as a curved dark space.

In the normal state, the mucous membrane at the entrance to the tube—namely, of the membranous portion—is paler than that in its vicinity, which is of a deep red colour. In order to recognise more easily the image of the structures seen in the mirror, it may be recommended to introduce a metal catheter into the mouth of the Eustachian tube, and keep it in position by means of a frontal band. The image of the shining end of the catheter in the mirror serves to define the relations of the parts seen.

To bring the different parts of the pharynx into view it is necessary to change the position of the mirror a little, by rotation from side to side and from before backwards; or in respect of the latter movement, what comes to the same thing, to alter the angle the mirror makes with the stem.

In examining the anterior boundary of the naso-pharynx, the angle which the mirror makes with the stem should approach a right angle, and the patient's head should be held upright. For the inspection of the superior wall of the post-nasal space, the angle of the mirror to the stem should be more obtuse, and the patient's head bent somewhat forwards; while to see the posterior wall, *Voltolini* recommends the use of as large a mirror as possible, and the head of the patient must be bent still lower.

In certain cases only very small mirrors can be placed behind the soft palate, and but a very limited region made out at a time.

For the observation of those parts which can neither be examined by anterior nor by posterior rhinoscopy—*e.g.* the back part of the floor of the nasal cavity—*Voltolini* recommends the use of two mirrors, which are both introduced into the pharynx. For accurate examination of the structures of the nasal fossæ, strong illumination from the front is also employed. The former method, concerning which the reader may be referred to *Voltolini's* work (p. 169), needs much practice; the latter is easily conducted through a speculum. Yet another, but more complicated, method is described by *Voltolini*, of which a complete account may be found in his work (p. 113). Even the most skilful observer meets occasionally with cases in which the obstacles to rhinoscopy are such that it is quite impracticable. *Schwartze*[1] states that in 7 per cent. of his patients in whom a rhinoscopical examination was desirable it was absolutely impossible; in 21 per cent. only isolated parts could be seen; 55 per cent. could be examined with ease; and 17 per cent. only by much painstaking and quickness of manipulation.

[1] "Die chirurgischen Krankheiten des Ohres," s. 46.

B. Digital Examination of the Pharynx.

In those exceptional cases in which pharyngoscopy for some reason or another is not practicable, or only so to a limited extent, exploration by means of the finger may be employed. Digital examination is likewise practised of course, in all cases in which it is specially indicated—as for instance, to determine the consistence and mobility of a tumour in the naso-pharyngeal region. The patient should sit so low that the finger of the examiner can conveniently reach behind the soft palate. The index finger is then introduced somewhat bent, with the palmar surface downwards for examination of the lower region of the pharynx, and upwards for the survey of the post-nasal space. In the former case it is best for the patient to put out his tongue; but for examining the naso-pharynx it should be kept in. The examining finger may, if thought proper, be protected from the teeth by a strip of adhesive plaster, or by the use of a gag. In exceptional cases the soft palate is so near the wall of the pharynx that considerable pains may be requisite to introduce the finger into the post-nasal space.

Still, by following the previous directions, an examination of the region will always be possible, except where adhesions exist between the structures. If the patient be instructed to move the head somewhat in different directions, it will be easier to reach the various parts with the finger. Thus for example, the posterior nares may be best felt when the head is bent backwards. Under ordinary conditions the pharyngeal tonsil and the neighbouring parts of the upper boundary of the pharynx may be explored, as well as the prominence round the opening of the Eustachian tube, and *Rosenmüller's* fossa behind it. The borders of the choanæ (posterior nares) may also be made out, besides in the majority of cases the posterior extremities of the middle, and sometimes of the inferior turbinated bodies. The examination, though at first it may be difficult, from spasm of the muscles of the palate, should be successful if the patient be gradually accustomed to it.

Digital exploration of the inferior region of the pharynx, from the structures at the base of the tongue as far as the epiglottis, is usually accomplished very easily. The parts may be examined with greater facility as a rule, if with the other hand the larynx be pressed somewhat upwards. In these methods of examination the main points to be noted are the width of the nasal meatus; the presence of secretions in the nasal cavities; the condition of the mucous membrane; the existence of ulceration; cicatrices, polypi, and other new formations (especially in relation to the Eustachian tubes); as well as deviations from the normal, in the position, form, and size of the mouth of the Eustachian tubes.

C. Examination by Auscultation.

The method of auscultation is one of the oldest employed in the investigation of diseases of the ear. The sound, more or less loud and shrill, which the patient produces by the *Valsalvan* method in perforation of the tympanic membrane, has at all times been looked on as a conclusive sign of that condition by those not possessing any special knowledge of otology. With the development of the examination of other organs by the aid of auscultation, its use in relation to ear affections has become more advanced, so that it constitutes at the present time one of the most valued aids to diagnosis in these diseases. The method is of service chiefly in regard to the investigation of morbid states of the structures of the middle ear, especially of the Eustachian tubes, the drum-head, and the tympanic cavity; and in this respect it is indeed indispensable. The object of the process is either to obtain information as to the space-relations of the middle ear, and as to any substances contained in the cavity; or else to become acquainted with the conductibility of sounds reaching the ear of the patient.

In estimating the space-relations of the Eustachian tubes and tympanum by auscultation, air is forced through the tubes, either by the patient himself or by the examiner. During its passage it produces certain sounds which naturally vary in accordance with the spaces through which it passes, their contents, and the condition of their walls. Before describing in detail the nature of these sounds, it will be necessary to indicate the methods by which it is usually possible to cause air to enter into the middle ear.

These are:—*The Valsalvan process;* and *The employment of the air-douche, with or without the catheter.*

(*a*) *The Valsalvan Process.*

This method consists in the patient, after a deep inspiration, making a forced expiration while the mouth and nostrils are closed. The air is forced in this way into the pharyngeal space, and being unable to find an outlet through the mouth or nose, enters other permeable passages. If the tubes are patent, and the air passes through them, it reaches the tympanum; and the patient experiences a sensation of pressure upon the drum-membranes, which are forced outwards towards the auditory canals.

Certain persons, when desired to follow out the instructions just indicated, do not comprehend what they are required to do, and especially is this the case with children. In such cases the author proceeds by closing the nostrils by external pressure with the fingers; and having

directed the patient to shut his mouth, instructs him to make a forcible movement, as in blowing his nose.

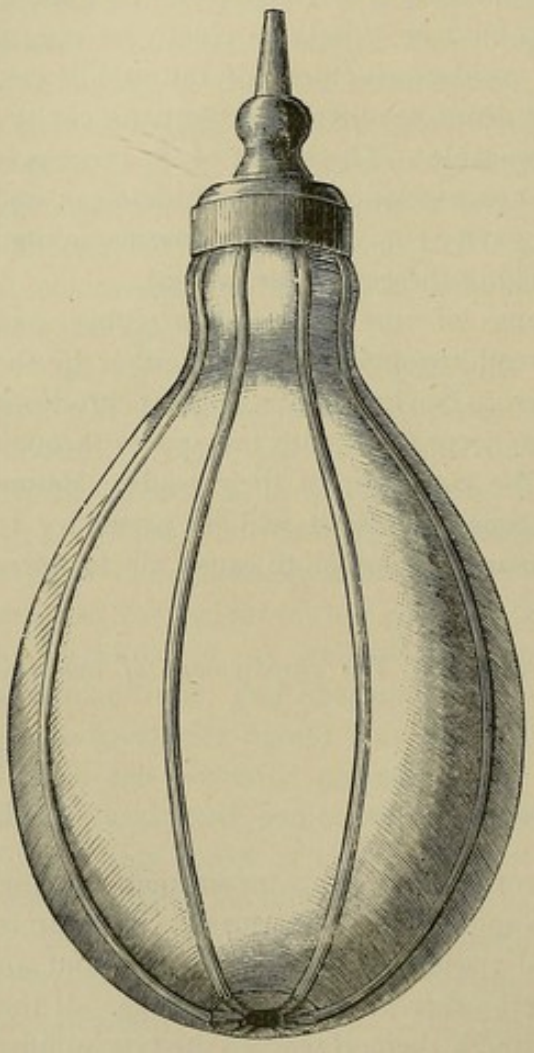
Under normal conditions air also passes through the tubes into the tympanum during the act of swallowing. This method was employed by *Toynbee* as a test of the permeability of the Eustachian tubes. It will be referred to farther on more in detail.

(*b*) *The Air-douche.*

In this method the examiner forces air into the middle ear through the tubes, with or without the aid of the Eustachian catheter, and either with the mouth or with some special apparatus. The latter are constructed with a view to produce either a single blast of air or a more continuous current, the first kind answering well enough for ordinary purposes. These are usually pear-shaped indiarubber balls fitted with a vulcanite nozzle, which may if required be introduced into the wide end of an aural catheter.

Fig. 71.

Indiarubber air-ball (half ordinary size).



Formerly air-balls were employed with variously constructed valves for the successive renewal of the air expelled (*Deleau*); but such arrangements have been almost completely given up; bags without valves being now used.

The air-bag used by the author, and represented in the adjoining figure (Fig. 71), has an opening about 5 *mm.* in diameter at the broad end, which may be closed by the thumb of the hand compressing the bag, and then uncovered for the renewal of the air for the next inflation. Successive blasts of air may in this way be forced through the catheter without the necessity of removing the air-ball. *Lucæ*[1] uses a double bag, similar in construction to that fixed to *Richardson's* apparatus for

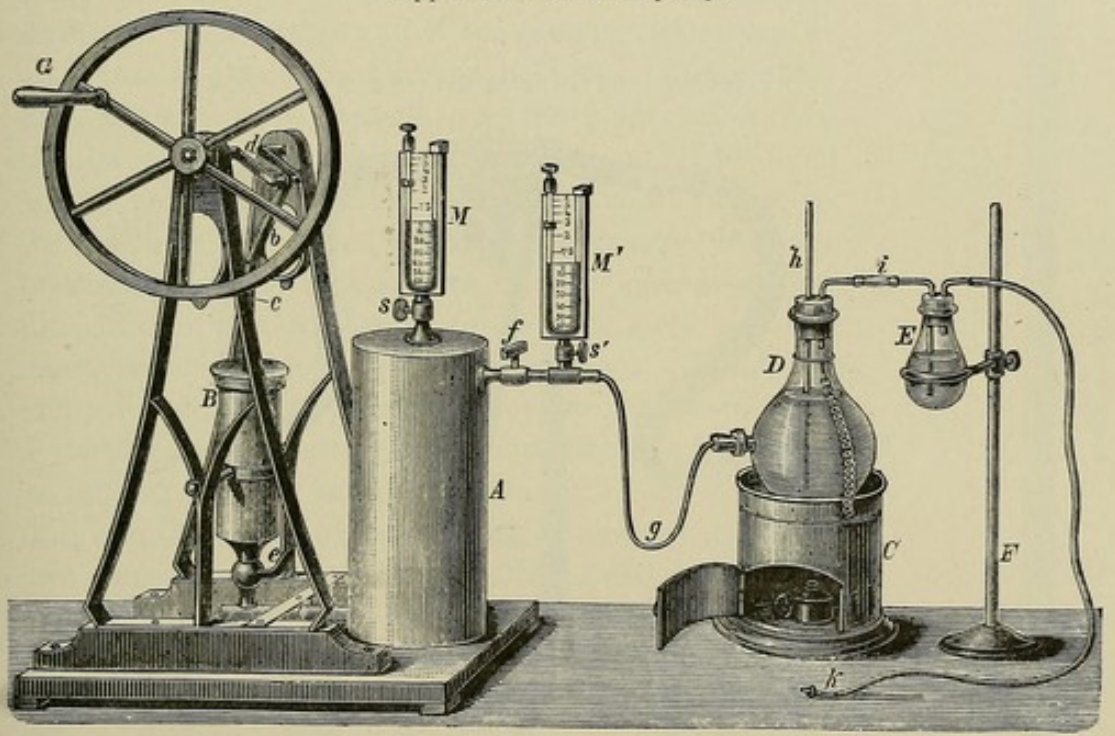
[1] "Apparat zur diagnostischen und therapeutischen Anwendung der Luftdouche bie Ohrenkrankheiten." Deutsche Klinik, 1866, Nr. 8.

producing anæsthesia. He says in recommendation of this, that instead of working intermittently, it produces a more constant stream of air, and that it is more portable. It has not so far, however, displaced the ordinary simple arrangement in general use.

A. Ott[1] has recommended an arrangement intended to obviate the repeated removal of the air-ball from the catheter for renewal of the air. Two tubes are fixed into the nozzle end of the ball, and fitted with pieces of indiarubber tubing, of which the end of one is to fit over that of the catheter, and the end of the other is to be held between the teeth of the examiner. The latter can be thus closed while the bag is being compressed, and then released for the admission of fresh air.

Fig. 72.

Apparatus with force-pump.



B, Force-pump; *A*, reservoir; *M*, manometer to measure pressure of the air in reservoir; *k*, nozzle for insertion into catheter; *e*, *f*, stop-cocks; *M'*, manometer to measure pressure of air current.

This instrument again, has however not found its way into practice.—*Zaufal*[2] employs an apparatus in which air is forced in by the foot acting on a treadle-arrangement; and he advises also the use of a disinfecting filter through which the air is to be passed before reaching the catheter.

For the introduction of a more continuous current of air various forms of apparatus have been constructed, in which force-pumps are ordinarily used. In most of the older forms the piston is pushed forwards and drawn backwards in the

[1] "Eine Modification der Ballondouche." Archiv für Ohrenheilkunde, xiv. Bd., S. 186, u. ff.

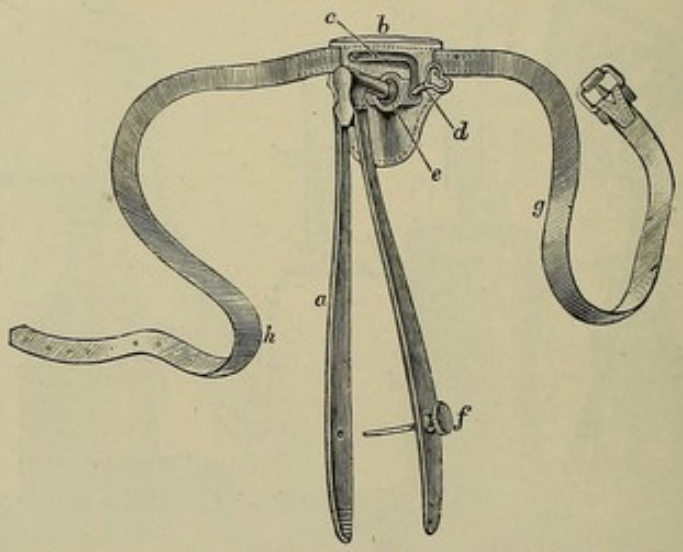
[2] "Desinfectionskapseln in Verbindung mit den üblichen Luftdouche-apparaten." Archiv für Ohrenheilkunde, xvii. Bd., S. 1-7.

compression tube—a laborious affair during a prolonged sitting. In the author's arrangement (Fig. 72) a handle is used for this purpose.[1]

If it be desired to continue the injection of air into the Eustachian tube for some time, it will be necessary to fix the catheter. The author cannot entirely agree with the advice of some aurists in intrusting the instrument into the hands of patients, as they are very apt to turn it on its axis, or press it too firmly against the walls of the Eustachian tube, in which case the end of the catheter may become obstructed. Or again, they may at once snatch the instrument out on experiencing the unusual sensation of the passage of air, and possibly injure themselves. The author therefore employs a frontal arrangement for fixing the catheter, constructed on the plan of *Kramer's* forehead band. It is represented in Fig. 73.

Fig. 73.

Forehead band for fixing the catheter.



b, Padded frontal plate; *g*, *h*, lateral straps to go round the head; *e*, ball-and-socket joint; *c*, spring connecting forceps with frontal plate; *f*, adjusting screw.

Catheterisation of the Eustachian Tube.

This indispensable aid to both the diagnosis and treatment of many aural affections was employed in the first place by *Guyot*, a postmaster of *Versailles*; who according to his own account, cured an impairment of his own hearing by its means. There can however be no doubt that *Guyot* merely originated the idea, and that the merit of its practical employment belongs to the English military surgeon *Archibald Cleland*. *Guyot* introduced an instrument through the mouth, and reached probably only somewhere in the vicinity of the mouth of the Eustachian tube; whilst *Cleland* for the first

[1] The description of this complicated apparatus has been omitted, as its construction may be sufficiently understood from the illustration.—Eds.

time catheterised the tube through the nose, and that almost on the same principles by which the present practice is guided. With regard to the history of aural catheterisation, the introduction of which into France is due mainly to *Saissy* and *Itard*, and to *Wilhelm Kramer* in Germany, reference may be made to previous text-books of ear diseases, especially to the works of *Lincke*[1] and *Martell Frank*.[2] Here we may at once proceed to the description of the necessary instruments, and to the operation itself.

Fig. 74.
The Eustachian catheter.



The *Eustachian catheter* consists of a tube of german silver, silver, or vulcanite, 15 *cm.* long (Fig. 74). At its outer conical end a metal ring is fixed on the same side as that to which the point of the catheter is directed. The farther end of the catheter is curved at an obtuse angle of about 40° to the stem. The author, like *Kramer*, uses instruments the points of which, though well rounded off, are not bulbous. The outer end is wider than the rest of the tube, so as to receive the nozzle of the air-ball previously described. Bulbous instruments, which are said to obviate injuries during introduction, he considers to be not only not advantageous, but positively disadvantageous. A bulbous end is an obstacle to the passage of the catheter through a narrow nasal meatus, and is also liable to be caught in relaxed folds of mucous membrane in its introduction into the mouth of the tube, which narrows upwards, and thus the opening of the catheter may be blocked in a way not likely to occur when its end is more pointed. It is likewise important that the end of the beak should be cut straight—that is, at right angles to the shaft of the tube of the catheter—otherwise the sharp angle may injure the parts, besides being liable to be covered by the lining of the mouth of the Eustachian tube, and thus lead to its being closed.

Instruments of different sizes are required in accordance with the varying size of the nasal passages in different persons. The largest employed by the author (Fig. 74) has a calibre of 3 *mm.*; the narrowest 1 *mm.* They are of equal width throughout, being more easily cleaned than those with conical ends. The catheters are numbered 1, 2, and 3, on the outer

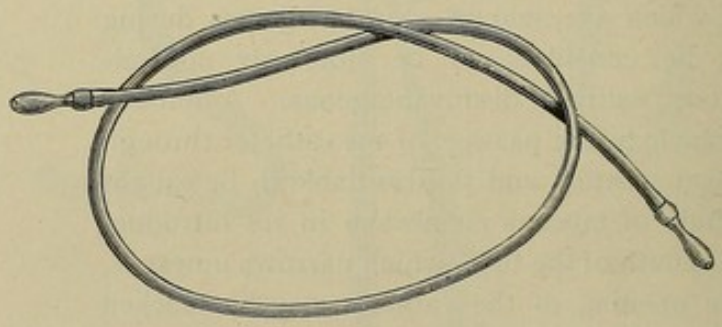
[1] "Handbuch der theoretischen und praktischen Ohrenheilkunde," 1837—1840.
[2] "Practische Anleitung zur Erkenntniss und Behandlung der Ohrenkrankheiten." Erlangen, 1845.

end. Other marks—*e.g.*, a line engraved on the tube in the older instruments, which was supposed to indicate the distance of the mouth of the Eustachian tube—are useless, on account of the varying measurements in different patients.

Metal instruments are more durable, more easily cleaned, and more suitable for use by beginners. The vulcanite catheters are more easily damaged or broken, but have the advantage of not being affected by certain substances which attack metal. Nervous patients too, on seeing their flexibility, are more easily amenable to treatment with them. It is therefore well to have a few at hand for use in suitable cases. Before being used, care should be taken to see that the catheter is quite clean; and metal instruments should be slightly warmed. It is advisable for each patient to have his own instrument during treatment; and where this is not convenient, the catheter should be boiled after each application in a 5 per cent. solution of carbolic acid, and then syringed out. A simple syringing with hot water is not sufficient. A case related by *Dr. Coutagne*, as well as a more recent one of *Burow's*, sufficiently indicates the necessity for great precaution in this respect. *Burow*[1] relates six cases of syphilitic infection followed by general symptoms, brought about by catheterism. He also quotes other cases, recounted in medical literature, of a similar transmission of syphilis.

Fig. 75.

The Otoscope.



The otoscope[2] is employed in connection with the air-ball or the catheter for the purpose of aural auscultation. This is an elastic tube (Fig. 75) about two feet long, and of about $\frac{1}{4}$-inch bore. The one used by the author has nozzles—one of vulcanite, and the other of ivory. One of these (*e.g.* the ivory end) is invariably used by the aurist, and the other always for insertion into the patient's ear. In this way possible contamination by pus or other matters in the auditory canal of the patient is avoided.

In employing the otoscopic tube, care should be taken that its lumen is not occluded, either by its becoming bent or by its opening becoming

[1] "Uebertragung von Syphilis durch den Tubenkatheter." Monatsschrift für Ohrenheilkunde, xix. Jahrgang, p. 129.

[2] The editors deprecate the current use of the term "otoscope" to denote the tube employed in auscultation of the middle ear. In accordance with its etymology, the aural speculum would be thus more appropriately designated. Otophone would perhaps be a more suitable name for the instrument.—Eds.

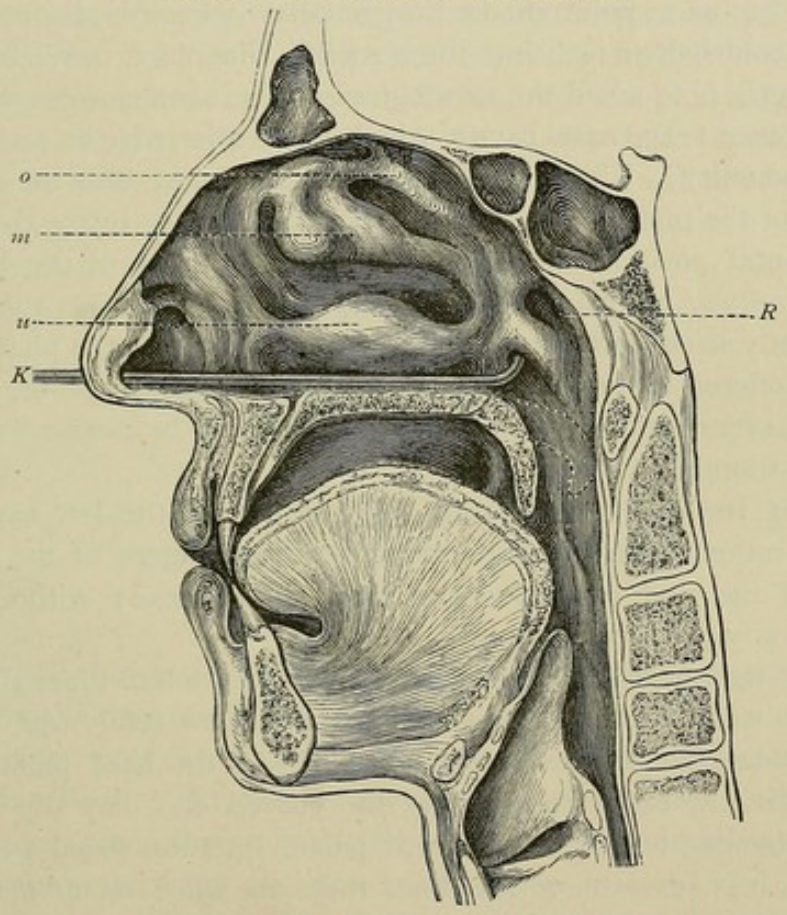
blocked by foreign matters. The latter may often occur from accumulations of cerumen or exudation in the auditory canal, and might give rise to fallacies in auscultation.

The author uses a tube of a similar length and diameter to that of *Toynbee*, its inventor. Shorter or thinner ones are unsuitable; a longer one being however more convenient for a tall observer.

The employment of the catheter for purposes of diagnosis is carried

Fig. 76.

Sagittal section of cranium (right half).



o, Superior turbinated body; *m*, middle turbinated body; *u*, inferior turbinated body; *R*, *Rosenmüller's* fossa, limited in front by the limbus cartilagineus; in front of the limbus is the mouth of the Eustachian tube, in which is placed the end of the catheter, *K*. Below the catheter is seen a sectional view of the hard palate, with the soft palate in continuation behind, directed downwards. The dotted line represents the position of the soft palate at a certain moment during the act of deglutition.

out in the following way :—After selecting a suitable catheter and air-ball, the examiner holds the latter underneath his left arm, with its nozzle end backwards, and throws the otoscopic tube with its ivory end backwards over the left shoulder. He then takes the catheter in his right hand, and stands or sits opposite the patient in such a way as to bring the nasal cavity of the latter at a convenient height for the purpose of passing the catheter. In most cases the most suitable elevation for the nasal meatus is

that of the examiner's shoulder. No set rule can however be laid down in the matter: in many cases it is better for both to sit; in others for the patient to sit and the examiner to stand.

The patient having previously cleared the nasal cavities—by blowing his nose, if necessary—holds his head in such a way that the lower nasal meatus has a horizontal direction. The aurist, leaning then the fingers of his left hand against the patient's forehead, raises slightly the tip of the nose with his thumb. Holding the outer end of the catheter loosely between the thumb and index finger of the right hand, and with the curved beak raised so as to point almost horizontally backwards, he introduces the latter for about half an inch into the nostril. The object of raising the beak of the catheter is to avoid the cartilaginous ridge at the lower and inner part of the entrance to the nasal cavity, which would otherwise be an impediment to its introduction. The beak being thus introduced into the meatus, the outer end of the instrument is at once raised so as to bring the shaft into the horizontal position, in correspondence with that of the lower nasal meatus; *and with the point of the beak kept down all the time*, the catheter is passed gently backwards as far as the posterior wall of the pharynx. The resistance offered by the pharynx to the further passage of the instrument gives a sensation similar to that felt if the catheter be pressed against the ball of the thumb.

During the entire manipulation the thumb of the left hand remains under the catheter, which glides along it. The fingers of the same hand are closed up, and rest upon the side of the nose; without however exercising any pressure upon it.

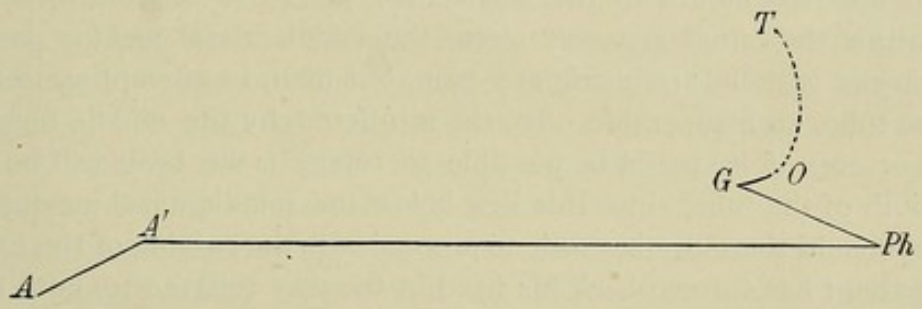
When the extremity of the catheter has been felt to touch the posterior pharyngeal wall, it is to be drawn back—*the beak being kept still directed downwards*—as far as the posterior margin of the hard palate. In this movement it may easily happen that the curved end may slip back again over the rounded border of the hard palate into the nasal passage. To avoid this, it is advisable *to somewhat raise the outer end of the instrument while it is being drawn back*, by which means the depressed beak meets with more resistance at the margin of the palate. The sensation given to the fingers by this resistance is very like what would be felt by drawing the curve of the catheter against the side of an extended finger.

The beak of the catheter being now hitched against the border of the palate, the shaft of the instrument will have to be turned for from $\frac{1}{4}$ to $\frac{3}{8}$ths of the circumference, in order that the point of the beak may enter the opening of the Eustachian tube. Since however the mouth of the tube is not situated immediately above the margin of the hard palate, but at about 5 *mm.* behind this, the catheter must be again pushed forwards for that distance before it is rotated outwards. After it is turned round, the outer end of the instrument is to be moved a little downwards and

inwards towards the septum, when the point of the beak will advance gradually into the mouth of the tube (compare Figs. 76 and 77). If the end of the catheter has advanced far enough into the tube, it is held there firmly by the thumb and index finger of the left hand. With restless patients a small portion of the lower part of the nose may also be lightly held between the thumb and finger, thereby preventing the instrument being moved out of position by movements of the head. In children this is especially advisable; but in every case a slight support is derived from the remaining fingers of the hand which are resting against the nose.

Five movements may be distinguished in the method of introducing the catheter just described. First, its introduction through the nostril; second, its advancement as far as the wall of the pharynx; third, its withdrawal to the posterior margin of the hard palate; fourth, a second advance as far as the mouth of the Eustachian tube; and fifth, the rotation

Fig. 77.
Schema for catheterisation.



and pushing forwards of the instrument into the tube, together with its reception by the fingers of the left hand.

During the first four movements the beak of the instrument, and so the ring fixed on its outer end, is always kept downwards; whilst in the last movement, when the point of the catheter is introduced into the tube, the ring looks in the same direction as the latter.

The adjoining diagram (Fig. 77) serves to indicate the entire process. *A A'* shows the direction of the catheter in the first movement of its introduction through the nostril; *A' Ph* denotes the second movement in which it is pushed back as far as the pharyngeal wall; *Ph G* indicates its direction in withdrawal to the border of the hard palate; *G O*, the fourth movement, shows its fresh advance as far as the mouth of the Eustachian tube; and *O T* represents the fifth action of rotation into the tube. The dotted line must be imagined oblique, from the middle below, upwards and sideways.

The patient has his head free all the time. With children, or with persons who cannot keep their heads still, the occiput may be rested against something firm, or when necessary the head may be supported by

an assistant in the proper position. The author cannot endorse *Von Tröltsch's* recommendation for the operator to put his left hand round the head to keep it firm, as he can find much better use for it as described. In general it is to be stated that throughout the process as little force or precipitation as possible should be used in the manipulation.

With very difficult cases the author has of late employed cocain to diminish the sensibility of the nasal mucous membrane. It may be applied either in the form of a 5 per cent. spray solution, or by means of a piece of cotton-wool dipped in the solution and left for some minutes in the nasal cavity.

During the first movement of the process of catheterisation, it commonly happens that a patient inclines his head backwards, seeking instinctively as it were, to escape from the instrument. In such cases, if the movement were continued, the catheter might pass into the middle, or even the superior, instead of along the lower meatus, and in its further progress meet with obstacles and cause pain, especially in the final introduction into the mouth of the Eustachian tube. It may however often happen that the catheter passes along the middle nasal meatus as far as the pharynx without producing any pain, but then, in attempting to turn it into the tube, an insuperable obstacle is offered by the middle turbinated body; or even if it should be possible to rotate it, the beak will be above the mouth of the tube, since this lies below the middle nasal meatus. No attempt should therefore be made to proceed with the passing of the catheter if the patient has thrown back his head in the way referred to, until he has again brought it into the proper position.

It sometimes happens, on account of the frequent irregularities of the turbinated bodies, as well as from deviation of the nasal septum to one or the other side, that even the thinnest catheter cannot be passed at all, or only with great difficulty, with the beak turned downwards in the ordinary way. In such cases the operator should not at once desist from the attempt at catheterisation; but should endeavour, holding the instrument lightly between his fingers, to feel his way with it along the passage. Usually first during the posterior half of its progress, but sometimes even in the outer third of the passage, it may be necessary to move it carefully to one or other side, or even turn it round its axis before it is found practicable to introduce it. In other instances again, it will only be possible to pass the catheter by turning its beak *upwards*. When in the pharynx it must be turned so that the beak is again directed downwards, the further manipulation being then as usual. All these and similar difficulties are more or less easily overcome by practice. In general however it may be unreservedly stated, that skill in catheterisation is not characterised by rapidity of introduction into the Eustachian tube, but rather by the ease and certainty with which the instrument is passed through the nasal meatus.

Those cases in which, on account of irregularities of structure, it is quite impossible to pass the catheter into the pharynx, must be counted as *very rare.*

The author has hitherto met with but extremely few cases in which both nasal fossæ were impermeable to the catheter. Congenital, or even acquired cases of this kind, are generally only unilateral, and in such the instrument may as a rule be introduced into both Eustachian tubes through the free side. *Löwenberg*[1] recommends previous rhinoscopy, or else the employment of strong illumination of the nasal meatus by means of a reflector, with the view of better avoiding impediments to catheterism.

Obstacles again may present themselves to the rotation of the instrument in the last stage of catheterisation, and these may be either of a temporary or a permanent nature. Tumours in the region of the pharynx, as well as very enlarged tonsils, sometimes narrow the post-nasal space so greatly that the necessary room does not exist for the turning of the instrument. In contrast to such impediments are those of a more temporary character due to contraction of the muscles of the pharynx. These usually disappear spontaneously in a little time, while any attempt to overcome them by force results only in injury, accompanied by bleeding. To succeed in such cases it is often only necessary to desist from any attempt for a short time, as the muscles soon relax, and the process may then be completed with ease.

If, exceptionally, the opening of the Eustachian canal be very deeply placed, it may possibly happen that the catheter cannot be rotated, even though its beak has reached the tube. In such instances, even when the manipulation has been properly carried out, the ring of the catheter is seen to be directed somewhat downwards ; and when opposite the opening of the tube, which is far up in the pharynx, the ring must look almost directly upwards.

Too much stress cannot be laid upon the necessity for beginners to adhere strictly to the rules laid down for the proper performance of the process of catheterisation. All haste, and especially any attempt to evade one or other of the indicated movements in the manipulation, not only in most cases delays its completion, but is prejudicial to the acquirement of that degree of certainty which can generally be otherwise soon gained.

Some cannot at first appreciate the necessity for the carrying out of all the movements. In the second stage, for instance, in which the catheter is pushed forwards as far as the pharynx, they may attempt to cut short the movement, and begin to rotate the instrument haphazard as soon as they think they have reached the posterior margin of the hard palate. Exceptionally this may be successful, but as a rule nothing but pain and remonstrance on the part of the patient result.

[1] "Ueber eine Methode zur Erleichterung der Schwierigkeiten bei der Einführung des Katheters." Archiv für Ohrenheilkunde, vol. xix., p. 79.

Others attempt to dispense with the fourth movement, after having touched the pharynx, by simply drawing back the instrument to some distance and at once rotating it. If the distance of the Eustachian tube from the posterior wall of the pharynx were constant, this might be feasible; but inasmuch as it varies from ½ to 1 in., it will only exceptionally happen that the mouth of the tube will be hit upon; the beak will be either behind it, in *Rosenmüller's* fossa, or in the nasal cavity in front.

In the normal condition, the limbus çartilagineus projects outwards to the extent of some lines. It might be suggested to take this prominence as a guide to the mouth of the Eustachian tube, which is situated just in front of it. As against this, it is to be remarked that the prominence referred to is not always sufficiently developed to allow of its easy detection with the catheter. It is generally so insignificant, especially in young persons, that even a practised operator detects it with difficulty, if at all. Just in those cases indeed in which catheterisation is necessary both for diagnosis and treatment, as in catarrh of the naso-pharynx and middle ear, it is apt to be quite obliterated on account of the swelling of the surrounding parts—so much perhaps as to be even indistinguishable to the eye on the cadaver.

Besides the marks referred to, all other structures which may serve as guides in catheterisation are so variable in position, form, and size, that for beginners they can be but of small service in this respect.

Löwenberg recommends that the catheter, after being pushed back to the pharynx, shall be rotated so that its beak looks towards the opposite Eustachian tube, and then drawn back until it hooks against the septum. It is then to be rotated again to the side which is to be catheterised, and passed thus into the mouth of the tube. There is no doubt that catheterisation is feasible in this way, but the author cannot admit it to be simpler or more certain than the method above described. He has observed too that it is usually more disagreeable to the patient. In certain cases, especially in some anomalies of the lateral pharyngeal wall, it may be adopted if the other method has failed; but its general use, and in particular for beginners, cannot be recommended.[1]

The manipulation being completed, it is necessary to know whether or not the instrument is really in the mouth of the tube. The position of the ring on the outer end of the catheter is not a certain criterion. In some cases, above adverted to, even though the instrument is in proper position, its direction, and so that of the ring, is not the usual one. On the other hand, there are others in which, though the ring of the catheter has the ordinary correct direction, the beak of the instrument is not really in the tube.

The fact that the patient, if the instrument is properly introduced, can speak or swallow without inconvenience, depends not so much on its correct position as upon the degree of sensitiveness of the pharynx.

[1] *Löwenberg's* method, first introduced by *Giampietro*, is not only invariably employed in this country, but also in many clinics abroad. The editors, unlike the author, believe it to be the most simple and expeditious mode of catherisation. The method originally devised by *Kuh*, and strongly advocated in some quarters, in which the posterior lip of the mouth of the Eustachian tube is taken as a guide in the procedure, likewise offers no advantages except in occasional instances.—Eds.

Some persons are in no way disturbed in the way referred to, even with the beak of the instrument directed downwards; while others cannot accomplish these acts, though the instrument is correctly placed.

A somewhat more trustworthy, though still uncertain, means of judging as to the correct situation of the catheter consists in the fact that when its beak is inserted in the Eustachian tube it cannot be further rotated, on account of the point striking against the upper wall of the tube. If, however, the instrument is not in the tube, but in *Rosenmüller's* fossa, then under normal conditions it may be rotated completely round its axis, instead of, as in the first case, for only about three-eighths of its circumference. This criterion would be a very good one if there were no abnormal conditions which may also prevent the rotation of the catheter. But inasmuch as such do sometimes exist, the value of the test is to this extent nullified. Reference may here be made to the folds of mucous membrane and pseudo-membrane, first described by *Voltolini*[1] and the author,[2] which are found sometimes stretched obliquely across *Rosenmüller's* fossa, dividing it into upper and lower segments. Their presence would equally prevent the complete rotation of the catheter. The above signs therefore, though not in every case giving certain evidence of the proper position of the catheter, should be noted as of a certain value. The chief means of proof however rest upon the results of auscultation, of rhinoscopic inspection, and also of digital examination. If rhinoscopy is possible, it gives absolute proof of the true position of the instrument; while digital examination, though less conclusive, is very valuable in those cases in which a rhinoscopic observation is impracticable. A positive result of auscultation of the tube is of course certain evidence that the catheter is in it; but since the result is sometimes negative, there only remains inspection by rhinoscopy as the means which can in all cases yield absolute evidence in the matter.

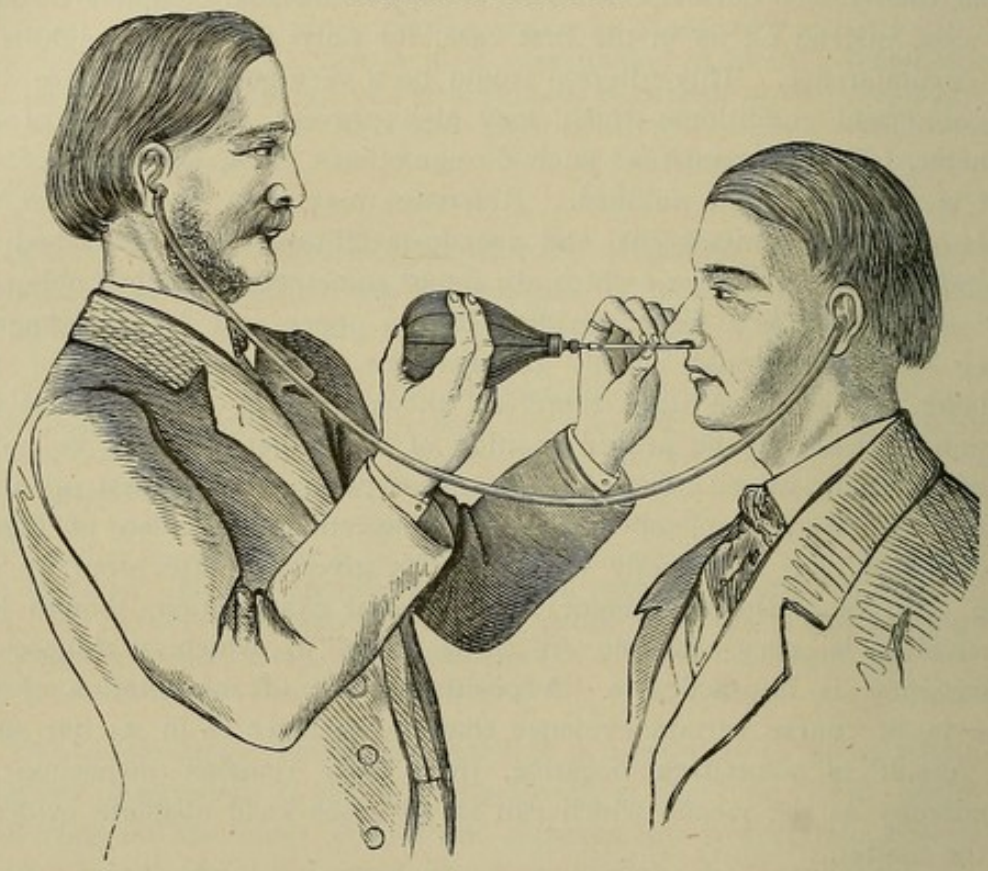
In regard to contra-indications to catheterisation, *Schwartze* distinguishes them as absolute and relative. Amongst the first kind he counts:—ulceration of the structures of the naso-pharynx, with great tendency to hæmorrhage; high fever; severe inflammatory pain in the ear; acute pharyngitis; and traumatic emphysema of the pharynx. As relative counter-indications, he enumerates:—debility during convalescence; great nervous irritability from aggravating local conditions; advanced old age; and early childhood to about the fourth year inclusive. According to the author's experience, such contra-indications cannot be so rigidly maintained; for he has treated many patients with advantage with the

[1] "Die Pharyngoscopie und ihre Verwerthung für die Ohrenheilkunde." *Virchow's* Archiv xxi., 1, S. 45.

[2] S. Berichte des Wiener allgemeinen Krankenhauses.

catheter who were suffering from purulent inflammation of the middle ear with high fever. There are certain cases in which the use of the catheter is urgently indicated in order to clear out accumulations from the tympanum; otherwise the patient is exposed to the greatest danger, and no other method is effectual in accomplishing this object. Though all the circumstances referred to should come under consideration, the

Fig. 78.
Auscultation of the ear.



author cannot, according to his knowledge, recognise "absolute contra-indications."

1. *Auscultation in connection with the Catheter and Air-douche.*

The catheter being properly adjusted in the Eustachian tube, if air is blown through, it enters the tympanic cavity, and even into the mastoid cells. The air which previously filled the spaces of the middle ear is at first compressed to a certain degree, and all such structures as are movable, yield somewhat to the compression. If the mouth of the Eustachian tube is not quite filled by the beak of the catheter, some of the air may flow back towards the pharynx.

In entering the cavity of the middle ear, the air produces a sound,

for the more distinct perception of which the otoscopic tube is employed, one of the nozzles being placed in the external auditory canal of the patient, and the other in that of the auscultator. It is best for the tube to lie above that hand of the aurist which is maintaining the catheter in position, as in this way the nozzle is not so apt to fall out of the patient's ear. It is not advisable for the patient to hold the nozzle of the tube in his own ear, because, being unacquainted with its purpose, he may easily shut up its orifice, and the result of auscultation may thus become *nil.* Exception to this should only be made in very rare cases, in which on account of the narrowness of the auditory meatus, the end of the tube will not remain fixed in the ear; and then it should be seen that the nozzle is held properly, and also that the elastic tube is not compressed. Before being used the otoscope should be inspected, to see that it is not stopped up by cerumen or other matters derived from the auditory canal. If such exist, they may be removed with a probe, or the end of one branch of a pair of ear-forceps.

In introducing air through the catheter by means of the air-ball, the aurist takes this from under his left arm, and holds it so that the opening in the broad end is covered by the right thumb, while his fingers support it in such a way that the index and middle fingers are above and the other two below. The nozzle of the ball is then placed in the catheter, the end of which should be thoroughly closed by it; and then pressure is made both by the thumb and fingers upon its surface. In emptying the air-ball, care must be taken that the force used does not act in pressing forwards the catheter farther into the Eustachian tube or against its walls. This is best done by making a gentle counter-pressure with the fingers of the hand supporting the catheter, as though to draw the instrument somewhat out of the tube.

The air in passing thus into the middle ear produces a tolerably broad sound as heard through the otoscopic tube, seeming almost as though it were blown directly through the tube into the ear of the auscultator, but somewhat weakened in intensity on account of the intervening tympanic membrane. This sound may be best imitated by pressing the lateral borders of the tongue firmly against the hard palate, thus leaving the dorsum concave, and then blowing with a moderate strength. The air-ball, being emptied, does not need to be withdrawn from the catheter in order to be refilled. All that is necessary is to remove the thumb from the opening at the base. The air then re-enters, and, the thumb being replaced, the air-bag may be again compressed, and fresh air expelled; the operation being repeated as often as desired. It is not difficult to distinguish the sound which is produced by the actual entrance of air into the middle ear from other sounds, which may be heard when the end of the catheter is not really in the mouth of the Eustachian tube. Once heard, the normal sound

will be always recognised again. It is easy to understand that certain sounds may be produced in imperfect catheterisation. During catheterisation of one ear a sound may be indeed perceived in the other one into which no air enters. All such may however be distinguished from the sound which accompanies a proper catheterisation, as the result of entrance of air into the tympanum. In this case it is perceived quite close—as it were "blown into the auscultator's own ear." But slight practice is needful to recognise the place of origin of the sounds heard. It is easy to determine by auscultation whether the air passes only as far as the tympanic cavity and is there confined, or also through this.

When the normal sound, or the abnormal sounds to be subsequently described, are perceived so near as to suggest their originating in a space in immediate communication with the auscultating ear, a certain criterion is thereby afforded of correct catheterisation. It is otherwise if the result of auscultation be negative. If no sound be heard, or a remote sound only, this is by no means an indication that the procedure has not been properly conducted, and the catheter not in the correct position. If the Eustachian tube is quite occluded somewhat above the end of the catheter, the sound may be heard "*more distant from the ear*"; or if the point of the catheter impinges on the occluding structure, the sound may be entirely absent.

In such a case rhinoscopy is the only reliable means for determining the position of the catheter; and if this be impracticable, the matter remains in doubt should digital examination likewise give no positive result. Besides the air-ball, other apparatus may of course be employed for the introduction of air. The mouth should, for obvious reasons, only be used for this purpose in cases of extreme necessity. The previously described force-pump apparatus may however be employed if a continuous or strong current of air is desirable; as when it is wished to observe the appearance of the drum-head while air is entering the tympanic cavity.

For diagnostic purposes, auscultation of the ear can only be satisfactorily conducted with the assistance of the catheter, other methods leading only to false conclusions. The catheter must be introduced into the Eustachian tube, and maintained there, so that other sounds than such as result from the passage of air into the middle ear cannot be produced.

The examination of the phenomena of auscultation in connection with the various objective changes to which they correspond will be undertaken later on in this work. At this stage however attention may be directed to those data which have special reference to diagnosis. The following points should be observed in relation to this matter:—

(*a*) Is the sound produced by the entrance of air into the middle ear heard as though produced in a space in direct communication with the ear of the auscultator or not? Sounds which are so perceived may be described

shortly as "near"; those not so heard, "remote," "somewhat remote," "very distant," etc.

(*b*) Whether the sound has a *large* and *full* character, as from the entrance of a free current of air; or whether it is on the contrary weak, as from a *meagre* current.

(*c*) Whether the sounds are strongly resonant ("*stark consonirend*"); or perceived as "whistling," "rattling," etc.

(*d*) Whether the sound remains of the same character during the whole time of the passage of the air-current, or whether it changes; and, in this case, whether the change is at the beginning or at the end of the inflation.

(*e*) Whether, besides the sound, the ear of the auscultator perceives also a sensation of concussion, and of change of temperature, and in what degree.

(*f*) Whether any other auscultatory phenomena are observed, and under what conditions—as of duration, etc.

(*g*) Whether the sensations received by the ear during the first act of inflation by the air-ball are repeated with the succeeding acts; or whether other phenomena are then perceived; and if so, what is their nature.

(*h*) Whether the said phenomena of auscultation are observed in the employment of catheters of different sizes; and if not, in what manner they vary.

The sounds described by the author as "*secondary auscultation sounds*" are to be carefully noted during the examination. These are the more or less distinctly audible sounds following, after a longer or shorter interval, upon the primary sound due to the actual entrance of air into the middle ear. They are caused by the retraction of normal or abnormal structures, the position of which is altered by the current of air; such as the tympanic membrane, and false membranes which may be stretched out in the tympanic cavity. In connection with these secondary sounds, the same points are to be noted as with the primary; but more particularly their duration, and the interval which elapses between them and the primary sound.

Secondary auscultation sounds occur very frequently. The tympanic membrane is usually pressed outwards in inflation, and returns to its original position after a longer or shorter interval, producing in this way a sound which is distinctly perceptible both to the patient and the observer. The sound in question is as a rule only of very short duration, and has a distinctly crepitating character, and is nearly always recognisable by the patient. In certain morbid conditions its duration may be considerably lengthened—a sign which is sometimes very valuable in diagnosis. (Further details on this point may be found in the author's work.[1])

[1] "Ueber die bei der Auscultation des Gehörorganes wahrnehmbaren secundären Geräusche." Wiener medicinische Presse, 1867.

2. *Auscultation of the Ear when the Air-douche is used without the Catheter.*

Before speaking of this mode of auscultation some other methods will be described which have been adopted with the object of introducing air through the Eustachian tube into the middle ear. Such a procedure has already been mentioned under the name of the *Valsalvan method.* With this may be ranged the so-called *Politzer process*; that described by *August Lucæ*; and also the method introduced into practice by the author. They all aim at dispensing with the use of the catheter for purposes of diagnosis and treatment; and after having given some account of them the question as to how far this is attainable will be discussed.

(*a*) *Politzer's Process.*

Politzer recommends an air-bag with a nozzle of vulcanite formed like the curved portion of an ordinary aural catheter, and connected with a second part, also of vulcanite, by an elastic tube about two inches long. The second part can be either screwed separately on to the air-ball, or fixed on the ordinary nozzle of the latter.

Instead of this complicated nozzle an ordinary aural catheter may be used. A somewhat shorter nozzle is however always preferable, since with this less force is lost in expelling the air. The nozzle has at various times been modified in different ways by different aurists. Some recommend one of an olive shape, so as not to injure the mucous membrane; others employ a short simple tube of vulcanite slipped over the ordinary pointed nozzle of the air-ball, so that its end projects for about an inch. The author uses the nozzle represented in Fig. 79. It is shaped like an aural catheter, but is shorter, and is to be screwed on to the air-ball. He prefers it to *Politzer's*, as being more easy to use, and less troublesome to clean.

With the object of avoiding injury to the nasal mucous membrane, the author, following *Löwenberg's* advice, employs protective tubing. This is a piece of elastic tubing from 3 to 4 *cm.* long, which is drawn over the extremity of the nozzle so as to project for about $\frac{1}{3}$ *cm.*

Hæmorrhage from the nasal mucous membrane cannot always be avoided with any of the nozzles in vogue. Many individuals bleed even from simple pressure upon the nostrils; and the author has frequently seen hæmorrhage from the back part of the nasal cavity. It may be more easily obviated if a piece of protective tubing be used instead of a hard nozzle. If this piece of tubing be kept by the patient for his own use, the possibility of infection may be prevented.

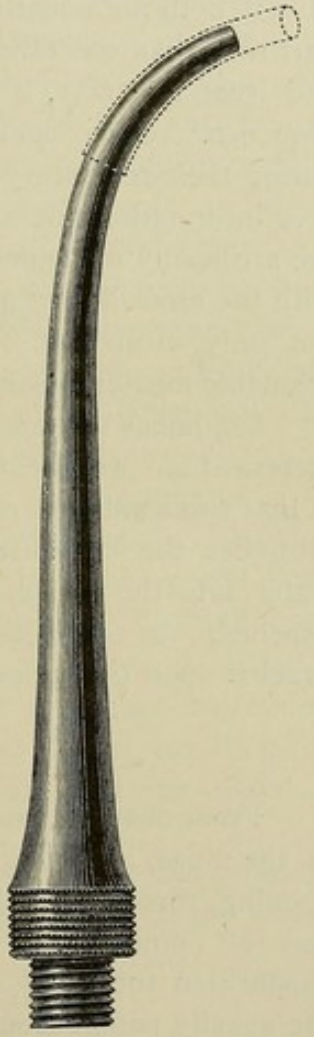
Politzer's method is carried out as follows:—The patient first takes a little water into his mouth, and is instructed to swallow it at a given sign. If it is desired to auscultate the ear, the otoscope is used as well. The nozzle of the air-ball is now introduced into the nostril for a short distance, and both alæ nasi compressed by the thumb and index finger of the left hand, so as to shut off the nasal cavities completely from the outside. The

patient is now directed to swallow the water, and at the same moment the air-ball is quickly emptied by the right hand.

The entrance of air into the middle ear is explained thus:—At a certain moment during the act of swallowing the soft palate is drawn back against the pharynx, thus shutting off the upper, or post-nasal region of the pharynx, from the lower. The mouths of the Eustachian tubes become at the same time dilated in the act; and the air, forced through the nose into the naso-pharynx, having its escape cut off in front by the closure of the nostrils, behind by the soft palate, finds its way along the Eustachian tubes into the tympanum.[1]

Fig. 79.

Air-ball nozzle (ordinary size). The dotted line represents an elastic protecting tube.



During the influx of air into the tympanic cavity, sounds of a rushing or cooing kind are heard if the membrane is intact, which are due only to a very small extent to the actual entrance of air into the middle ear. They are for the most part accessory sounds produced during the act of swallowing, or through other incidental occurrences in the post-nasal region.

Kramer,[2] in speaking of catheterisation of the Eustachian tube, remarks: "If the patient, on inflation through the catheter, does not perceive the air either in his ear or throat, he may be directed to swallow at the moment the air-ball is again emptied: by this expedient the inflation will usually be successful." The author, before *Politzer* had introduced his method, followed *Kramer's* directions in appropriate cases, and reported on these in 1862. Even without using the catheter, the author had carried out inflation of the middle ear during a movement of deglutition by simply emptying the air-ball, the nozzle of which was inserted into the nostril of the patient. It will thus be seen that the fundamental principle on which this method is based had been already previously recognised, and that a claim to "practical application of a new principle" cannot be sustained.[3]

Advantages and Disadvantages of Politzer's Process.

The great advantage of this method of inflation is chiefly in dispensing

[1] Compare *A. Politzer*, "Ueber ein neues Heilverfahren gegen Schwerhörigkeit und Ohrensausen in Folge von Unwegsamkeit der Eust. Ohrtrompete." Wiener medicinische Wochenschrift, xiii., 6, 7, 8, 10 (1863).

[2] Die Erkenntniss und Heilung der Ohrenkrankheiten. Berlin, p. 493.

[3] *Von Tröltsch*, "Das *Politzer'sche* Verfahren zur Wegsammachung der Ohrtrompete," etc. Archiv für Ohrenheilkunde, vol. i., p. 41.

with the use of the catheter. The unpleasant sensations accompanying its introduction are thus avoided on the one hand, and on the other inflation of the middle ear is practicable in cases in which, on account of anomalies in the post-nasal region or elsewhere, the catheter could not be employed, or is objected to by the patient. The latter cases are indeed rare nowadays, being confined almost entirely to children; and it is with them, and in cases of nasal obstruction, that the process is of such great value. Certain disadvantages are nevertheless necessarily associated with this mode of inflation. For instance, the air cannot be blown into only one Eustachian tube if both are equally patent, but will pass through both; and if one is narrower than the other it will certainly enter the wider tube. Diagnosis and treatment may, it is obvious, become erroneous or imperfect in consequence.[1] Since again the air is admitted through the Eustachian tubes during their temporary dilatation in the act of deglutition, auscultation will give information not as to their usual condition, but as to that when they are artificially distended. With stenosis or occlusion of one tube, inflation with the air-ball may give rise to unpleasant consequences in the other ear, not only cicatricial or otherwise morbidly changed, but even healthy tympanic membranes having been lacerated in this way.[2]

Giddiness too, and even syncope, may ensue upon the sudden greatly increased air-pressure in the middle ear. Another objection to this method is that some patients object to swallowing the water, or to using a glass at all under the circumstances; besides which air is often forced with the water into the œsophagus, and gives rise to discomfort until it is again expelled. In other cases the patient, instead of swallowing the water, may expel it upon the operator during the compression of the air-ball.

(*b*) *Lucæ's Method.*

From observations made on a patient in whom the external structures of the nose, including the nasal bones, were destroyed, leaving a large opening, through which the post-nasal region could be seen, *August Lucæ*[3] was of opinion that, contrary to the current view, the mouth of the Eustachian tube was not dilated during the act of deglutition; but "that the usually patent mouth of the cartilaginous portion of the tube is forcibly closed during swallowing, and opens again afterwards." According to him the passage of air through the tube is due not to dilatation, but on the contrary, to closure of its orifice, whereby in connection with the

[1] Compare *W. Kramer*, "Ueber *Politzer's* neues Heilverfahren gegen Schwerhörigkeit in Folge von Unwegsamkeit der Eust. Ohrtrompete." Deutsche Klinik. 1864, 34.

[2] *S. Pagenstecher*, "Zum *Politzer'schen* Verfahren," Archiv für Ohrenheilkunde, ii. Bd. S. 11;—*v. Tröltsch*, "Lehrbuch der Ohrenheilkunde." Many other authors likewise refer to these unfortunate accidents with *Politzer's* process.

[3] "Zur Function der Tuba Eustachii und des Gaumensegels." (Nach zwei im physiologischen Vereine zu Berlin gehaltenen Vorträgen.) Von *Prof. Dr. August Lucæ.*

retraction of the soft palate against the pharynx, the atmospheric pressure in the space becomes increased ; on the palate resuming its ordinary position, a sudden compensation ensues, through which the ventilation of the middle ear is effected.

That the Eustachian tube really is dilated throughout the cartilaginous portion during deglutition appears distinctly from the fact that air can be introduced through the catheter more easily during the act; less force being required to compress the air-ball, and the auscultation sound becoming at the same time more distinct and louder.

Again, in inflation by the *Politzer* process *Lucæ* holds that the Eustachian tube does not become patent in consequence of the act of deglutition ; but "as a result of increased pressure of the air in the naso-pharyngeal space, closed in front by compression of the nostrils, and behind by the opposition of the soft palate to the pharyngeal wall, the contraction of the mouths of the Eustachian tubes is overcome, and the air forces its way into the tympanic cavities." He further remarks : "That this is really the case, we may learn from the fact that air can be forced into the middle ear in a similar way by bringing about a movement of the soft palate by which the post-nasal region is more or less perfectly shut off below. Such a condition occurs during phonation, which according to my (*Lucæ's*) experience, may be advantageously employed for this purpose in catarrhal ear-affections in the following simple manner. The well-fitting olive-shaped nozzle of an elastic ball-syringe is introduced into one nostril. The other nostril is closed by pressure of the finger, and the air-ball emptied while the patient sounds the vowel "*a*" (ah) loudly and continuously. The patient perceives more or less distinctly the entrance of air into the middle ear; and if there be a copious secretion in the post-nasal region the operator hears a rattling sound, resulting from the air breaking through the raised-up velum, and carrying down the accumulation."

From this it will be seen that *Lucæ's* method consists in the prolonged intonation of the vowel "*a*" (ah) while the air-ball is used in the manner described.

Advantages and Disadvantages of Lucæ's Method.

It might be supposed, from a consideration of the advantages and disadvantages associated with *Politzer's* process, that by *Lucæ's* method some of the latter might be obviated. The chief imperfection of this procedure, however, is that the post-nasal space is not sufficiently shut off during phonation of the vowel "*a*" (ah), and the air forced in easily overcomes the slight resistance of the velum, escaping downwards into the lower portion of the pharynx instead of into the Eustachian tubes. It cannot be denied

that in some cases the process is not without value; still it is not successful in the majority of instances, or is so only to a slight extent.

Lucæ's remark that this method "is especially superior in the treatment of young children" is quite true; but illustrates the general correctness of the above criticism. In children the post-nasal space is usually narrower than in adults, and the Eustachian tubes are shorter and more easily permeable. The air forced into the space by the elastic bag, seeking an outlet in all directions, finds its way also in part into the tubes. *Schwartze* has indeed called attention to the fact that the tubes may be inflated in the ordinary way with the air-ball in children without any action at all on their part. This however is not the case in adults, whose naso-pharynx is fully developed. A successful inflation requires in their case that the post-nasal space be completely shut off below, and for this the movement of the velum as it occurs in the phonation of a vowel does not generally suffice.

(*c*) *The Author's Method.*

The post-nasal space is, as already described, completely shut off by the soft palate at a certain moment during the act of deglutition. At the same instant the Eustachian tubes are strongly dilated: a condition which, as previously stated, may lead occasionally to serious consequences as a result of strong inflation. It is however possible to bring about a perfect closing off of the upper region of the pharynx by the palate without any very perceptible accompanying dilation of the tubes. This may be done by simple pressure of the root of the tongue against the most posterior part of the palate in association with a simultaneous forcible expiratory effort. The air forced upwards in expiration cannot then find an outlet either through the mouth or through the nose; and the stronger the expiration the more is the soft palate stretched, and the more forcibly pressed against the wall of the pharynx. In practice, since many patients would not comprehend thoroughly the instructions given in regard to the desired position of the tongue, we must be content with something approaching this as nearly as possible, and such may be found in the utterance of the sound "*hk*," with emphasis on the "*k*."

A graduated scale may be formed by the interpolation of the vowels of the German alphabet: thus, *hak*, *hek*, *hik*, *hok*, *huk*, represent in order, a greater or less degree of shutting off of the post-nasal space; the weakest closure answering to the sound "*hak*," the strongest to "*huk*." Stronger closure however than the last, occurs with the sound "*hk*" without a vowel. With "*hak*" the tongue is least pressed backwards, with "*hk*" the most. If one of these syllables be pronounced, a peculiar sensation is felt in the ear, similar to that experienced when inflation by *Valsalva's* method is practised. Its character is that of a sensation of tenseness in the

drum-membrane, and depends, in fact, upon that condition. The air in the naso-pharyngeal region is more or less condensed by the action corresponding to the sound, and escapes in part through the Eustachian tube towards the tympanic cavity. This method may be thus also considered as one of a slight expansion of the tube.

This process is conducted as follows :—The nozzle of the air-bag having been inserted into the nostril, the patient is instructed to pronounce one of the above syllables, and at the same moment the bag is compressed. If successful, the manipulator will be able to recognise the entrance of air into the middle ear by means of auscultation ; and if there be present a perforation of the tympanic membrane, the characteristic sound of this will be heard. The patient himself perceives the sensation accompanying the entrance of air into the tympanic cavity; and on inspection the aurist may recognise the corresponding familiar appearance of the drum-membrane. In a word, all the signs of the entrance of air into the tympanum are distinctly present if the tube be permeable. It is well to get the patient to repeat the syllable a few times before the procedure, so as to make sure that he will do what is required.

It has been previously noted that one drawback to *Politzer's* process lies in the fact that air is forced into both tubes whether this be desired or not. The author has, however, devised a method by which the air may be more or less restricted to *one tube only*. If the patient bends his head strongly towards one shoulder, the air may be made to enter the middle ear on the side turned away from that shoulder, especially if the nozzle of the air bag be inserted into the nostril of the same side as the ear to be inflated. At any rate, should air enter both ears, more pressure is felt by the patient in the one which is directed upwards. Whether in this position of the head the muscles of one side act more energetically ; or whether the expired air is directed more forcibly towards one side of the soft palate, and so a certain direction given to the air forced into the nose ; or perhaps again whether, as *Urbantschitsch* supposes, the position of the tongue is chiefly influential in bringing about the result, cannot be exactly determined. In any case, a certain contribution to diagnostic and therapeutic resources is contained in the method described.

Advantages and Disadvantages of the Author's Method, considered in connection with those before described.

In comparing the author's process with that of *Politzer*, the forme possesses, in the first place, the advantages of great simplicity and saving of time. The swallowing of water, with its attendant unpleasantness, is also avoided. As the Eustachian tubes too are not artificially dilated in the process, the pressure of air in the middle ear is more moderated, which

is in many cases most desirable. Further, it is possible to ascertain the persistent state of the tubes more accurately by this method than by that of *Politzer*, in which the information yielded concerning them has regard to their forced dilatation. Another advantage, as the author holds, consists in the fact that by sustaining the sound of the syllable on the "*k*," the structures are kept in the position in which it is possible to prolong the pressure-effect of the air for a longer period than when this is brought about during the momentary act of deglutition. The significance of these facts will become clear in the description of diseases of the middle ear.

Over *Lucæ's* method the author's has the advantage of bringing about a more perfect closure of the post-nasal space by the soft palate. *Politzer's* process is in some cases successful where that of the author fails, and has further the advantage of producing a stronger pressure of air, such as is in certain conditions desirable. For the rest, the author can confirm the experience of certain otologists that air enters the middle ear most easily in *Politzer's* process, so that sometimes it succeeds where the other methods are ineffectual. It must however be observed that the contrary likewise occurs, and that occasionally it fails in instances in which the author's method or that of *Lucæ* is successful. This fact is connected with certain anatomical conditions of the naso-pharyngeal space, of which further mention will be made later on.

Regarding the employment of all these substitutes for the use of the catheter in auscultation—that is, for purposes of diagnosis—the same may be approximately said as was mentioned in respect of *Valsalva's* process. The auscultation is imperfect; for even with normal tubes these various methods sometimes do not evoke any sound of the entrance of air at all, and the sounds when heard do not afford the precision requisite for diagnosis. At best, information is in most cases obtained merely as to the permeability of the Eustachian tubes, and of a perforation of the drum-membrane, if present. *They can never be used as a complete substitute for the employment of the catheter in diagnosis.* Regarded as aids to diagnosis, they should not however be left out of consideration; and their practical value will be discussed farther on.

3. *Auscultation in connection with Sounding Instruments and with Speech.*

Hitherto we have spoken only of auscultation during the passage of air into the spaces of the middle ear—a process which may be compared to auscultation of the respiratory sounds in the chest. We may however apply the method with reference to the deviation of waves of sound towards the ear, in respect both of tones and speech.

In auscultation of conducted tones, a vibrating tuning-fork is used,

which is placed upon the head, and the intensity of tone conducted is estimated with the otoscopic tube. For comparison of the degree of conduction on the two sides two otoscopes are employed at the same time, and the tubes alternately compressed so as to facilitate the comparison. Tuning-forks varying in pitch should be used, as cases occur in which, of two tuning-forks struck equally strongly, the sound of that with the higher pitch is heard much louder by the examiner than that of the lower one.

In many patients also, especially such as hear their own voice-sounds intensified, the examiner likewise detects this intensified conduction to the ear by means of the otoscope. To observe this the patient should be requested to sing a note or count out loudly whilst the otoscopic tube is used. In this way the increased *autophonia* or *tympanophonia* can be usually recognised objectively.[1]

D. Tactile Examination: employment of the Eustachian Bougie.

Besides the investigation of wounds and ulcers by the probe in accordance with ordinary surgical principles, the employment of the Eustachian bougie requires special consideration.

It is to be observed that in the use of bougies, and more particularly in regard to metallic instruments, the greatest care is called for, on account of the delicacy and the great functional importance of the deeper structures of the ear. With Eustachian bougies an important lesion cannot be easily produced under normal anatomical conditions; but in the employment of metallic probes, introduced perhaps through the external auditory canal, or through fistulous passages leading in the direction of the labyrinth, such a result might easily happen. In using such instruments it is therefore advisable to conduct the manipulation under the best possible illumination, assisting always the hand with the eye.

Eustachian bougies may be employed either with a view to diagnosis or to treatment. The information to be sought by their aid is the permeability of the tubes; and the degree, position, and extent of any contractions present in their course; as well as the structural cause of the obstruction, as far as this can be ascertained. The bougies in use are made either of catgut, celluloid, laminaria, or of elastic material. Whalebone bougies being stiff, and thus easily causing injury, should only be used after having been placed for two or three days in a dilute solution of carbolic acid, when they become quite soft and pliable (*Radzig*[2]).

[1] Compare the author's contribution, "Ueber Autophonie und Tympanophonie." Monatsschrift für Ohrenheilkunde, i. Jahrg., Nr. 8.

[2] "Ein einfaches Mittel die Brauchbarkeit der Fischbeinbougies (für die Tuba) zu erhöhen." Monatsschrift für Ohrenheilkunde, xx. Jahrg., Nr. 3.

The mode of introduction is as follows :—The length of the catheter is first marked off on the bougie ; behind this a second mark is made at a distance of 25 *mm.* ; and farther back again another at an interval of 15 *mm.*

The catheter having been properly introduced into the mouth of the Eustachian tube, the bougie, previously oiled a little at the end, is passed carefully along the catheter, and on if possible, through the tube into the tympanum. If it has been pushed beyond the first mark, it must be in the tube ; if it has been introduced beyond the second mark, the extremity must have passed the cartilaginous portion of the tube ; and when the third mark has been reached, the bougie, if correctly introduced, has penetrated as far as the tympanic cavity. It may however be pushed still farther on towards the posterior wall of the cavum tympani, generally beneath the tendon of the tensor tympani.

With regard to the selection of bougies, the same principles should be observed as with their employment in other parts. It is best to begin with a moderately thick instrument with a conical end, and if necessary take thinner or thicker ones afterwards, if more suitable. When the bougie has penetrated to the tympanic cavity, the patient feels it in his ear, localising the sensation in the deeper parts of the external auditory canal. The existence of such a sensation, together with the absence of any such other as might be connected with its presence in a false position in the naso-pharyngeal region, furnishes evidence of its correct introduction through the Eustachian tube. Corroboration of this would be also afforded by unimpeded deglutition, speech, and respiration, as well as in doubtful cases by the use of the rhinoscope. Where rhinoscopy is impracticable, further evidence is derived from the steadiness of the catheter, and from the presence of the curve which the bougie exhibits after its removal, provided always it be drawn out without any twisting on its axis.

If the bougie passes only with difficulty through the tube, the amount of pressure needful for its introduction, as well as the degree of tightness with which it is grasped in the canal, will afford a measure of the contraction of the latter. The situation of the stenosis and its extent may be known respectively from the distance it has advanced before resistance is felt, and from the length through which it has further to be passed before the resistance ceases. The amount of force necessary to overcome the greatest impediment offers some ground of conjecture as to the structural cause of the narrowing. If the tube be completely closed at some point, and this be due not merely to temporary swelling of the parietes, but by their adhesion together, then the thinnest bougie cannot be passed without producing a lesion.

Immediately after the introduction of the instrument, inflation of the tube should only be made with the greatest care. Even with the most

skilful manipulation superficial injuries of the mucous membrane of the cartilaginous portion of the tube may be readily caused. The air blown through may then penetrate very easily into the submucous areolar tissue, and still farther, producing thus a traumatic emphysema; and of course such a result happens much more readily if, through forcible introduction of the bougie, a false passage has been made.

CHAPTER III.

GENERAL PATHOLOGY OF DISEASES OF THE EAR.

The justification for the existence of the specialty of otology consists only in the necessity for such special knowledge and dexterity as can be acquired in no other way than by a lengthened and thorough study of the subject, and which cannot usually be attained in an adequate degree by the general practitioner.

From this point of view it should be considered so as to recognise the proper position of the aurist ; and he himself must duly realise the fact, if he desires to acquire a proper competency in its practice.

The principle of "division of labour," in regard to the study of the human organism both in health and in disease, cannot however be carried out in so perfect a manner as is possible in the case of the mechanical arts. The independence and delimitation of the individual parts from the organic whole cannot be made in so complete a sense. Every organ, in a morbid as in a normal state, is subject to the common laws governing the organism, and the higher the organism the more intimate is this correlation.

It is by this truth that the nature of the specialist's attainments should be regulated. His study should pass from an adequate understanding of general medicine in practice and theory to the consideration of his special province, rather than in the contrary direction, in order that his knowledge may rest upon a satisfactory foundation. This thorough general standpoint having been attained, he will soon be able to convince himself that the ear in its different morbid states remains subject to the same natural laws as affect other organs with similar anatomical structures; that pathological changes peculiar to the organ of hearing have no existence ; and that there can be therefore no justification at all for any *special* pathology of the ear.

As however the most diverse tissue-elements contribute towards its formation, and diseases of the neighbouring structures exercise great influence upon its function, an accurate acquaintance with such diseases must be gained. The fact also that the ear is not rarely affected by diseases of organs standing in no direct anatomical connec-

tion with it, emphasises the need for a familiar acquaintance with general pathology.

Possessing such a knowledge, the specialist will gain likewise a general survey concerning symptomatology and prognosis, by means of which he will receive great assistance in his own department. With this the present subject may be dismissed, in order to proceed to another, which exemplifies more strikingly the utility of the specialty; that namely of the general treatment of aural diseases.

CHAPTER IV.

GENERAL THERAPEUTICS OF DISEASES OF THE EAR.

1. Syringing the Auditory Canal.

SYRINGING out the ear, though apparently simple, really needs particular attention to insure success. It indeed commonly happens that in cases simply of cleansing the auditory canal, the process may be carried out for months without effect by an unpractised hand, when a few minutes suffices if it be properly performed. This fact, together with the other, that harm also may result from ignorant manipulation, makes it necessary to describe the method thoroughly.

The requisite appliances are—the syringe (Fig. 80), a vessel to receive the outflowing water, a towel, and cotton-wool. The author uses almost always brass, or German-silver syringes, like that represented in Fig. 80. Vulcanite syringes are cheaper, but more easily broken, and apt also to become bent from the warmth, with the result that the stream of fluid becomes irregular, and its discharge difficult. The so-called irrigator is also employed in practice, but the syringe is more suitable. The water for injection should be aseptic, and of a temperature of 28-30° R. (95-99° F.). If it be cold, reflex phenomena, as giddiness and vomiting, or even attacks of syncope, may easily be excited; and this should only be used where warmth is contra-indicated, as in profuse hæmorrhage from the ear. Before injection, the temperature of the water should be carefully ascertained, more especially when this is left to the patient or his friends.

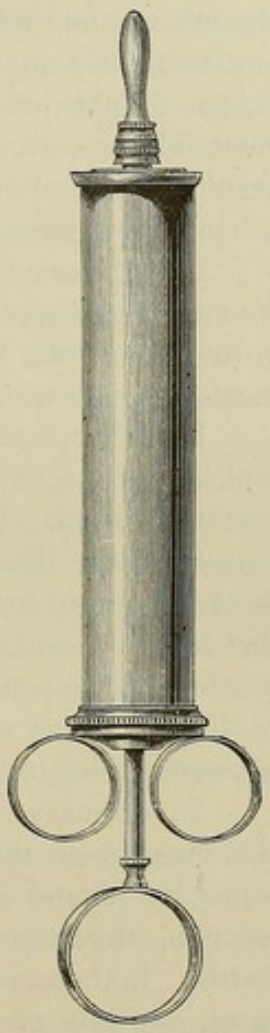
The process of syringing should be carried out in the following manner. The patient having been placed in a position in which the ear may be conveniently reached, the manipulator fills the syringe, putting his right thumb in the ring of the piston, and the middle and index fingers in the side rings. With his left thumb and index finger he now takes hold of the upper part of the auricle, and draws it upwards, backwards, and outwards, in order to straighten out the bend in the auditory canal. The syringe is then emptied by counter-pressure of the thumb and fingers of the right hand. In doing this care should be taken not to force in the water violently, and also that the stream be directed towards one side of the auditory canal, and not directly towards the tympanic membrane.

Though the nozzle of the syringe is naturally brought into the immediate vicinity of the ear, contact with the auditory canal should be avoided, especially in painful affections.

In accordance with the object for which the injection is undertaken, and the special conditions of the case, many precautionary measures have to be considered, the account of which will be for the present deferred.

Fig. 80.

Ear syringe (half the ordinary size).



Schmiedekam's testimony in reference to the reflex phenomena which may follow on syringing is interesting. He brought the pressure of a column of water of 117 *cm.* to bear upon his tympanic membrane. Intense pain ensued, followed by giddiness and nausea. The pressure was then taken off; when the preceding symptoms had disappeared he repeated the experiment—this time with a pressure of 52 *cm.* only. The same symptoms immediately reappeared in an increased degree, the giddiness reaching almost to the point of producing syncope; and actual vomiting occurred, while dizziness continued for the rest of the day.

Schmiedekam considers these phenomena depend, not upon pressure-variations in the labyrinth, but reflexly upon irritation of the auricular branch of the pneumogastric nerve. That such an irritation exists, and can induce the symptoms mentioned, may be conceded; but it does not follow that they may not also depend in part upon an increased labyrinthine pressure.

On the grounds above indicated, the syringing process should not be too prolonged. Cases have occurred in which severe aural affections have been provoked in this way. Immediately after the process the auditory canal should be again examined to ascertain if it has been successful, as well as to note the possible presence of any condition which may have arisen from the injection itself. The parts should then be carefully dried, otherwise eczema or inflammation of the auditory canal or of the tympanic membrane might occur, particularly in delicate individuals. All the irregularities of surface of the external ear should be wiped dry, and the water remaining in the auditory canal should be soaked up with a piece of cotton-wool held by a pair of aural forceps. It is advisable for the patient to bend his head to the side, so as to allow as much water as possible to run out. Lastly, it is well to insert a loose plug of cotton-wool into the canal, and allow it to remain there for an hour.

2. The Employment of Liquid Applications to and through the External Auditory Canal.

Valuable as is the introduction of medicated solutions into the external auditory canal in many aural affections, their injudicious use may be, on the other hand, not only prejudicial but even positively injurious. It is a constant observation, that efficacious remedies may be employed as instillations by patients for months, or even years, when perhaps with the same materials, improvement often begins in a few days, or even a complete cure results, provided only simple instructions be given as to the proper manner of employing them.

Liquid remedial agents are best introduced into the auditory canal by means of a spoon or a small bottle. Small drop-bottles, resembling an eprouvette, from which the number of drops to be instilled may be measured, and which the patient can himself use, are advantageous.

In every case, before the desired fluid is introduced, the parts on which it is to act should first of all be freed from any foreign matters which may be present. For this purpose it is necessary either to syringe out the ear, or where this is not advisable, to clean out the canal with cotton-wool introduced by the forceps. If neither can be done, it is well to fill the auditory canal once or twice in succession with the solution to be applied, and to permit it to flow out again at once. Pus, or other matters, having been thus washed away, the liquid may be again dropped in, and allowed to remain for its own effect.

In ordinary cases, the patient should lean his head over to the side opposite to the ear which is to be treated, and with his face turned somewhat round to the lower shoulder. Then, before instilling the solution, the auricle should be drawn backwards, upwards, and outwards. If these instructions be neglected, the liquid, in the majority of cases, will not reach the deeper parts of the auditory canal. To further facilitate its entrance, the patient may at the same time open his mouth. After the fluid has remained in the auditory canal as long as circumstances demand, it is allowed to flow out by simply bending the head over (except when such solutions are used as may stain the skin), and the canal should then be plugged with cotton-wool. If it be desired to keep up the action of the solution, this plug is not changed; but if its continued operation is not required, a fresh piece of cotton-wool should be inserted. Should it be wished to lessen the after effects of the application, the ear may be syringed out with plain tepid water, or with a neutralising fluid, if necessary—as, for example, with a solution of salt when nitrate of silver has been employed.

Instillations into the auditory canal ought, like simple injections, to

be warmed before introduction. The choice of remedial agents and other considerations will be discussed further on. Brief mention will, however, be here made of certain rules which under all circumstances should regulate the mode of treatment in question.

a. Only such agents should be used as are completely soluble in the liquid employed.

b. No substance should be used which acts on matters in the auditory canal in such a way as to hinder the effect of any subsequent application.

c. Materials should be avoided as much as possible which by their action either affect the colour of the structures so as to interfere with further examination, or which are in themselves detrimental. If such substances must be employed, any secondary products formed should be removed as soon as possible.

In some cases the object of the instillation of solutions into the auditory canal is to act, not on those parts, but upon the structures of the middle and internal ear; and this cannot always be effected, even though a perforation of the tympanic membrane exists.

In those very instances in which applications to the middle ear are indicated, the Eustachian tube is also apt to be so much narrowed by swelling of the mucous membrane that it is impossible for air to find a passage through it. When in such a case even a large perforation is present, liquid introduced into the auditory canal either cannot reach the middle ear at all, or only to such a small extent as to be of little benefit.

From experiments made by the author in reference to this matter, the following conclusions were deduced [1]:—

a. With perforation of the tympanic membrane, if the opening is free, fluids instilled into the external auditory canal pass easily into the tympanic cavity, provided that the structures of the external and middle ear are otherwise normal.

β. With a normal condition of the Eustachian tube and tympanic cavity, liquids thus introduced into the tympanum escape through the Eustachian tube without entering into the mastoid cells, if the head of the patient be bent over as usual towards the opposite shoulder.

γ. The greater part of the solution introduced can reach the posterior region of the middle ear if the patient lies on his back with his head propped up behind on the opposite side. In such a case the liquid should be introduced into the auditory canal with a small syringe.

δ. When there is complete occlusion of the Eustachian tube, with perforation of the membrana tympani, a part of the fluid can enter into the cavum tympani, if there is space enough for its reception, and

[1] "Untersuchungen über die Anwendung von Heilmitteln auf das Gehörorgan, etc." Zeitschrift für praktische Heilkunde, Wien, 1864.

if at the same time the cells of the mastoid process are accessible and contain air: the air then escapes towards the mastoid cells.

ε. The passage of liquid into the spaces of the middle ear is possible, on account of the escape of a portion of the contents of the spaces, and through the compressibility of the gases present.

ζ. If with an aperture in the drum-membrane, the liquid introduced into the tympanic cavity does not flow out through the Eustachian tube when the head is inclined towards the opposite shoulder, it may be concluded that abnormal space-conditions exist, either in the tympanum itself, or in the course of the Eustachian tube.

η. With perforation of the tympanic membrane and co-existing occlusion of the Eustachian tube, very little effect can be produced upon the latter by the instillations of liquids into the external auditory canal.

The above results should be borne in mind when it is desired to produce a direct action upon the structures of the middle ear by means of solutions. When, however, it is a question of bringing about an effect by means of diffusion or absorption the case is different, for a satisfactory action is not impossible in these cases through an intact tympanic membrane. The number of those substances from which such an influence may be expected stands, however, in no proportion to the large number of persons who even nowadays resort to the plan of introducing liquids into the ear, either from their own notions or by medical advice.

3. On the Injection of Liquid Remedial Agents through the Eustachian Tube.

Great progress in the treatment of affections of the middle and internal ear has been made by the process of injection through the Eustachian tubes. As has just been set forth in the previous section, liquids cannot always be introduced through the external auditory canal into the middle ear, even when the tympanic membrane is perforated; so that the Eustachian tube must be utilised for this purpose in all such cases in which it is necessary to adopt this method of treatment. Even since its introduction into practice objections have been raised against it, sometimes on the supposed ground of the danger which the admission of fluids into the tympanum may occasion, and at others because the injection was said to be useless for the reason that none of the solution could, as was affirmed, reach the tympanic cavity. These statements show sufficiently that such antagonistic opinions have been accepted from theoretical considerations rather than as the result of experience.

If it were still necessary to adduce evidence that even when the drum-head is intact it is possible to introduce liquids through the tuba Eustachii into the tympanum, and still farther, the requisite proofs are

easily furnished from the results of examinations made by *Kramer*,[1] *Schwartze*,[2] and the author.[3] These demonstrate that, without any solution of continuity in the membrane, the fluid injected through the tube may reach as far even as into the mastoid cells. The entrance of fluid is rendered possible, according to the author's investigations, partly on account of the displacement of the structures bounding the cavity of the tympanum, but chiefly by reason of the mobility of the tympanic membrane. In part also it occurs from the compression or dislodgment of the contents of the middle ear towards the mastoid cells, or even through the Eustachian tube. The entering fluid passes most readily into the tympanum if its contents are gaseous, on account of their compressibility. Evidence as to the entrance of the liquid is afforded by auscultation, during which a splashing sound is heard, apparently close to the auscultator's ear. Inspection of the tympanic membrane before and after is less trustworthy. If the membrane is movable, a bulging is almost always observable, recognised from its altered reflex-appearances; but in many cases it is so tense that such a movement cannot take place, and in others the entering air may alone bring about a bulging, even when the injection has run down towards the pharynx. The patient's own sensations cannot, it is obvious, furnish any reliable information in the matter.

The methods of injection through the Eustachian tube are:—

a. By employment of the Eustachian catheter.

b. By the Author's method, without the employment of an aural catheter.

c. By the use of Weber-Liel's catheter for the tympanic cavity.

a. Injections into the Middle Ear through the Eustachian Catheter.

In this procedure a small syringe is necessary, in addition to the ordinary air-ball apparatus by which the medicated liquid is blown into the middle ear. In case of need, this may be effected by the mouth.

The syringe used by the author is similar to that employed for subcutaneous injections; except that, instead of the needle, a tube or nozzle like that represented in the drawing (Fig. 81) is attached. The nozzle, as well as the mountings of the syringe, may be of vulcanite, so as not to suffer from the action of solutions. Such a syringe is far more convenient than the glass tube which has been recommended for the introduction of the liquid into the catheter, and may be so manufactured as to serve both for subcutaneous injection and for catheter

[1] Deutsche Klinik, 1863.

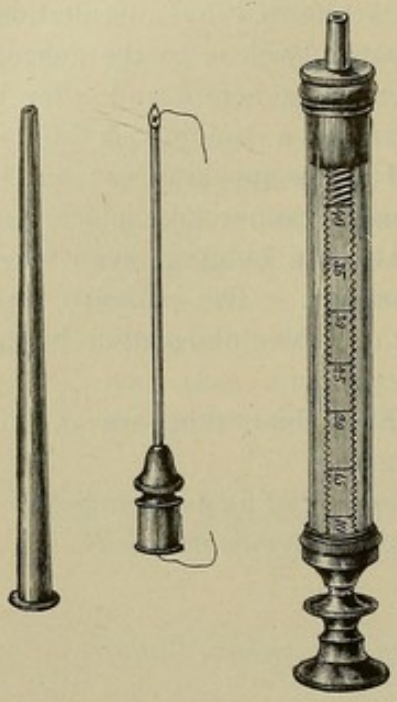
[2] *Schmidt's* Jahrbücher, 1863, 120 Bd., Nr. 11.

[3] "Untersuchungen über die Anwendung von Heilmitteln auf das Gehörorgan, etc." Zeitschrift für praktische Heilkunde, Wien, 1864.

purposes. With regard to the choice of a catheter for injection, the author is satisfied both from experience and experiments on the cadaver, that, contrary to what has been stated, there is no difference between elastic and metal catheters of the same bore. If a solution is used which would act upon a metallic catheter, a vulcanite one may be used, otherwise the author prefers the former kind, on grounds set forth when speaking of *catheterisation*. The thickness of the catheter, on the other hand, as well as the width of bore, are points of some importance.

It is inadvisable to use too thick an instrument, even if it can be made to enter well into the Eustachian tube. *Schwartze* has drawn attention to the fact that with the funnel-shaped mouth of the Eustachian tube the employment of such large instruments is apt to push the usually relaxed mucous membrane into folds, and in consequence to block up the lumen of the catheter. If an attempt be made to overcome this obstacle to injection by using more force, an artificial emphysema may very easily be produced. The impediment is naturally more marked the farther the catheter is pushed into the tube; but if, on the other hand, the point of the instrument is not carried onwards to at least two-thirds of the length of the cartilaginous portion of the tube, the greater part of the liquid injected flows back into the pharynx.

Fig. 81.



3. 2. 1.

1, Syringe; 2, needle; 3, nozzle.

These circumstances must be borne in mind in selecting a catheter, as well as in its introduction and fixation. With a normal tuba Eustachii, a metal catheter 2 *mm.* in diameter at the point is most suitable for the purpose of injection, and it should be introduced for two-thirds of the length of the cartilaginous portion, and held in such a way that its point is free in the tube. Numerous exceptions exist to these rules, especially in respect to the diameter of the catheter. These, however, will soon be discovered by the aurist who makes himself acquainted with the circumstances of the case. The mode of injection is briefly as follows:—

The small syringe having been filled with the tepid solution and placed behind the right ear like a pen, the catheter is introduced, and held in position by the left hand. Its correct introduction is then ascertained by means of auscultation, and the solution is quickly injected

into the catheter with the syringe. The air-ball is now employed to impel it with the air-current into the middle ear. It is well to accustom oneself to put back each of the instruments used into the same place as it occupied just before the operation, the whole manipulation being in this way simplified and shortened. The external auditory canal is afterwards plugged with cotton-wool, but not too tightly, so as not to interfere with the return of blood from the injected tympanic membrane through the veins of the canal.

As already mentioned, the patient is made aware of the entrance of the liquid into the tympanic cavity by a sensation of fulness, and by a feeling of tension in the membrana tympani, as well as by the peculiar sound in the middle ear. The feeling of fulness lasts, as a rule, only until the tympanic membrane has returned to its original position, which is usually indicated by a secondary sound. In very rare cases it happens that the injection is followed by severe stabbing, bursting pain in the ear, lasting for some minutes, and indeed sometimes for several hours, or even one or two days. An inflammatory attack is only very exceptionally induced.

The extreme rarity with which such results follow upon injection, in comparison with the universal employment of the process, indicates strongly that in such cases some abnormal condition must be present. Generally it is an excoriation of the mucous membrane to which the pain is to be referred; the solution, which is as a rule an astringent, coming into more intimate contact with the nerves from the absence of epithelium. In other instances the result may be due to detachment of the false-membranes frequently met with in the tympanic cavity, from the membrana tympani or other part of the middle ear. These are, however, rare abnormal conditions. It will likewise be seen later that the establishment of a consecutive inflammation sometimes comes into our plan of treatment.

b. Injection through the Tuba Eustachii without the Employment of the Catheter.

a. Method for the conveyance of the solution into both Eustachian tubes.

Apart from those instances in which it is impossible to introduce the catheter, or others in which the patient objects more or less strongly to its employment, there are cases in which its use is best avoided, for the reason that better results may be attained without it. In this class may be included all those conditions in which, not only the mucous membrane of the middle ear, but also that of the naso-pharynx, is morbidly affected. Injection through the catheter is in such cases never attended

with permanent, and seldom indeed with temporary, success. The state of the naso-pharyngeal mucous membrane is not only not improved, but even injuriously influenced by the unavoidable irritation due to the introduction of the catheter; and if the ear disorder should be for the time benefited by the injection, it reverts to its previous condition by continuity of irritation from the pharynx. These patients, again, are much more sensitive to catheterisation than others, and often complain of severe pain during the process.

If we further consider how frequently such affections occur in childhood, when catheterisation is unusually difficult, if not impossible, and also that the manipulation presupposes a greater amount of practice than every practitioner can devote to its acquirement, ample grounds will be seen to exist for the employment of a method which not only renders catheterisation superfluous, but which in many cases yields even better results.

The author in the method referred to uses a glass or vulcanite syringe, well rounded off at the anterior extremity, and capable of containing about 100 grammes ($3\frac{1}{2}$ oz.). Its olive-shaped nozzle should be sufficiently large to permit the nostril to be completely closed after its insertion. A vessel to receive the outflowing liquid will also be needed. The process is conducted as follows:—

The patient being placed as for catheterisation, and having cleared out his nose, holds his head in such a way that the nasal meatus has a horizontal direction. The operator, standing in front and taking the syringe in his right hand, slightly raises the tip of the nose with his left thumb, as in the introduction of the catheter, and inserts the nozzle within one nostril, while he at the same time closes the other nostril by pressure upon its side with the left index finger. The syringe, being held horizontally, with its nozzle free from contact with the wall of the meatus, is then emptied with the requisite amount of force. During this procedure the soft palate is instinctively made tense, so as to shut off the post-nasal space below and prevent the fluid running down into the pharynx.[1] The tongue is also drawn back, and pressed against the soft palate, so as to close the passage more firmly. The liquid which enters the post-nasal space through one nasal meatus can only, in the majority of cases, flow round towards the opposite Eustachian orifice, and so back through the opposite side of the nose. If then, the latter is closed, the liquid under the pressure employed passes through the Eustachian tube, when this is patent, towards the middle ear.

The degree of force with which the liquid enters the middle ear will

[1] In Fig. 76 the dotted line represents the direction of the soft palate at the moment of injection.

depend upon the force with which the syringe is emptied, upon the completeness with which the outlets by the nostrils and palate are closed, and upon the permeability of the Eustachian tubes. By varying the force with which the syringe is evacuated, and the degree of completeness with which the nostril is closed, it is thus possible to regulate the strength of the injection through the tubes.

The same sensations and appearances accompany the entrance of fluid into the middle ear by this method as when the catheter is used in the process. If there is a perforation of the tympanic membrane, and the tuba Eustachii is patent, the injected solution as a rule runs out of the ear through the external auditory canal, clearly proving thus the efficiency of the procedure. If both membranes are perforated, it often happens that the liquid escapes from both ears.

The author has not infrequently observed that, when considerable narrowing of the tube exists, and air can only with difficulty or during the act of swallowing be forced through it, yet fluid injected by the above process found its way into the middle ear, and flowed away through a perforated membrana tympani. From this fact he conjectures that the Eustachian tube is dilated by the muscular contraction of the tense velum palati, and the passage of liquid thus facilitated. If the perforation of the drum-membrane is not too small, nor the Eustachian tube too narrow, mucus or exudation present in the tympanic cavity can be washed out into the external auditory canal,—especially in children, in whom the tubes are generally relatively wider than in adults, and in whom their horizontal direction renders it easier for the liquid to enter them.

The smallness of the post-nasal space in children also favours the passage of the injected fluid into the middle ear. Accordingly it very rarely happens with them that the above method is unsuccessful, if the Eustachian tube is not completely occluded. It may, however, fail in adults; and for such cases special measures are available to facilitate the introduction of the fluid into the tympanum.

In the adult, the pharyngeal mouth of the Eustachian tube is much wider, and its posterior lip is more prominently developed, than in the child. Even when the tube is considerably narrowed in its further course, a more or less deep depression leading into it is usually conspicuous in the pharynx. The posterior lip, or border, of the mouth of the tube, projecting farther towards the median line, presents an obstacle to liquid injected through the nose, and conducts it thus more directly towards the orifice. The fluid tends to collect in this depression, and may then be carried onwards through the tube into the tympanum by the patient practising the Valsalvan method of inflation immediately after the injection has taken place. By this means the fluid, which is collected at the pharyngeal orifice of the tube, is conveyed simultaneously with the air into the middle ear.

The different manipulations in connection with this mode of injection into the middle ear should be conducted in accordance with the special requirements of the case. The degree of force with which the syringe is evacuated, the extent to which the nostril unoccupied by the syringe is closed, and finally, the practice of the Valsalvan process after injection, must be adapted to circumstances. Besides that, in all cases the fluid injected should be allowed at first to flow away through the other nostril, with the view of clearing out the post-nasal region. There are many cases in which it is well not to close the other nostril at all, in order that the liquid may not enter the middle ear with too great a degree of force. This may indeed happen if the nose be blown violently after the injection, even though great contraction of the Eustachian tubes exist, and may be followed by disagreeable results.

In most instances the conditions under which the liquid passes through the tubes cannot be estimated beforehand with certainty, and it is therefore necessary to proceed with great caution with patients who are being treated for the first time by this process, or who are particularly sensitive. On the first occasion it is desirable not to close the second nostril at all, or only to a slight extent, and not to direct the Valsalvan method of inflation to be practised after injection. Having become acquainted with the special conditions of the case, the process may be afterwards regulated in correspondence with them.

After the procedure the same precautionary measures should be observed as when the catheter is also employed. The same appearances and sensations are exhibited in the ear, and also other subjective as well as objective symptoms, to which reference must here be made.

Violent sneezing, followed by increased secretion, may come on after a few minutes, or sometimes in the course of a few hours. These symptoms point to an irritation of the nasal mucous membrane, and will vary according to the sensibility of the patient and the nature of the curative agent employed. The secretion generally ceases after some hours, but sometimes lasts longer, though very seldom for more than a day. These symptoms may be accompanied by more or less headache, and occasionally by giddiness; both of which, however, soon disappear again. If there is much swelling and hypertrophy in cases of chronic catarrh of the naso-pharynx, the increased secretory activity usually brings a feeling of relief and comfort in the mucous membrane.

Another occasional occurrence is an attack of suffocative spasm, resulting from the entrance of a few drops of the injection into the larynx. It occurs with children more often in proportion to the number of cases than with adults, and is usually due rather to fear and restlessness than to imperfect closure of the post-nasal space by the soft palate and tongue.

That the tongue really aids in closing the post-nasal space below during injection through the nose by this method, is proved by cases of defect of the velum palati. The liquid injected flows out again by the other nostril; none, or only extremely little, running into the pharynx, unless the tongue is carried forwards again into its ordinary position. This fact has been frequently observed in syphilitic subjects.

It is advisable to explain beforehand to the patient that he should keep his mouth open, in order that any of the liquid which may happen to come into his throat may the more easily escape. He may also be assured that no harm can result from accidentally swallowing some of it. In the case of those patients—as for example, young children—who cannot be made to comprehend such matters, it is well to acquaint the friends with them, in order to avert any unnecessary disquietude.

Though in general so beneficial, and even in many cases preferable to injection through the catheter, this method, nevertheless, shares the disadvantages associated with all processes which dispense with the use of that instrument. The principal drawback to all these methods consists in the fact that one ear alone cannot be exclusively treated, as is sometimes desirable. The effect is upon both, and upon other structures as well, which is often unnecessary, and may even be injurious. The employment of the procedure in question is consequently limited by certain indications which are to be strictly observed, and is proper only in cases in which both auditory organs call for treatment.

β. Method for the introduction of solutions into one Eustachian tube only.

A large experience has satisfied the author that this object may be attained in many, though not in all cases, by the following process:—

The patient bends his head over towards the shoulder of the same side as the ear which is to be treated, at the same time also inclining his face somewhat downwards—a position similar to that taken in the process of introducing solutions into the external auditory canal of the other ear. The aurist now introduces with a small syringe from thirty to fifty drops of the desired solution into the lower nasal meatus of the same side as the middle ear into which the injection is to be made. On withdrawing the nozzle of the syringe, he then immediately closes the nostrils of the patient by the pressure of his fingers, and directs him to blow up forcibly into his ears, according to the Valsalvan procedure. In the described position of the head, the mouth of the lower Eustachian tube is situated in the deepest part of the pharynx, and the injected fluid will accordingly for the most part accumulate there, whence it may afterwards be blown up through the tube by the Valsalvan method of inflation.

If there be a perforation of the tympanic membrane, the inflated fluid may not infrequently be observed to run out through the external auditory

canal. The disadvantage of the method is that some of the liquid may possibly be sent into the other ear. Experience shows, however, that when patients come to understand the meaning of the process, they soon discover a certain position of the head in which the solution can be made to enter the one ear satisfactorily. It must, nevertheless, be repeated that the method is not always successful. Still, as its adoption is only desirable in cases in which a more certain process is impracticable, it may always be accepted as a valuable resource in treatment.[1]



Fig. 82.

Weber-Liel's catheter for the tympanic cavity (half the ordinary size).

c. Injection into the Middle Ear by Employment of Weber-Liel's Catheter for the Tympanic Cavity.

Many instances occur in practice in which the above-described methods of injection are found to fail. The injection either does not reach the tympanum at all, or in insufficient quantity. It is generally, too, just in those very cases in which cleansing and injection into the middle ear are most indicated, as with so-called retention-masses, that these modes of procedure prove unsuccessful. The failure is but very seldom attributable to complete obliteration of the Eustachian tube, due to coalescence of its walls. It is, as a rule, attributable only to extreme narrowing, caused by inflammatory swelling of the mucous membrane to such a degree as to completely close up the lumen of the tube.

The point at which this condition takes place most easily is just that at which in all cases the liquid finds its advance most retarded—that is, at the isthmus tubæ. Here the Eustachian tube is not only narrowest, but is also bent, and the fluid injected has to pass this angle in order to reach the cavum tympani through the osseous portion of the tube. Under unfavourable conditions the fluid flows back again from this point into the naso-pharnyx without entering the tympanum. It is in such cases prin-

[1] Compare *Josef Gruber*, "Bericht über die im Jahre 1862 im Wiener allgem. Krankenhause behandelten Ohrenkranken." Further, Oesterreichische Zeitschrift für praktische Heilkunde, 1863, Sitzungsbericht vom 22. Juni, und Deutsche Klinik, 1865. The reader will gather from the above-cited sources that the procedures just described were designed by the author, and were certainly not adapted, as insinuated by *A. Politzer* in his text-book, from the method recommended by *Saemann* in No. 52 of the Deutsche Klinik for 1864. The latter method consists in the employment of fluid instead of air in *Politzer's* process, so that the liquid evacuated from the balloon is forced through the tubes during an act of swallowing. This process has not been adopted in practice, and should be ignored, on account of the mischievous results by which it may be followed.

cipally that *Weber-Liel's* catheter for the tympanic cavity is of such great service.[1]

It consists of an elastic tube $1\frac{1}{4}$—$1\frac{1}{3}$ *mm.* in diameter, made of spun silk, and covered with indiarubber varnish. The tube has a funnel-shaped expansion at its outer extremity for the reception of the nozzle of the air-ball, or syringe. In length it should be from 3-4 *cm.* longer than the ordinary Eustachian catheter, in order that its inner extremity shall project beyond that of the latter.

For special purposes, tympanic-cavity catheters may be employed, the inner end of which is fenestrated laterally: usually, however, these are not required.

They should be of different calibres, and should be marked on the outer end with three lines in the same way as Eustachian bougies. They are introduced by the same rules as these. Communication is thus established with the cavity of the tympanum, into which liquids may be introduced through them in the quantity and with the force desired.

Weber-Liel uses also his catheter with his so-called "*Tympano-Koniantron.*" This is a longitudinally perforated vulcanite piece with a small lateral tube. A little of the medicated solution is introduced into the tympanic catheter, into the funnel-shaped extremity of which the koniantron is then fixed. An air-ball, the nozzle of which is inserted into the lateral tube, then sprays the fluid into the middle ear. The instrument is, however, somewhat uncertain in its action, and is but rarely employed in practice.

[1] "Ueber Anwendung von örtlich wirkenden Arzneien gegen Veränderungen in der Paukenhöhle." Monatsschrift für Ohrenheilkunde, i. Jahrg., Nr. 5.

SPECIAL PART.

I.

DISEASES OF THE EXTERNAL EAR.

CHAPTER V.

DISEASES OF THE AURICLE AND OF THE EXTERNAL AUDITORY CANAL.

1. Malformations.

Abnormal position; Deformity and Absence of the Auricle; Supernumerary Auricle; Fistula auris congenita.

THE inclination of the auricle to the side of the head is easily recognised to vary within considerable limits. The position, however, does not seem to notably affect the power of hearing, if the organ be normal in other respects. It is on grounds of sentiment only that surgical treatment may be called for on account of an external ear which stands out very prominently from the head.

The unusual position of the auricle may be either unilateral or bilateral, and is but seldom congenital. Instances in which the skin of the upper part of the auricle is adherent to that at the side of the scalp are very rare indeed. The author has seen three such cases. In one, advice was sought for an external otitis; the other two were accidentally noticed, and in neither was there any ear affection present. The patient with the otitis externa had perfect hearing, both before and after the occurrence of the inflammatory condition. The edge of the upper part of the auricle was notched in two of these cases, as in those of *Wreden*, who observed five instances of such adhesion.[1]

An abnormally situated auricle is much more frequently an acquired condition; due most often to an unsuitable head-dress, or absurd arrangement of the hair; and for this reason is observed more commonly in women. The disfiguringly prominent ear, as just mentioned, comes sometimes under observation with a view to amelioration. Suitable means in the reverse sense to that of the above-indicated causes may be adopted, or the adjustment of pads and bands, with the object of keeping the projecting auricle close to the head, may be employed. If such treatment proves, after a sufficiently prolonged trial, ineffectual, recourse may be had to

[1] "Zur Casuistik der angebornen Missbildungen des Ohres." Monatsschrift für Ohrenheilkunde, Jahrg. iv., Nr. 1.

operative measures. In this connection the author has repeatedly carried out the following operation. An appropriately shaped elliptical portion of integument, involving the posterior surface of the auricle and the contiguous opposed surface of the mastoid region, is dissected up. The limiting incisions meet at the line of attachment of the auricle at acute angles above and below. The edges of the wound are to be drawn into apposition by sutures, and the auricle brought into its natural position by means of a suitable bandage.

Greater importance belongs to abnormalities of arrest and excess of development of the auricle. These also may be either one-sided or bilateral. Defect of development to an extreme degree is ordinarily associated with arrested development of the deeper structures of the ear, especially with absence or atresia of the external auditory canal, as well as with defective development of the middle and internal ear.

According to *Virchow*,[1] deformities of the external ear occur frequently in association with malformations of the auditory ossicles, the lower jaw, certain parts of the upper jaw, and of the sphenoid and palate bones; as well as with instances of arrested development in the structures of the throat. They are to be considered as connected with irregularities in the region of the first branchial cleft. Asymmetry of the two sides of the face is frequently associated with malformation of one auricle.—*Schwartze*[2] points out that *Stahl* had indicated the significance of deformity of the auricular cartilage in relation to cranial development.

His,[3] in his careful description of the embryonic development of the human auricle, considers that the majority of cases of deviation from the normal arise between the second and fifth months. According to *Virchow*, malformations of the auricle are mostly of locally limited causation.

Defects of particular parts of the auricle (crura furcata, antihelix, lobulus, antitragus) without other complications are very common, and have no importance. Of rarer occurrence is the diminutive ear (microtia), which may either be in other respects well developed, or on the other hand may exhibit also some malformation. In this way peculiar forms result, resembling sometimes the ears of animals (cat's ear, hare's ear).

In a medical student, who had very good hearing and was highly intelligent, the author observed, in addition to extreme smallness of the auricles, complete absence of the antihelix on both sides. *Hoppe* relates that a peculiarly formed auricle was observed in a certain Swiss family through several generations; its direction was forwards, covering the external auditory canal, in such a way as to leave only a very narrow channel for the admission of the sound-waves.

Congenital absence of the entire auricle is exceedingly rare. The author has never observed such an instance; the auricle having been

[1] *Virchow's* Archiv, xxix. Bd., S. 62; xxx. Bd., S. 221; and xxxii. Bd., S. 518.
[2] "Pathologische Anatomie des Ohres," Berlin, 1878, S. 26.
[3] "Die Formenentwickelung der menschlichen Ohrmuschel." Vortrag, gehalten am iii. otolog. Congresse in Basel, 1884.

always represented at least by a small duplicature of the integument, containing usually a more or less imperfect auricular cartilage. The most frequent forms of combined diminutive and malformed auricle which have been noticed by the author are represented in the Figs. 83 and 84. As a rule they are unilateral, the other ear being well developed. When bilateral, the rudimentary auricles generally resemble one another both in structure and appearance. A rudimentary auricle may be situated in a quite unusual position, as nearer the cheek, or towards the neck. This should be kept in mind in planning an operation for the construction of an artificial auditory canal.

To what an extreme degree malformations of the deeper parts may exist in connection with a rudimentary auricle is exemplified clearly by a preparation of the author's, represented in Fig 85.

The external auditory canal was completely absent, and the auricle

Fig. 83.

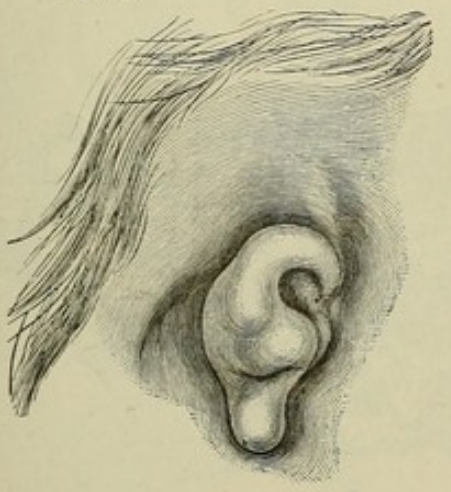


Fig. 84.

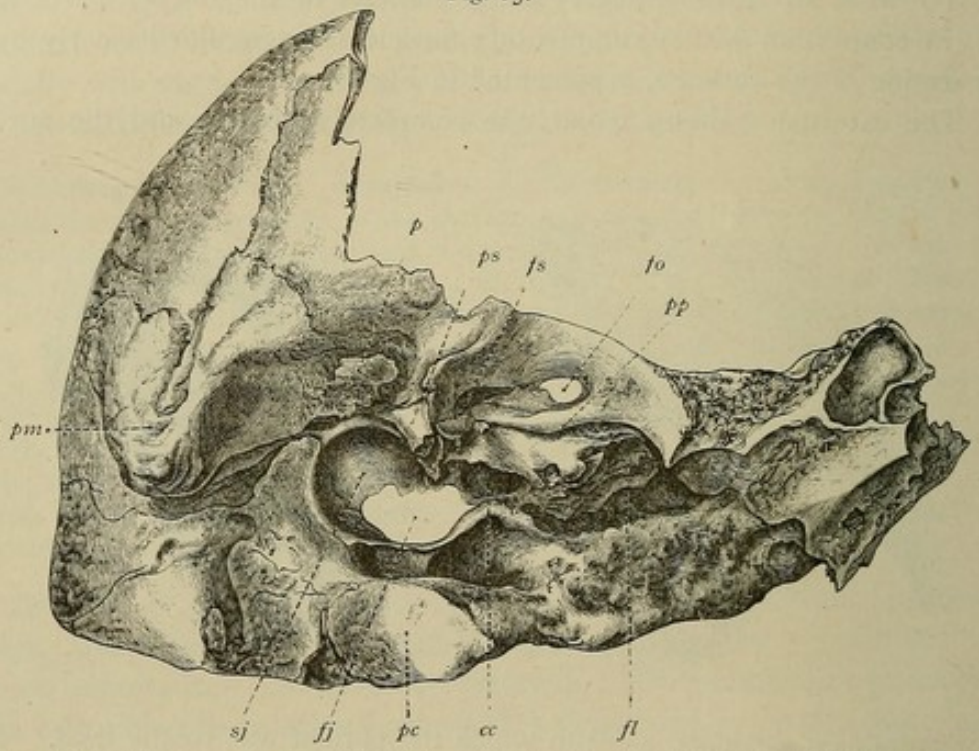


rudimentary on the same side on which the patient was totally deaf. The other ear was quite normal. The auricle was represented by a small fold of integument in the position of the lobe of a normal ear. The entire external auditory canal, the tympanic membrane, and the auditory ossicles were wanting. The promontory was indicated by a very low, longish prominence. The fenestra ovalis and the fenestra rotunda were both absent. The spaces of the labyrinth were represented by a single anterior semicircular canal, and a rudimentary internal auditory canal through which a bristle penetrated into a curved canal, ending on the inferior surface of the petrous bone. The condition of the other structures could not be determined, the specimen having been received in the macerated state.

Figs. 86 to 89 represent a very interesting case of a patient seventeen years of age, whose left ear was well developed, with good hearing power, but who had on the right side a rudimentary auricle 1 *cm.* wide and 2 *cm.*

long, covered by normal skin with a lobular appendix. This imperfect auricle was in the ordinary situation, standing out from the side of the head at a right angle (cat's ear), and contained a cartilage, which passed into the deeper parts. There was no external auditory canal. The two sides of the face were unequally developed, the right half of the forehead being more prominent and larger than the left, while the left zygoma was more developed than the right. The right naso-labial fold was obliterated, but the left corner of the mouth was the higher of the two. On wrinkling the forehead (Fig. 87) the right half remained smooth, and on attempting

Fig. 85.



pm, Mastoid process; *p*, rudimentary pars tympanica; *ps*, proc. styloid; *fs*, foramen stylo-mast.; *fo*, foramen ovale of the sphenoid bone; *pp*, proc. pteryg.; *fl*, foramen lacerum; *cc*, canal carot.; *pc*, proc. condyloid; *fj*, foramen jugulare; *sj*, sulc. jugularis.

to shut the eyes (Fig. 88) the right eyeball remained partly exposed. When the patient tried to whistle, the mouth was drawn to the left. The pharynx was normally developed, but the right side of the soft palate was lower than the left, and the uvula was drawn over towards the left side. In saying *a* (ah) the left half of the velum was raised higher than the right, and the uvula was drawn still more to the left. There was no derangement of the sense of taste anywhere on the right half of the tongue.

On rhinoscopic examination, the pharyngeal orifices of the Eustachian tubes appeared quite normal, and catheterisation was easily performed on both sides. On using the air-douche, and with the Valsalvan method of

inflation, air passed freely into both middle ears, and the patient felt as if something was pressing towards the rudimentary auricle. He heard the watch on contact with the deformed auricle, as well as with the adjacent

Fig. 86.

Rudimentary auricle.

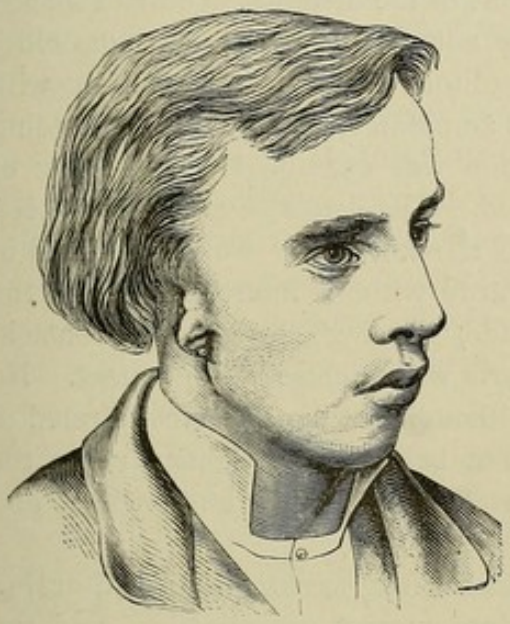


Fig. 87.

Represents an effort to wrinkle the forehead.



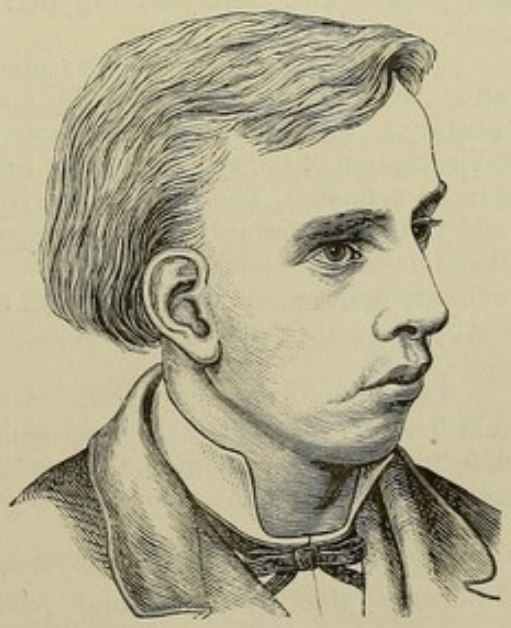
Fig. 88.

Represents an attempt to close the eyes.



Fig. 89.

Appearance with an artificial auricle.



bony structures; and tuning-forks of different pitch, when placed on the vertex and left mastoid process, were heard towards the defective right side.

In this case there existed not only defect of the external structures of

the ear, but, as indicated by the congenital paralysis of the parts supplied by the facial nerve, a defective development of that nerve also. The imperfect condition appears to have been confined to the peripheral portion of the nerve trunk, since the structures innervated by the fibres given off in the Fallopian canal exhibited no impairment of function.

The patient sought advice on account of the disfigurement, and wished the deformed ear to be removed. The author considered the possibility of constructing an artificial external auditory canal in connection with removal of the auricle. The latter was amputated, and after the bleeding had been stopped by ligatures, the region was examined with a view of discovering if any trace of a canal existed. The defective auricle was seen to be attached to the bone, with which the lower jaw was articulated in front, and which was continued backwards without interruption into the mastoid process. An attempt was made, keeping close to the mastoid process, to penetrate into the deeper parts with a chisel and hammer. No sign, however, of a canal was visible, although the bone was penetrated to almost 1 *cm.* in depth. The author, not being quite satisfied as to the course of the great vessels, then desisted from further endeavours, and applied an antiseptic dressing.

The patient was discharged after nearly four weeks' treatment, during which healing took place without any intercurrent complication, and the treatment of the paralytic symptoms by electricity remained ineffectual. His hearing distance for the watch, which on admission was on contact only, was 1 *cm.* He was supplied with an artificial auricle (Fig. 89).

This case recalls an autopsy made by *Moos* and *Steinbrügge* on an infant which died when eleven days old, and in which the right external ear was rudimentary.[1] The whole of the osseous and membranous labyrinth was normal with the exception of the communication between the vestibule and cochlea, which could not be defined. The facial nerve could be traced as far as the hiatus Fallopii, and farther downwards the Fallopian canal was closed by bony material as far as the stylo-mastoid foramen. The tympanic membrane, the annulus tympanicus, the auditory ossicles, the tensor tympani muscle, and the nerve-plexus of the tympanic cavity, were all absent. The external auditory canal and the Eustachian tube were obliterated.

The author's case is opposed to the opinion expressed by *A. Politzer* in his text-book (p. 865), that a deficient mobility of the velum palati indicates a probable defective development of the Eustachian tube; for though the right side of the palate was paretic, the tuba Eustachü was perfectly normal.

Excessive development is seen on the one hand either in the immoderate size of individual parts, or of the entire auricle (*Macrotia partialis et totalis*); or on the other hand in multiplicity of the auricle, or portions of it. When more than one auricle is present the condition is

[1] "Pathologisch-anatomischer Befund in einem Falle von Missbildung des rechten Ohres." Zeitschrift für Ohrenheilkunde, x. Bd., 1. Heft.

described as polyotia; the multiplicity of parts only, is exemplified in the so-called *auricular appendices.* Partial macrotia is very common, especially as regards the lobe, in women who wear heavy earrings. According to *Lincke's* account, certain races in India, Africa, and America consider it an ornament to have the lobe of the ear hanging down to the shoulder. They consequently use weights from childhood with this object. Macrotia totalis is less frequent, and if unilateral is almost more disfiguring than when present on both sides.

Auricular appendices are most often seen just in front of the tragus. That they are true auricular structures and not nævi or other growths is, according to *Rohrer,*[1] evident from the fact that with defective development of the auricle, such appendages often replace it. According to *Virchow* they consist of skin, subcutaneous areolar tissue, and reticular cartilage. *Max Schultze,* in one case, observed the rudimentary cartilage of the auricular appendix to be in connection with the condyle of the lower jaw.

Wreden saw an interesting case of macrotia in a student twenty-two years of age. The right auricle was 3 in. long, and stood out from the side of the head like a cone (asses' ear). The helix and antihelix were undeveloped, the auditory canal and tympanic membrane were normal, and the hearing good. The left auricle was well formed and of proper size (2½ in.). The left auditory canal, however, was much contracted; the tympanic membrane was placed at an extreme inclination, being horizontal. On this side also there was complete deafness, owing probably to defective development of the labyrinth. The patient's father was deaf and dumb from birth, and his mother, during the pregnancy, was thrown from an ass and much frightened. *Langer*[2] relates two cases of double-bodied monsters, in each of which four auricles were present. *Wilde* speaks of *Cassebohm's* account of a child who, besides two ears normally situated, had two others lower on the neck. Two petrous portions are also said to have been present in each temporal bone. *Birkett*[3] reports the case of a girl who, in addition to irregularity of the ears, had a large growth over the middle of each sterno-cleido-mastoid muscle, which resembled the lobe of the ear. Each contained a small artery and a fibro-cartilage analogous to the auricular cartilage.[4]

Prognosis.—Since defective development of the auricle, especially to an extreme degree, is usually associated with defects of the internal structures, great caution is necessary in regard to prognosis, as well as to any proposed surgical interference. It is impossible to give any certain opinion concerning the prospects of hearing during the period of infancy, and equally so to take any remedial measures with a fair likelihood of success. At such an early date, if the external auditory canal and auricle should be wanting, no

[1] "Ueber Bildungsanomalie der Ohrmuschel." Vortrag, gehalten in der 58. Versammlung Deutscher Naturforscher und Aertze in Strasburg, 1885.

[2] "Zur Anatomie des Gehörorganes doppelleibiger Missgeburten." Oesterreichische medicinische Wochenschrift, 1846, Nr. 11.

[3] Transactions of the Pathological Society, London, 1858, vol. ix., p. 448.

[4] For further information concerning this subject we refer the reader to *Voltolini's* article "Die Krankheiten des äusseren Ohres." Monatsschrift für Ohrenheilkunde, ii. Jahrg., Nr. 1.

information can be obtained as to the presence or absence of the deeper structures. The only criterion of the functional capacity of the ear is the result of tests of the acoustic power, and those can evidently only be applied when the child is able in some way to respond distinctly to such trials. One cannot therefore easily acquire any certain data during the first six months of life on this point, when defect of the auditory canal and auricle exists.

If the child, however, has reached an age at which evidence is ordinarily offered by its behaviour as to the possession of hearing power, and it then gives no response to very loud sounds, one may with certainty conclude that with defect of the sound-conducting apparatus there is also deficiency of the deeper parts, and that the deafness will probably be lasting. It happens but very rarely that any capacity of hearing is exhibited after the first year of life, if none has shown itself within the second six months.

Much care besides must be exercised in estimating the hearing power in connection with defect of one ear when the auditory faculty of the other ear is normal, since it is easy to be led into error through the capacity of the sound ear. On the whole it will be best, if one ear be normal, to defer any operative procedure on the defective ear until such time as the patient and his friends are able to give a clear account of his sensorial perceptions, and an accurate examination of the deeper structures can be made, especially in reference to the condition of the middle ear.

Even if the conclusion be arrived at that the ear in question is only partially and not totally deaf, the action of the surgeon will have still but a very limited scope. It is not justifiable, as is still done, to attempt the construction of an external auditory canal through a rudimentary auricle without any guide, and without any trustworthy data as to the position of the tympanic membrane and the tympanic cavity. In the majority of cases, as already intimated, the defective auricle is not normally situated, so that even if the structures of the middle and internal ear, including drum-membrane, were properly developed, and the endeavour to make an artificial canal were successful, this would in all probability not lead to the tympanic membrane, and would consequently be useless.

In these cases information regarding the position of the tympanic cavity is to be sought, partly through external examination with the finger, and partly by auscultation in varying the spot at which the end of the otoscopic tube is applied. Only when an accurate idea has been obtained of the probable situation of the structures, should any operative interference be taken into consideration.

In a patient of eighteen, whose rudimentary auricle is represented in Fig. 83, there was complete absence of the right external auditory canal, but a normal left ear. An operation was undertaken for the formation of an artificial auditory canal

in the situation of the lower depression. The attempt was made twice in early childhood, but without any success whatever. Examination now made it evident that, if an artificial canal had been completed, it would have been abortive, the tympanic cavity being placed more than ½ *cm.* behind the auricle, and the tympanic membrane, if it really existed, being covered simply by integument.

The operation with the object of making an external auditory canal would be attempted by cutting through and turning back all structures covering up the tympanic membrane, and by keeping the canal open by some suitable material.

In cases of excessive development, the redundant structures should be removed according to the ordinary rules of surgical practice. In macrotia the appearance may be improved by judicious excision (*Martino*).

The abnormality erroneously described as *fistula auris congenita* is also to be considered as an instance of arrested development. Small fossæ are sometimes present in front of the auricle or in the ascending curve of the helix. Such a depression may lead into a canal several millimètres deep, ending in a *cul-de-sac*, the walls of which often secrete a white, creamy matter. These fistulæ not infrequently occur in all or several members of a family, sometimes descending from father or mother to the nearest male, or perhaps only to the female descendants; sometimes a certain number of males and females exhibiting the condition, others not doing so. They are remnants of the first branchial cleft, and have no relationship to the canals or cavities of the ear. The designation fistula auris is therefore inappropriate. No treatment is called for unless their walls become inflamed, as occasionally happens from being irritated by pins and other foreign bodies, or if an encysted tumour should develop from occlusion of the external orifice.

A record of the older accounts of malformations of the external ear may be found in *Lincke's* text-book of practical and theoretical otology, as well as in *Schwartze's* work on the anatomy and pathology of the ear. Of later writers might be mentioned, *Wreden* ("Beschreibung und Kritik einer angebornen Missbildung des Ohres, etc.," Petersburger medicinische Zeitschrift, xiii., S. 204); *Voltolini* ("Section der Gehörorgane eines Hemicephalen," Monatsschrift für Ohrenheilkunde, iv., 1870); *Zaufal* (Prager medicinische Wochenschrift, i., 46); *Cassells* (Glasgow Med. Journal, viii., p. 185); *Kiesselbach* ("Versuch zur Anlegung eines äusseren Gehörorganes bei angeborner Missbildung beider Ohrmuscheln mit Fehlen der äusseren Gehörgänge," Archiv für Ohrenheilkunde, xix. Bd., S. 127); *Beckler* (*Schmidt's* Jahrbuch, 1879); *Blau* ("Mittheilungen aus dem Gebiete der Erkrankungen des äusseren und mittleren Ohres," Archiv für Ohrenheilkunde, xix. Bd.); *Stetter* ("Zur operativen Beseitigung angeborner Ohrmuschelmissbildungen," Archiv für Ohrenheilkunde, xiii. Bd.); *Moos* ("Eine eigenthümliche Missbildung des rechten Ohres, etc.," Zeitschrift für Ohrenheilkunde, xiii. Bd.); *Truckenbrod* ("Eine Missbildung des Ohres," Zeitschrift für Ohrenheilkunde, xiv. Bd.); *Gellé* ("Précis des Malad. de l'Oreille," Paris, 1885, S. 11); *Roosa* ("A Practical Treatise on the Diseases of the Ear," London, 1885, S. 97-102); *Urbantschitsch* ("Ueber Fistula auris congenita," Monatsschrift für Ohrenheilkunde, xi., 1877); *Schwabach* (Zeitschrift für Ohrenheilkunde, viii., S. 103); and others.

2. Injuries.

Injuries of the auricle alone, or with associated lesions of other structures, are of frequent occurrence. Arising from violence of various kinds, they exhibit many varieties in degree and extent, from a simple excoriation to loss of the entire auricle.

Treatment.—A rational observance of the ordinary rules of surgery, with proper antiseptic precautions, leads almost without exception to rapid recovery.

3. Burns and Scalds.

Both burns and scalds of different degree are met with on the external ear. The author has several times seen scalds in waiters who were pushed against while carrying soup; and has had burns under his observation due to sprinkling with sulphuric acid. In the case of a child, suffering from a purulent inflammation of the middle ear occurring in connection with diphtheria, for whom the author prescribed an instillation of a weak solution of sulphate of zinc, some very strong carbolic acid solution, which had been ordered for another purpose by the medical attendant (*Dr. Haucke*), was inadvertently dropped into the ear by the nurse. Deep destruction ensued in the auditory canal and on the auricle and neck, from which recovery took place only after weeks of treatment, but without damage to the ear. *Blau* has related a similar case.[1]

Treatment.—If blisters should form they should be pricked at the lowest part with a needle, and their contents evacuated. The epidermis is to be left untouched, as this forms the best protection for the exposed papillary layer, and the pain is considerably lessened. If, however, it has been already removed, the wound should be dressed with a mixture of equal parts of lime water and linseed oil, or with lint and simple ointment. In cases of severer burns with much pain, this may be mitigated by the application of nitrate of silver; the superficial eschar which is produced serving as a protection from the air. If the burn is situated on the posterior surface of the auricle and upon the skin of the neighbouring part of the scalp, the contiguous surfaces should be kept apart during the healing process, otherwise adhesion of the auricle may easily result. Of this the author has seen several instances from want of such precaution. Scars with deformity of the auricle, and even total occlusion of the external auditory canal, may result from burns with sulphuric acid.

[1] "Mittheilungen aus dem Gebiete der Erkrankungen des äusseren und mittleren Ohres." Archiv für Ohrenheilkunde, xix. Bd., II. "Verbrennung der Ohrmuschel durch Carbolsäure."

4. Frost-bite.

Frost-bite of the auricle is of rather frequent occurrence. When it is only slight (pernio), the patient complains of itching of the ear, which is usually of an intensely red colour. In many cases these symptoms very soon disappear, but in others the phenomena last longer, or return after a time, especially in cold, damp weather. In severer instances, vesicles form containing blood, which subsequently become inflamed and ulcerated; while in the worst degrees, sloughing of the auricle may take place.

Treatment.—In the slighter degrees of frost-bite, the application of cold is indicated. Fomentation with Goulard's lotion, or rubbing with ice-water or snow, are also useful. If the itching returns, soap-liniment may be employed; and the author has found benefit from painting with a solution of equal parts of tincture of iodine and tincture of opium. Others recommend painting the part with collodion, or with a solution of nitrate of silver, or the application of ointments containing camphor or oil of turpentine. In severe cases, the treatment must be conducted in accordance with ordinary surgical principles. Gangrenous parts should be removed as soon as possible.

5. Blood-tumour of the Auricle (Othæmatoma).

In connection with lesions of the auricle is to be considered that condition which is designated blood-tumour of the auricle. By this is understood a swelling of variable size, which makes its appearance on the auricle, and, according to many observers, also in the external auditory canal, as a consequence of the subcutaneous effusion of blood. They are distinguished according to their origin as traumatic, when due to injury, and spontaneous when arising without external cause. The othæmatoma traumaticum is often associated with further injuries, especially with fracture of the auricular cartilage. Respecting the spontaneous variety, the causes cannot always be ascertained. In very rare instances extravasations of blood into the nasal cartilage (rhino-hæmatoma [1]) have been observed simultaneously with this condition; and *Kindt* [2] states that in the course of his six years' experience at the asylum at *Colditz*, hæmatoma duræ matris was present post mortem in four-fifths of the cases in which hæmatoma of the ear existed.

Reliable observations by various otologists [3] have well established the

[1] *Köppe*, "De hæmatomate cartilaginum nasi." Halie, 1869.

[2] "Ueber das Vorkommen der Ohrblutgeschwulst an der Königl. Landes-Heil- und Verpflegs-Irrenanstalt, *Colditz*." Inaug.-Dissert., Leipzig, 1867.

[3] *S. Schwartze*, Archiv für Ohrenheilkunde, ii. Bd., 3 Heft, S. 213; *Wendt*, daselbst, iii. Bd., S. 26; *Toynbee*, l. c.; *Josef Gruber*, Berichte des allgemeinen Krankenhauses 1867, u. ff.; *Brünner*, Archiv für Ohrenheilkunde, v. Bd., S. 26; *Moos*, Zeitschrift für Ohrenheilkunde, ix. Bd., 2 Heft; *Mayer*, Archiv für Ohrenheilkunde, xvi. Bd.; *Blau*, Archiv für Ohrenheilkunde, xix. Bd., u. A.

fact that spontaneous (idiopathic) othæmatoma occurs not only in the insane,[1] as used to be generally thought, but in the sane also. It is met with at all ages, even in children. *Weil*[2] observed it in an infant of eighteen months suffering from otitis media with perforation of the tympanic membrane.

The pathological changes favouring the occurrence of othæmatoma are, softening processes in the cartilage (*Virchow*[3]), cartilaginous degeneration (*L. Meyer*[4]), and atheromatous disease of the vessels, occasioning

Fig. 90.

Spontaneous othæmatoma in an idiot. The same condition was present in the left ear. In the upper part, the blood was effused into the substance of the cartilage. On the surface traces of the crura furcata are seen.

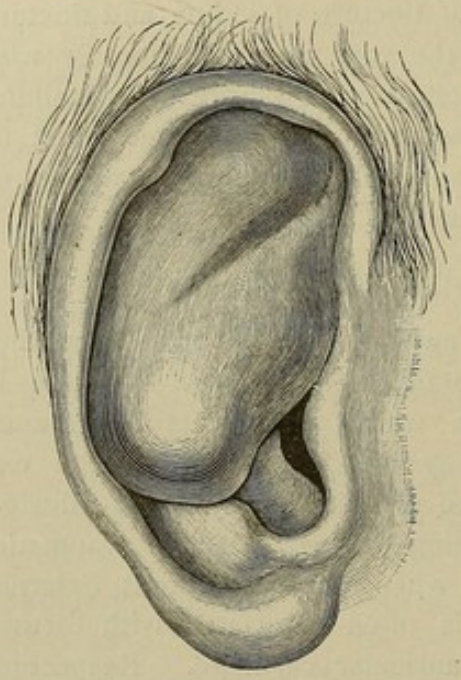
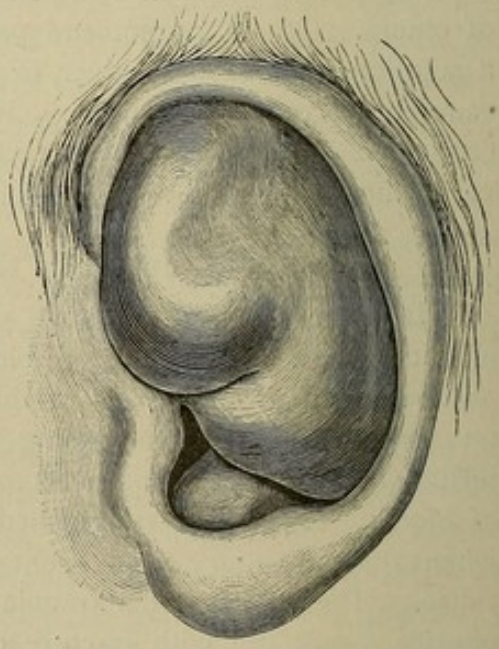


Fig. 91.

Spontaneous othæmatoma in an idiot. Pieces of cartilage could be detected by the touch through the surface of the tumour, which was very elastic.



their rupture. According to *Haupt*,[5] it is the softening with fissure of the cartilage taking place in aged and cachectic, especially insane subjects, which encourage the formation of the tumours.

The influence of diseases of the nervous system in the development of othæmatomata is indicated by their frequency in the insane. Of 620

[1] For details on this subject the reader is referred to the various text-books on Insanity, and to *Flinzer's* very exhaustive treatise, "Ueber Othæmatom bei Irren," published in Schmidt's Jahrbücher der in- und ausländischen gesammten Medicin, 117 Bd., Jahrg., 1863, Nr. 1, S. 77, u. ff.

[2] "Beitrag zur Casuistik der Othæmatome." Monatsschrift für Ohrenheilkunde, xvii. Jahrg., S. 41.

[3] "Die Lehre von den Geschwülsten," i., S. 135.

[4] *Virchow's* Archiv, xxxvii. Bd.

[5] "Ueber das Othæmatoma," Inaug.-Dissert., Würzburg, 1867.

cases treated in the year 1867 in the *Colditz Asylum*, there were observed 36 blood-tumours of the auricle, or the remains of them. Six of these patients suffered from mania, 3 from delirium and melancholia, and 24 were imbecile (9 being epileptic, and 10 having progressive paralysis). The tumour was unilateral in 22 cases. In the interval 1843-66, othæmatoma was met with 140 times in a total number of 11,839 insane patients.

The development of these tumours, as is to be expected from the nature of the case, is favoured by a condition of hydræmia. The author has, however, been unable to find in the literature of the subject any instance of the occurrence of othæmatoma in connection with hæmophilia.

Spontaneous othæmatoma has been observed by the author almost exclusively on the outer (anterior) surface of the auricle, extending in two instances only into the external auditory canal. Other writers state it to have been seen on the posterior surface of the auricle. It commences most commonly in the upper part, in the fossa triangularis (fork of the antihelix), or in the upper half of the concha; appearing as a larger or smaller, more or less distinctly fluctuating circumscribed tumour; the skin covering it being either normal or of a livid-red colour. The surface is regular and smooth, if the blood has been effused into the subcutaneous areolar tissue; or if, as is often the case, the extravasation has taken place into the substance of the cartilage itself, or between this and the perichondrium, the external surface exhibits more or less definitely the ordinary elevations and depressions of the auricle. When the blood collects between the cartilage and the perichondrium, certain parts of the former are then generally found adherent to the latter.

Bürkner[1] relates a case of *hæmatoma of the tympanic membrane* in a woman of twenty-five in the fifth month of pregnancy, who had suffered from chronic articular rheumatism, and became suddenly very dull of hearing. She had *tinnitus* and pain in the ear, the tympanic membrane being of an intense bluish-red colour, and bulging outwards. There was no exudation present in the cavity of the tympanum. After a period of three days, perforation of the membrane occurred, followed by otorrhœa. Some days later the pain ceased, the drum-membrane became reddish-yellow, and gradually regained its normal colour. The perforation was healed at the end of a week. At the expiration of pregnancy the same condition recurred. *Bürkner* considers the affection to have been due to the general congestion associated with the pregnancy.

An othæmatoma of the auricle usually develops very quickly, afterwards remaining stationary for some time if left to itself, and finally going through the metamorphoses presently to be described.

In traumatic othæmatoma the appearances vary very much from

[1] Archiv für Ohrenheilkunde, xv. Bd.

the commencement, in accordance with the nature and extent of the lesion.

In idiopathic othæmatoma the subjective symptoms are, as a rule, very unimportant, consisting mostly in a feeling of tension and a rise of temperature depending on the size of the swelling. An intelligent lady, in whom a blood-tumour of moderate dimensions appeared during the fourth month of pregnancy without any assignable cause, described the sensation of warmth to the author, merely as that experienced if the blood "rushed suddenly into her ears."

The subjective manifestations may of course be much more important

Fig. 92.

Spontaneous othæmatoma in an imbecile. The extravasation is partly into the substance of the cartilage.

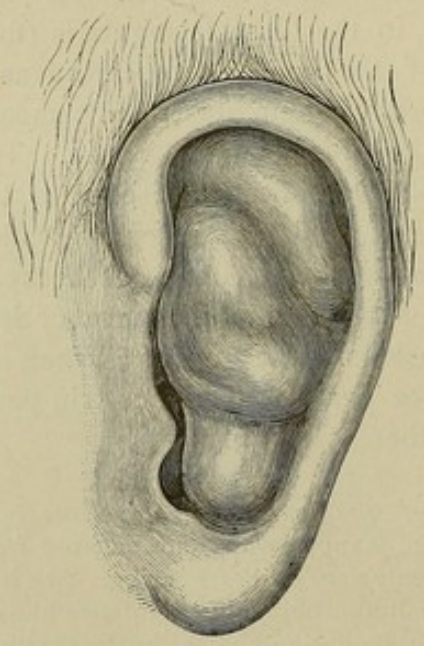
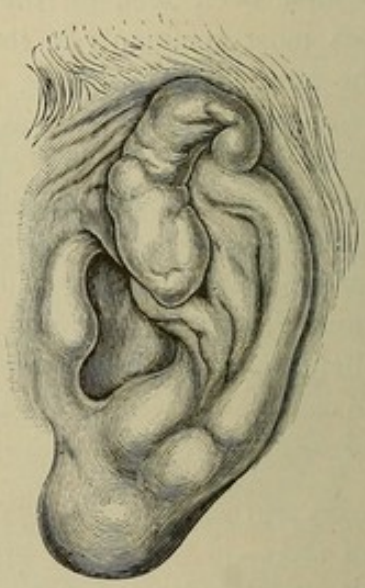


Fig. 93.

The same auricle after recovery. The effusion was evacuated by the so-called subcutaneous puncture.



in the traumatic variety, depending upon the severity of the injury and upon accidental circumstances. The hearing power of a patient with othæmatoma is only notably affected if it should interfere with the admission of sound by encroaching upon the external auditory meatus. In none of the patients coming under the author's observation was there any complaint in respect to subjective auditory sensations.

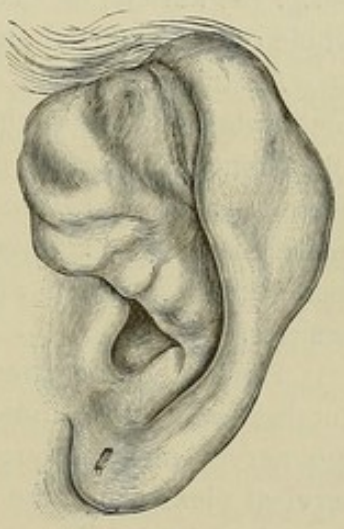
The changes taking place in the tumour vary in accordance with the amount of blood effused, with the pathological cause of the affection, with the condition of the structures into which the extravasation occurs, and with the extent of a possible accompanying injury.

In spontaneous othæmatoma the solid constituents of the blood

separate after a little while, and become deposited upon the walls of the cavity; the fluid contents are thus deprived of their colour, and are left as yellowish serum. The rapidity with which this metamorphosis occurs has led some observers to look upon the whole affection as a perichondritis, or as the formation of a serous cyst—neither of which views is, however, tenable. When left to itself the fluid contents are gradually absorbed, while the firmer constituents undergo further changes, and also induce hypertrophy of the neighbouring structures. Very considerable deformity may thus follow upon a large extravasation; and, in addition to this, much disfigurement may result when the tumour is of traumatic origin, if fracture of the cartilage and displacement of the fractured portions have taken place. In very rare cases evacuation of the extravasated blood is said to have occurred by spontaneous rupture of the overlying structures (*Schlager*[1]). The condition may become a dangerous one if, as the author once observed in a traumatic othæmatoma, ulceration of the surrounding tissues and septicæmia should ensue. In idiopathic cases such an event is hardly to be feared.

Fig. 94.

Traumatic othæmatoma (after natural recovery).



Hessler[2] treated a patient with a traumatic blood-tumour which underwent suppuration. After evacuation of the pus by incision, a cyst developed in the same situation. After this had existed for the space of a year it rapidly enlarged, and necessitated more radical operative treatment. *Hessler* holds, in cases of fracture of the cartilage, that exudation and cyst-formation occur as a result of perichondrial irritation; and that, if with the fracture a blood-vessel is ruptured, a hæmatoma forms.

Treatment.—The excessive deformity, which may permanently remain, renders careful treatment from the first especially necessary. This should have for its aims, the evacuation of the extravasated blood as quickly as possible, the prevention of a fresh effusion, and the union by adhesion of the separated structures by means of properly adapted pressure. The evacuation should be performed with a small aspirator. If coagulation have taken place, the clot should be removed through an incision, the depressions of the auricle filled up with cotton-wool, and pressure applied by a suitably arranged bandage, preferably by circular turns over the head. The dressing is to be changed as may be necessary;

[1] "Vorträge über die Erkenntnis und Behandlung der Geistesstörungen," i. Lieferung, S. 125.

[2] "Cyste in der Ohrmuschel nach traumatischem Othæmatoma," Archiv für Ohrenheilkunde, xxiii. Bd.

inflammatory symptoms or suppuration being met according to ordinary surgical rules. If a tendency to hyperplasia and deformity shows itself, early systematic massage[1] may be practised, by means of which the extravasated and inflammatory products are generally absorbed. Immediately after the appearance of the tumour, however, the author has been unable to effect a beneficial result in this way. If massage cannot be tolerated, or if it be unsuccessful after a short trial, the tumour should be painted over regularly with tincture of iodine.

6. Herpes of the Auricle (Herpes auricularis).

Herpes occurs on the external ear either independently or in connection with the same affection of the face or neck. As an independent disease of the ear it is rare. Its appearance may then be limited to certain regions —*e.g.* the auricle, or external auditory canal; or it may extend over the whole of the external structures, the tympanic membrane included.

As in other parts of the body, herpes of the auricle appears as an acute febrile disorder, characterised by the formation of groups of vesicles, and attended by severe shooting and stinging pain. The pain is sometimes present for days before the vesicles make their appearance, so that the malady is usually supposed to be rheumatism by the patient, and in some instances it goes on after the formation and even disappearance of the vesicles.

Here also the connection of the disorder with some change of the cutaneous nerves is indicated by the form and arrangement of the eruption; the nerves most frequently affected being the great auricular from the cervical plexus and the auriculo-temporal branch of the third division of the trigeminus. The efflorescence is consequently found more often on the anterior surface of the auricle than other parts. Possibly the affection may be more closely connected with the fibres of the sympathetic associated with these nerves than with the nerves themselves.

Etiology.—The disorder is generally referred by the patient to cold; or more rarely to an error in diet.

Course.—Fever always precedes the formation of the vesicles, and in severe cases does not cease when they make their appearance. If the eruption comes out at intervals, the fever likewise manifests intermissions. In a young patient of the author's the fever was prolonged in this way for fully twenty days.

The vesicles may be either isolated or confluent. They exhibit a red border, which is more distinct the more purulent are the contents. The

[1] Compare *Wilh. Meyer*, "Zur Behandlung der Ohrblutgeschwülste." Archiv für Ohrenheilkunde, xvi. Bd.

vesicles are most developed on the helix and in the fossa of the helix (fossa navicularis), where they are usually confluent; but may also appear in the external auditory canal, either in isolated groups, or confluent by the coalescence of one or more large ones, in which case the auditory canal may be more or less blocked up. Sometimes the eruption forms on the tympanic membrane; and if early rupture takes place, the excoriated bases of the vesicles may become evident. Later on the vesicles either dry up and form yellow or yellowish brown scabs, which fall off, or their contents appear more and more cloudy, and become purulent. In the latter case either cicatrisation takes place, or herpetic ulcers are established. In the external auditory canal the condition may resemble that in otitis externa, if the contents of the vesicles have become evacuated.

In many cases of herpes auricularis deafness is present, as well as subjective auditory sensations, even if the external auditory canal is not affected.

Prognosis.—The disorder is always curable. Its duration seldom extends over ten days, but may last for several weeks. In one case fully nine weeks elapsed before perfect recovery took place.

Treatment.—Attention should be directed to the general condition of the patient. As regards the local condition, little active interference should be exercised. When the pain is severe, cold compresses may be employed, as long as no vesicles have appeared. When they have formed they may be powdered with a little starch, and protected with cotton-wool; and if the pain should continue or become worse, an ointment containing opium may be applied on pieces of lint, and renewed according to the requirements of the case. Dermatologists are opposed to the evacuation of the vesicles, but the author has observed no bad results from such treatment: it should, however, be done with care, and the epidermis should remain to protect the inflamed base of the vesicle. If a tendency to ulceration be exhibited, some iodoform-powder may be dusted over the part. When herpes in the auditory canal is attended by otorrhœa, a weak solution of zinc sulphate may be used (zn. sulph. 0·1—0·3, glycerini, aq. dest. āā. 10·0), from ten to fifteen drops being poured lukewarm into the ear, and allowed to remain there for five minutes. A plug of cotton-wool is afterwards to be placed in the auditory canal as a protection against external injurious influences.

7. Eczema of the External Ear.

The symptoms associated with eczema of the ear differ somewhat from those of the same affection in other parts of the body in accordance with the peculiar anatomical relations of the auricle. Besides the usual symptoms of the disease, others present themselves in connection with the

special aural functions; and thus these cases come under the observation of the aurist at least quite as commonly as under that of the dermatologist.

The varieties described as different forms of eczema (*eczema pustulosum*, *impetiginosum*, *squamosum*, etc.) are, as *Hebra* has pointed out, really only stages of one and the same disease. On the external ear, therefore, as on other regions of the body, we have but to distinguish an *acute* and a *chronic eczema*; the last characterised by frequent relapses and great thickening of the integument.

Acute eczema of the auricle is met with much more frequently than the chronic form. It occurs in individuals of all ages and in both sexes; oftener in early childhood than in later years; and much more commonly in females than males. Girls during the establishment of menstruation, and women at the climacteric period, are particularly subject to the disorder; and the author has often observed in such cases that with both ears the eyelids were likewise affected, whilst no other part of the body was attacked. Both ears, or only one, may exhibit the disease, which may involve the whole auricle, and extend beyond this to adjacent parts, or may implicate circumscribed sections only of one or both ears.

Etiology.—Eczema occurs on the ear either as an independent affection (*eczema idiopathicum*), or it is associated with some general ailment, as scrofula, rickets, chlorosis, hæmorrhoids, affections of the female sexual organs, etc. (*eczema symptomaticum*). The idiopathic form either becomes developed on the ear itself from the first, or spreads to this from the neighbouring parts. Its cause cannot always be elucidated, but in most cases its presence may be connected with some local irritation (*eczema artificialis*). It may arise as a result of constant scratching or long-continued pressure; from the application of acrid substances; or through irritation by morbid discharges. Sometimes it originates through plugging the external auditory canal with coarse, unsuitable materials; and may occasionally also be due to the irritation of fungous organisms present in the canal. The author has repeatedly observed eczema on both ears in patients, especially children, wearing caps made of coarse material which covered the ears. With their discontinuance the eczema disappeared, and did not return. *Politzer*[1] also has observed eczema on the upper part of the crista helicis in both ears, in persons who slept upon hard horse-hair pillows.

The *subjective symptoms* do not differ notably from those which attend the presence of eczema on other parts of the body, if the disorder is confined to the auricle. The patient complains of itching and a certain degree of tension; more severe pain being felt only when pustules or

[1] Lehrbuch der Ohrenheilkunde, S. 663.

furuncles become developed. If the more deeply situated parts—*e.g.* the skin of the external auditory canal and the tympanic membrane—are affected, the symptoms manifested may then have reference to the auditory function. They consist of internal noises of diverse kind and duration, and of deafness in varying degree. The tinnitus may be due to extreme congestion of the deeper structures causing continued irritation of the terminal filaments of the auditory nerve; or, as is probably the more common cause, it may result from an excessive accumulation upon the tympanic membrane of epidermic scales, exudation, or other morbid products. Such an accumulation may increase the intra-auricular pressure, and lead thus to the occurrence of these subjective sounds.

The deafness associated with the eczema may be occasioned by the same changes in the deeper structures as may induce the subjective auditory sensations; but it may also be referred to impeded sound-conduction through the collection of morbid products in the external auditory canal; or, again, to the changes in the tympanic membrane itself. In these cases the hearing may possibly become better, and the noises in the head diminished temporarily, by the execution of movements of the lower jaw, or by traction on the auricle, in consequence of the increased space in the auditory canal which is thus for the moment produced. The same result may, of course, be brought about more effectually by clearing out the meatus.

The *objective appearances* in eczema of the auricle are similar to those of the same disorder in other regions of the body. All possible gradations in severity occur, from the simple red, secreting fissure denuded of epidermis, as seen especially in children at the angle of insertion of the auricle, up to a condition in which the entire auricle appears so swollen and disfigured as to be almost unrecognisable, and covered at some parts with crusts, at others with vesicles, or scales and fissures. In severe cases, particularly where marked inflammatory symptoms are present, the glands in the neighbourhood of the ear become enlarged, in adults as well as in children. The author recalls an instance in which this condition in a patient misled his medical attendant into diagnosing a syphilitic affection, and prescribing an inunction treatment. In this case simple local measures were followed by complete recovery.

But though the objective signs as they present themselves on the auricle exhibit no particular deviation from the common, those of eczema of the external auditory canal and of the tympanic membrane are in many respects peculiar. In the deeper parts of the canal, or on the drum-head, an opportunity of observing the formation of vesicles rarely occurs. They vanish very soon in these situations; the epidermis desquamates very early; the dermis swells to a greater or lesser extent, though generally in an equable manner; and sooner or later a cloudy, serous discharge appears,

which becomes gradually purulent or sanguineo-purulent, especially if pustules are developed. The appearances become then very similar to those of a diffuse inflammation of the external auditory canal; and if the auricle in such a case should not likewise be affected, a doubt as to the nature of the disease might be present. If the case be of some duration, the absence of perforation of the tympanic membrane is in favour of the existence of eczema. With long-continued otitis externa diffusa, perforation is seldom absent. If the disorder be of but short duration, with slight pain only, this again would point to its being eczematous.

The history of the case should be thoroughly investigated and, taken in connection with the subjective symptoms and objective signs, will furnish trustworthy data for diagnosis.

In the later, so-called desquamative stage, with copious shedding of the epidermic scales, the integument becomes much swollen, whereby the auditory canal may be narrowed, or even occluded.

Chronic eczema manifests the same symptoms as the acute variety, being distinguished from it solely by the occurrence of frequent relapses and by its prolonged duration. The intensity of the morbid changes is no criterion. In an acute eczema of recent date, the objective signs may be strongly marked; while in the chronic form they are sometimes but slight. When the disease is chronic, however, the skin generally becomes considerably thickened.

Prognosis.—Eczema of the external ear is curable, nor does it recur so easily as eczema in many other situations. The constitutional state, as well as unfavourable external conditions, will naturally influence the progress of recovery.

Treatment.—This is still in its main features similar to that observed by the author whilst *Hebra's* hospital assistant: that is, it is symptomatic, but has special regard to the local anatomical and physiological conditions. In the first place, all crusts must be softened and removed by the application of lint moistened with glycerine, olive or almond oil, or some simple ointment. The further treatment is then to be regulated in accordance with the existing symptoms. Antiphlogistic measures must be adopted with pain and severe inflammatory symptoms; for this purpose, dressings of Goulard or borax solutions, with ice if necessary, are very serviceable. If these are not well borne, simple ointment spread on small pieces of linen and changed often may be applied to the eczematous parts.

In the slighter forms of acute eczema of the auricle, the application of glycerine or a simple fat; vaseline; ung. altheæ; or a glycerine ointment (glycerini puri 25·0, amyli puri 5·00), is usually successful. Care must, however, be taken that the affected parts come into prolonged contact with the medicament. To this end, small wads of charpie, moistened with glycerine, or pieces of lint spread with the necessary salve, are adapted to

the natural depressions and projections of the parts, and fixed by suitable bandages. The dressings should be renewed twice daily, the accumulated secretion being then removed by dabbing the parts with some absorbent material.

If the results from the above remedies are not satisfactory, mild astringent applications should be tried. The following may be recommended: oxide of zinc ointment (ung. emollient. 10·0, oxydi zinci 0·1—0·3); boric acid ointments (acid. boric. 5·0, paraffini, ceræ alb. āā 10·00, ol. ricini 30·00; or acid. borici 5—10·0, glycerini, paraffini, ceræ albæ āā 25·0, ol. oliv. q. s.; or *Hebra's* diachylon ointment (empl. diachyli simpl., ol. oiivæ āā partes æquales; or the following formula: ol. olivæ optimæ 500·0, lithargyri 130·0, ol. lavand. 10·0); or *Wilson's* oxide of zinc ointment (prepared lard 50 parts, gum benzoin in powder 1 part; heat slowly for 20 hours in a closed vessel; strain through linen, and add purified oxide of zinc, 10 parts. Mix well and press through linen). The last ointment may also be used mixed with alcohol in the proportion of 10 parts of the unguent to 1 of alcohol. *Neumann* recommends an ointment composed of equal parts of *Wilson's* and *Hebra's*. If recovery does not take place after employment of the above remedies, the author uses soft soap (sapo viridis) as long as vesicles and fissures are perceptible. A piece is washed over the affected part with water as long as a lather is formed. If the process is painful, cold applications may be afterwards made. This inunction should be carried out twice a day, and continued until secretion has ceased and vesicles are no longer formed; and if these symptoms reappear the treatment should be renewed. At night time the affected parts should be covered with one of the above-mentioned fatty preparations.

If desquamation has set in, applications containing tar will be found useful. For this purpose, ol. cadini or ol. rusci, mixed with an equal proportion of some simple oil, may be painted on with a brush several times daily until a perceptible layer has accumulated. If, after the layer has scaled off, the desquamative process should be found still in progress, the paintings may be repeated. If the painting is not well tolerated, the remedies above named may be employed in the form of an ointment (ol. rusci 5·0, glycer. 2·0, ung. emoll. 25·0). *Neumann*,[1] in cases of slight infiltration and desquamation, recommends carbolic acid (acid. carbolic. 1·0, solve c. s. q. glycerini, ung. emoll. 20·0; or acid carbol. 10·0, alcohol, glycerin. āā 50·0, aq. dest. 250·0).

If the external auditory canal is implicated, all contained matters should first be removed. With very adherent accumulations of epidermic scales, washing out should not be persisted in, otherwise the structures may be

[1] Lehrbuch der Hautkrankheiten, Wien, 1880.

irritated. The material should be first of all loosened by the instillation of a solution of potash or of carbonate of soda in glycerine (1 part in 150); syringing will then remove it easily. In mild cases without pain the introduction of 10 to 15 drops of a solution of sulphate of zinc in glycerine (zinci sulph. 0·1—0·5, glycerini 50·0) three times daily, will usually be found efficacious. If not, the author, with *Voltolini* and *Knapp*,[1] uses a solution of nitrate of silver (arg. nit. 0·1—0·5, aq. fontan. dest. 10·0) for painting the walls of the canal. When severe inflammatory symptoms are present, the treatment should be as for external otitis. With great thickening of the skin and narrowing of the external auditory canal, the above-named ointments may be applied, and compression used at the same time. For this purpose, plugs or laminaria tents of the length of the canal, and furnished with a thread for their easy withdrawal, may be introduced, having been previously smeared with the desired ointment. Pieces of compressed sponge may also be employed in a similar way. In many instances it will be found necessary to change the kind of application frequently, or to revert to one previously used: this is especially the case with soft soap.

If with the local affection a general disorder is likewise present, remedies suitable to this should of course be employed. With anæmic individuals, for instance, a strengthening diet and iron is indicated. The author considers the ferruginous mineral waters containing arsenic (*Roncegno, Levico*) to be very useful, and prescribes from 1 to 4 tablespoonfuls daily in water. With scrofulous subjects, cod-liver oil may be administered; and in rickets some preparation of phosphate of iron (ferri phosph., calcii phosph. partes æquales: as much as can be taken up on the point of a small knife, three times daily). With gastric and hæmorrhoidal affections, alkaline waters may be given (*Carlsbad, Marienbad, Vichy*, etc.). In relapsing cases *Fowler's* solution may be ordered, commencing with two drops daily, and carefully increasing this to larger doses. It is advisable to prescribe some aromatic infusion to be taken after each dose.

In cases of inveterate dry desquamative eczema with glandular infiltration, *Weber* recommends an ointment of white precipitate with camphor, to be well rubbed in twice daily.—*Toynbee* treated chronic eczema of the ear by the application of emollients after cleansing the parts with tepid water. In cases attended with severe pain, he ordered small pieces of oiled linen or indiarubber cloth to be applied.—*Wilde* painted the eczematous surface with a solution of gutta-percha in chloroform. After this had scaled off, the application was repeated until the skin healed. With copious epidermic formation he used zinc ointment, or an ointment of the nitrate of mercury.—*Ladreit de Lacharrière*,[2] for alleviating severe itching, advises a wash of mallow and poppy decoction, the parts to be then painted with ol. amygdal. and ol. hyoscyam. (partes æquales).

[1] "Die Höllensteinbehandlung des Eczems der Ohren." Zeitschrift für Ohrenheilkunde, x. Bd., 3. Heft.

[2] "Ann. des Mal. de l'Or.," i. 3.

8. Acute Exanthematous Eruptions on the External Ear.

The acute inflammatory affections of the skin due to the contagion of *measles*, *scarlet fever*, and *small-pox*, implicate also the auricle, external auditory meatus, and tympanic membrane. On the auricle they do not usually come under the notice of the aurist, and produce no disturbance of function. In the external auditory canal, however, and on the drum-membrane, acute diffuse inflammation and its results are very easily developed, especially in small-pox, and must then be treated as described further on in otitis externa.

In many cases it happens, especially in small-pox and scarlet fever, that no abnormal symptom in respect to the ear is observed during the course of the fever; but that during convalescence, or still later, deafness comes on, with or without subjective auditory sensations. These disturbances are frequently brought about by accumulations of epidermis in the auditory canal and upon the drum-head, and may then be easily removed by syringing.

It is, however, advisable to first loosen the adherent accretions by the use of suitable instillations, as otherwise the injection might induce inflammation in the abnormally sensitive structures. For the same reason the necessary means should be adopted after the termination of the illness for the protection of the auditory canal against external irritating influences.

9. Other Inflammatory Processes affecting the Auricle.

Amongst such are to be enumerated: *erythema*, *erysipelas*, *furuncle*, and *perichondritis of the auricle*. These disorders are due to similar causes, and are to be treated on the same principles, as when they are present in other regions. Erysipelas of the auricle usually extends from the face or scalp; sometimes, however, the reverse is the case, the auricle being first of all affected, and the disease then spreading to the adjacent parts.

Perichondritis of the auricle, especially of its anterior surface, is one of the most painful of febrile diseases. When occurring on the posterior surface it sometimes leads to the formation of very large abscesses, and in rare cases the cartilage may become necrosed and the dead portion be thrown off, with resulting deformity of the auricle.

Knapp,[1] in speaking of this condition, lays stress upon the fact that the lobe of the ear remains unaffected. The author, however, has observed several cases in which the lobe also became inflamed. When the perichondritis is on the posterior surface this is almost always the case.

1 "Perichondritis Auriculæ," Zeitschrift für Ohrenheilkunde, x. Bd.

A case may here be mentioned which came under the author's observation, and is entirely unique. In an otherwise healthy girl of ten, *the lobe of each ear* presented a condition of chronic inflammation. The skin was intensely red, moderately swollen, somewhat hard to the touch, and but slightly painful on pressure. The swelling and redness did not extend higher than the upper margin of the lobe; the rest of the auricle, and indeed the whole ear, being otherwise healthy. The affection arose without any known cause in both ears at the same time, and when first seen had already existed for two years. The author requested *Professors Neumann* and *Weinlechner* to look at the case, and they agreed that they had never observed anything similar. They both also, with the author, came to the opinion that it was to be considered as one of chronic erysipelas. The redness diminished after prolonged use of Goulard water, but the ultimate result remains unknown, as the patient was lost sight of.

Inflammation accompanied by *diphtheritic exudation* occurs very seldom on the auricle, but it has been observed by the author and others. In some of these cases an inflammatory patch, which suddenly took on a diphtheritic character, was secondary to another inflammatory condition, or to some injury. In most instances, however, it was only an extension of the same disease, spreading from the external auditory canal. In one patient the author observed an ulcer the size of a sixpence, covered with diphtheritic deposit, in a man who had been working a good deal with quicksilver. The symptoms are not to be particularly distinguished from those which accompany a similar condition on other parts of the integument, and the treatment should likewise be on the same lines. Like perichondritis with necrosis, this diphtheritic affection of the auricle sometimes causes irregularities and defects of varied character and form. As a result of the disorder in question the author has repeatedly seen perforation of the auricle with great loss of substance, and similar consequences have been recorded by *Pomeroy*, *Wreden*, and others.

CHAPTER VI.

INFLAMMATION OF THE SOFT STRUCTURES OF THE EXTERNAL AUDITORY CANAL.

Clinical observation, no less than pathological investigation, shows that inflammatory processes in the soft structures of the external auditory canal are not to be classified upon an anatomical basis. With the exception of the slighter forms of erythema, which have their seat in the papillary layer of the cutis, it is difficult to make out any inflammation of the canal implicating but a single structural layer, or confined to a certain structure, as, for example, the glands found there. Several histological strata are generally affected simultaneously, and the clinical aspect of the malady is such as to correspond with this fact. For practical purposes, however, the different forms of inflammation to which the structures of the auditory canal are subject may be divided into two classes—viz., (1) *Circumscribed inflammation* (*otitis externa circumscripta*), and (2) *Diffuse inflammation* (*otitis externa diffusa*). In the former the morbid changes involve only the canal proper; in the latter, the tympanic membrane is likewise affected (*Von Tröltsch*).

I. Circumscribed Inflammation of the External Ear (Otitis Externa Circumscripta, Follicular Inflammation, Furuncle).

Furuncular inflammation—*i.e.* inflammation in the cutis and the subcutaneous areolar tissue, limited to a small area, and leading to the formation of an abscess—is frequently seen in the external auditory canal. This is probably to be accounted for by the numerous glands here present; for it is apparently those parts of the skin in which considerable secretion takes place that are peculiarly liable to this disease, the development of which may possibly be favoured by retention, or otherwise anomalous conditions of the gland products.

The circumscribed inflammation of the external auditory canal makes its appearance sporadically, or much more rarely epidemically. *Bonnafont*[1]

[1] L'Union, 1863.

observed such an epidemic in Paris in May and June of 1863, and the same phenomenon was seen in Vienna a little later.[1] In the latter city it was noted that the abscesses were usually developed in the outer third of the canal, near the tragus. The inflammation arises either idiopathically in otherwise healthy persons, or it is associated with the presence of some constitutional morbid state. In many individuals, especially in corpulent, full-blooded subjects, the disposition to the formation of furuncles is very marked. Patients too who are suffering from hæmorrhoids are peculiarly prone to this affection; and this may not improbably explain the views of earlier writers, who held the disease to be very often occasioned by disorders of digestion.

Etiology.—Catching cold, especially by exposure to a strong draught, is among the commonest causes of this form of inflammation. It is also very apt to arise in patients who have been for a long while troubled with otorrhœa dependent on a deeper disease of the ear, and is due either to some trophic disturbance, or to the continued irritation of the discharge, which frequently contains infecting cocco-bacteria. The employment of dirty plugs of cotton-wool also favours its development, for by them not only are there introduced into the canal all sorts of infecting matters, but they retain part of the discharge from the ear, and maintain it in contact with the integument. Besides this, the itching thus set up leads to scratching, whereby the irritation is still further increased. Immoderate syringing out, especially with a solution not of the proper temperature, or neglect to insure that the canal is dried after the injection, may also lead to an inflammatory attack. Again, direct mechanical, chemical, or other irritation may bring on the disorder. It is thus sometimes induced by violent scratching, and the introduction into the canal of irritating liquids, such as chloroform or ether, which may have been employed in this way with the view of relieving toothache or migraine. Solutions even of substances used in treating an otorrhœa—alum or nitrate of silver, for example—may occasion an attack of furuncle. The internal use of some medicinal agents appears also to favour its origin, the author having observed after prolonged administration of bromide of potassium an obstinate circumscribed inflammation in the auditory canal, which could only be cured by disuse of the drug.[2] According also to *Nothnagel* and *Rossbach*,[3] ulceration in the external auditory canal has been observed in chronic arsenical poisoning.

There is further no doubt that the inflammatory processes in question

[1] See *Prof. Gruber's* report of the patients treated by him in the Vienna General Hospital, 1863.

[2] Compare the author's contribution, "Zur Aetiologie der Entzündung im äusseren Gehörgange." Monatsschrift für Ohrenheilkunde, xii. Jahrg., Nr. 11.

[3] Handbuch der Arzneimittellehre, 5. Aufl., 1884.

may be caused by the contact of putrid substances with the skin lining the meatus. In this way may be explained the frequency with which furuncle occurs in persons who have much to do with the handling of decomposing animal matter; as, for instance, tanners, butchers, and scavengers. Lastly are to be mentioned the micro-organisms present and sometimes growing in the canal, which may occasion the development of a circumscribed, although much more often of a diffuse inflammation.

We owe to *Wreden* the first complete clinical account of fungi in the ear, and the morbid changes dependent on them. In his monograph[1] will be found an accurate description of them, and of the affections of the external auditory canal due to their presence. Before *Wreden*, *Mayer*,[2] *Pacini*,[3] *Schwartze* and the author had described fungi found in the ear. *Schwartze* had drawn attention to the possibility of the occurrence of an inflammation occasioned by their growth in the canal; but the fact itself was first confirmed by the arduous labours of *Wreden*. He, however, thought that they caused only an inflammation of the tympanic membrane; but it is now known that the auditory canal may also be the seat of such an inflammation, and this fact has been marked by the use of the term otitis parasitica. The fungi are generally present in the deeper parts of the auditory canal, and on the tympanic membrane. They are usually found mixed with epidermic scales and other substances present in the canal, such as cerumen, hairs, or exudation, in the form of membranous or conglomerated masses, and betray their presence by variously coloured spots or a peculiar coloration of the whole—deep brown, yellowish, greenish, or reddish. The varieties most often seen by the author have been the different kinds of *aspergillus* and *mucor mucedo*.

According to *Burnett*[4] all the fungi met with in the ear belong to the arthrospores. The varieties which occur are:—*Aspergillus niger*, *aspergillus glaucus* and *flavus*; *mucor mucedo* and *mucor racemosus* (*Bezold*); *ascophora elegans*; *trichothecium roseum*; *microsporon furfur* (*Kirchner*): and *eurotinus repens* (*Siebenmann*). Various fungi are frequently observed in the same ear; thus, the author has not seldom seen aspergillus with penicillium, or different kinds of aspergillus present together. *Cassell's*[5] statement, according to which aspergillus occurs outside the human body always along with penicillium, but in the human ear, on the contrary, always alone, is opposed to the author's observations. The spores of these fungi are found everywhere, suspended even in the atmosphere of rooms; therefore no special condition, as a damp house, is necessary to explain the occurrence of otomycosis.[6]

The question as to whether the presence of these fungi is *per se* sufficient to bring about inflammation appears up to the present to have been answered by

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[1] "Die Myringomikosis aspergillina und ihre Bedeutung für das Gehörorgan," St. Petersburg, 1868; also in the Archiv für Ohrenheilkunde, iii. Bd., and in the Monatsschrift für Ohrenheilkunde, i. Jahrg., Nr. 1.

[2] "Beobachtungen von Cysten mit Fadenpilzen aus dem äusseren Gehörgange." *Müller's* Archiv, 1844, S. 401, Taf. x.

[3] "Supra una muffa parasitica—Mucedo—nel condotto audit. esterno," Firenze, 1851, S. 7.

[4] Amer. Journ. of Otol. i., 1879.

[5] Glasgow Med. Journ., January 1875.

[6] *Siebenmann*, "Die Fadenpilze, Aspergillus flavus, niger und fumigatus, Eurotinus repens und ihre Beziehungen zur Otomycosis aspergillina." Zeitschrift für Ohrenheilkunde, xii. Bd.—*Cresswell Baber* (Brit. Med. Journ., 1879) found small black bodies in the water with which an ear had been syringed, which proved under the microscope to be mycelium and spores of penicillium. On closer examination it turned out that they were derived from the leather sucker of the syringe. This is mentioned as a caution in diagnosis.

experiment in the negative. No inflammation could be produced by simply introducing aspergillus into the auditory canals of animals or human beings. This result, however, is not inconsistent with the possibility that under certain special

Fig. 95.

Aspergillus flavus (× 100 diameters).

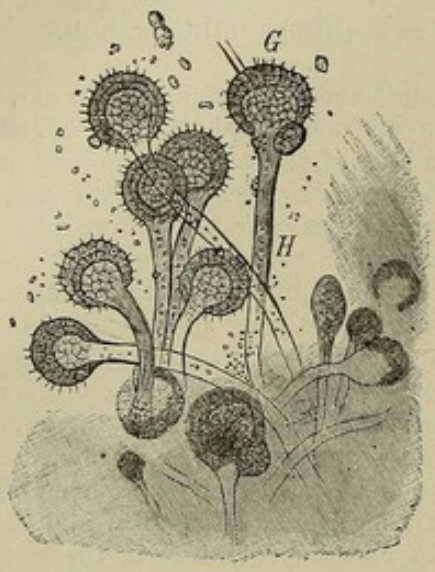


Fig. 96.

Mucor mucedo (× 100 diameters).

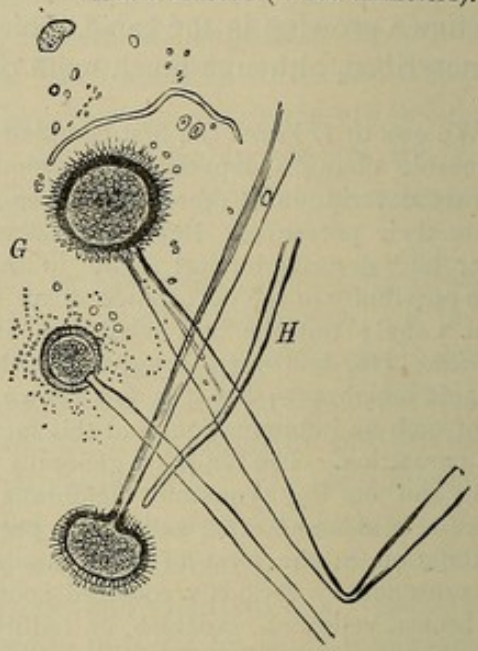


Fig. 97.

Mucor racemosus. Fruit-bearing hypha (× 100 diameters).

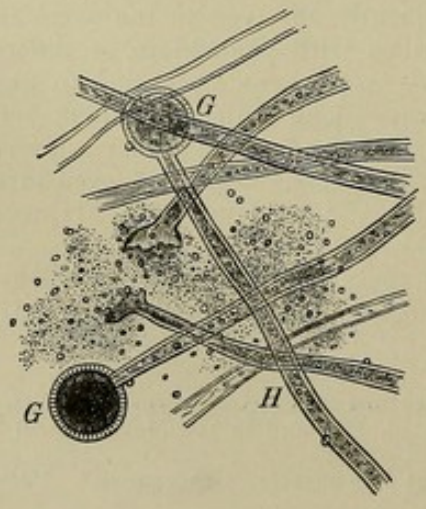
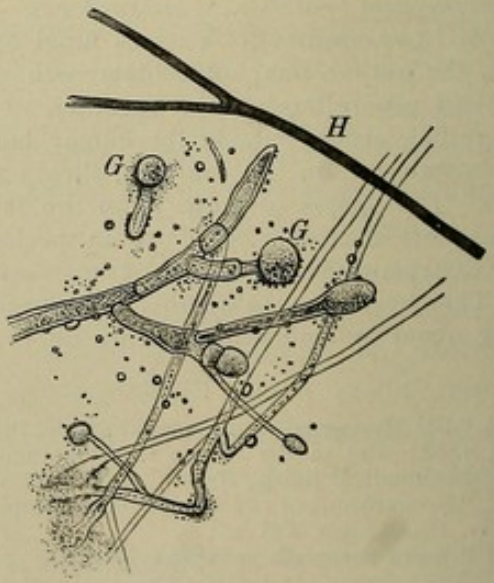


Fig. 98.

Mucor racemosus. Mycelium with spores in course of development (× 100 diameters).



In all the figures *H* denotes mycelium, and *G* spores.

conditions such an inflammation may ensue. The author considers that all the fungi enumerated may be present in the ear for a long period without setting up any change in the structures; but that, under certain local conditions, they have the

power of loosening the epidermis and producing an irritation of the parts, especially of the tympanic membrane, of sufficient intensity to bring about an inflammation. This would arise still more readily if the germs came into contact with an injured surface. *Politzer*[1] observed a case in which large accumulations of aspergillus were present in the canal without a trace of inflammation. By way of experiment he made a small incision in the skin, whereupon an inflammatory infiltration was induced, which only disappeared at the end of a fortnight.

According to *Siebenmann* and *Burnett*, the influence of cerumen is opposed to the development of fungi. Decomposing pus is likewise said to be unfavourable to germination, on account of the presence of ammonia and sulphide of ammonia, due to the decomposition. The instillation of oil, on the other hand, is said to favour their growth. Mucus and mucous membranes are stated by *Siebenmann* to be unfavourable media for the growth of aspergillus. *Burnett*,[2] however, observed in a patient, in whom a perforation of the tympanic membrane remained after a purulent inflammation of the middle ear, that some weeks after the otorrhœa had ceased, a recurrence of the inflammation took place, and a quantity of aspergillus glaucus was found in the purulent masses which were removed from the tympanic cavity. The inflammatory symptoms disappeared only after the use of alcohol.

Cocco-bacteria play also an important part in the inflammatory processes occurring in the ear. According to the investigations of *Löwenberg*,[3] the coccus of furuncle is morphologically different and larger than that associated with any other otorrhœa. Cocco-bacteria adhere very readily to cerumen, and if exudation into the auditory canal takes place, the conditions are very favourable for their development. *Löwenberg* explained the extension of the inflammatory process by the penetration of the micro-organisms into the migratory cells, whereby they are conveyed to other parts.

Kirchner[4] found the *Staphilococcus pyogenes albus*, described by *Rosenbach*, in furuncles situated in the external auditory canal, of which he made pure cultivations both in gelatine and agar-agar. Inoculations of these on white mice produced abscesses, whilst on rabbits they gave negative results. *Rosenbach*, however, considers staphilococcus pyogenes albus to be the pathological cause of abscess formation, and explains the peculiar tendency to the recurrence of furuncles in the ear by invasion of the connective tissue by the micro-organisms.

Course of the disease.—The *subjective symptoms* of otitis ext. circumscripta vary in accordance with the site and intensity of the inflammation. The disorder is very often attended with fever, especially if it affects the deeper portion of the auditory canal. Very sensitive individuals, and those also who are plethoric, are more likely to exhibit acute febrile symptoms. At the commencement of a severe furuncular inflammation, or when suppuration sets in, children and such persons may even become delirious from this cause. From the vomiting which occurs so readily in children under these circumstances, such cases may be mistaken for meningitis by practitioners unaccustomed to examine the ear. The nearer the disease is to the entrance of the external auditory canal the slighter, as

[1] Lehrbuch der Ohrenheilkunde, S. 690.
[2] Report of the First Congress of the American Otological Society.
[3] "Untersuchung über Auftreten und Bedeutung von Coccobacterien bei eiterigem Ohrenflusse, und über die durch ihre Gegenwart bedingten therapeutischen Indicationen." Zeitschrift für Ohrenheilkunde, x. Bd.
[4] "Zur Pathologie der Furunkeln des äusseren Gehörganges," Separatabdruck, 1885.

a general rule, is the pain. This fact is due to the anatomical relations of the soft structures; those parts which are situated externally yielding to distension by the infiltration more easily than the deeper ones in connection with the osseous portion of the canal.

The pain is differently described by patients. It is not limited to the ear, but generally shoots over the entire half of the head on the same side, or even over the whole head. Not infrequently the chief pain is experienced in some other region of the head, so that it may at first be thought to proceed from the teeth, occiput, etc.; and the patient only recognises the true seat of the affection from the occurrence of other symptoms, such as deafness, tinnitus, or otorrhœa.

The pain may be increased by certain incidental circumstances. Thus it is often aggravated by the movements of the jaw in mastication and swallowing, whereby the structures of the canal suffer pressure or tension. The lightest contact with the auricle, again, or the least pressure upon the tragus, or in the depression between the jaw and the mastoid process, often augment it very considerably. In many cases the pains are worse at night, disturbing the rest, and are usually associated with an exacerbation of the fever. They continue often without any relief until the spontaneous or artificial evacuation of the abscess, though sometimes a slight remission or intermission does occur. When the pus is evacuated, the violent pain ceases, provided a second focus of inflammation is not present; and the patient is only troubled at variable intervals with transient shooting pains in the ear, which come on less and less frequently with the decline of the disease, until they finally entirely disappear; though the feeling of itching and fulness usually becomes then more pronounced.

The special aural phenomena consist in deafness of varying degree, and subjective auditory sensations of different kinds and duration. The impairment of hearing is usually due to impeded sound-conduction from the presence of the swelling and the products of inflammation. In many cases, however, it is caused by the depreciated perceptivity of the auditory nerve in common with that of the entire nervous system, as a result of the intense and prolonged pain. This is shown by the fact that the degree of deafness stands in no direct proportion to the extent of the swelling in the auditory canal.

These special symptoms, in particular the subjective auditory phenomena, may also result from the co-existent hyperæmia of the deeper structures. Most frequently they are occasioned by the presence of inflammatory products, which, accumulated in the canal, press on the tympanic membrane, and thus indirectly increase the intra-labyrinthine pressure. That the subjective sensations depend likewise upon reflex changes, is indicated by cases in which they appear and disappear in

correspondence with an increase or decrease of pain without any other obvious cause. The tinnitus may continue during the whole course of the disease, and even until after the disappearance of all the morbid changes. Usually, however, it is periodical only, and is readily explained by the causes above mentioned. Very frequently indeed the disorder runs its entire course without any noises being present at all.

The *objective changes* are more important from the point of view of diagnosis than the subjective symptoms, and special attention must therefore be paid to them. In isolated cases no other alteration may at first be recognised beyond a slight yellowish-red discoloration of the skin, even though much pain and fever are present. In such, the extreme sensibility on examination is a much more marked feature than any visible change in the parts. In the majority of instances, however, there may be noticed even at this early stage of the affection a more or less circumscribed redness and swelling of the integument at one or more points in the auditory canal. The redness varies according as its site is in the cartilaginous or osseous portions of the canal, and according as the principal seat of inflammation is in the skin proper or in the deeper tissues. In the osseous region, the hyperæmia is more intense than in the cartilaginous portion. When the former is affected, its colour imparts to the tympanic membrane a light-violet shade. The surface of the inflamed part often acquires in a short time a somewhat moist (succulent) appearance, and is covered here and there with swollen epidermic scales, which are generally closely adherent to the skin.

Suppuration having commenced, the inflammation becomes more circumscribed. Even when the redness and swelling had been previously diffused, the latter takes an elongated or roundish form, varying in size from that of a bean to a hazel-nut, and generally larger in the cartilaginous portion of the canal. In this a distinct focus of suppuration can at this stage seldom be recognised, and the lumen of the canal is often so much narrowed, especially if several abscesses are developing simultaneously, that the deeper parts cannot be seen. Sometimes at this stage it cannot be said whether a circumscribed or a diffuse inflammation is present.

In severe cases, hæmorrhage from rupture of small vessels occurs, either at an early period, or more often at a later stage. When such extravasations take place beneath the epidermis, larger or smaller vesicles of a livid colour appear, and on rupture, or when punctured, the contents discharge themselves into the canal, and the vesicle collapses. The author cannot agree that this phenomenon in itself justifies the description of a distinct disorder, "*Otitis externa hæmorrhagica*," as given by *Politzer*,[1]

[1] Lehrbuch der Ohrenheilkunde, S. 687.

but considers the hæmorrhage merely an accident of the inflammatory process, such as may not seldom be observed in other parts.

In most cases the structures in the immediate neighbourhood of the ear become affected secondarily. Thus the lymphatic glands in the vicinity become swollen, chiefly those found in the substance of the parotid. The glands between the angle of the jaw and the mastoid process are apt to enlarge and become painful and very sensitive to pressure. The parts near the ear, especially in the mastoid region, may become red, swollen, and œdematous. The œdema is particularly liable to be seen in persons who have much fat in the neighbourhood of the auricle, and appears very readily in the parotid region; less frequently about the mastoid process, where hyperæmia is on the other hand more prone to extend. If the swelling in the auditory canal does not subside, suppuration sets in,—in many cases in the course of twenty-four hours. Usually pus begins to be evacuated after from two to three days, but sometimes somewhat later; and then a discharge, generally tinged at first with blood, is found in the auditory canal. According to its amount and consistence, it either collects there in greater or smaller quantity, or it flows away, causing sometimes excoriations or artificial eczema of the adjacent parts of the auricle, especially in delicate strumous children. If the seat of the abscess is near the orifice of the meatus, or on the tragus or antitragus, the discharge soon ceases after the evacuation of the abscess, or is reduced to a minimum. When, however, the swelling is in the osseous portion of the canal, the exudation is apt to be much more protracted, and the abscess correspondingly long in healing up. Sometimes large sloughs of connective tissue and membranous structures are thrown off, smaller fragments of the dead tissue passing off imperceptibly with the discharge.

Hribar[1] saw a case of spontaneous evacuation of an abscess in the auditory canal, in which the pus was discharged into the mouth through the duct of the parotid gland.

When the disorder affects the deeper parts of the auditory canal, there are usually several abscesses which form and come gradually to maturity, and in this way prolong the painful period. Less frequently, the suppuration continues from an abscess which has already discharged. This does not depend, according to the author's view, upon any special state of the patient, but rather upon the locality of the disease. Certain sections of the auditory canal appear to favour prolonged suppuration more than others, on account of their peculiar anatomical structure, but chiefly through their proportionately greater vascularity. Thus, inflammatory processes occurring in the upper parts of the

[1] Wiener medicinische Presse, 1871.

canal are, as a rule, more obstinate, and attended with more severe symptoms than when situated in the lower parts. The author is disposed to attribute this mainly to the presence of larger vessels in the superior wall, and also to the fissuræ tympanico-squamosæ found there, in which deeper foci of inflammation may be readily set up. Should inflammatory processes in the immediate vicinity of the drum-membrane lead to abscess formation extending to that structure, tedious suppuration is likely to be established.

When suppuration has once ceased, the swelling of the structures which accompanies it usually in the course of a few days disappears, followed by a more or less abundant desquamation of the epidermis, and generally also by an increased secretion from the ceruminous glands. This increase of secretion is possibly connected with augmented vascularity associated with the inflammatory process, and is at this period the more noticeable because the cerumen had previously passed away with the discharges, or was retained in the glands from temporary closure of their excretory ducts. In exceptional cases, especially in delicate children, but also in healthy adults, granulations form round the edges of the abscess-opening. They grow very rapidly, but in most instances soon disappear; though in others they may persist, and then require suitable surgical treatment.

Circumscribed inflammatory processes in the external auditory canal usually run an acute course, but no other disease of the ear is so prone to recur. When a disposition to the affection exists, attacks may occur from certain causes or at certain times for many years. The course of the inflammation, which otherwise lasts some weeks at the most, may in this way become protracted, and acquire a more chronic character. Such rare cases are distinguished by absence of pain and fever, with long-continued discharge. They usually depend upon some dyscrasia, or upon some injurious external cause, and in the majority of instances acquire the character of diffuse inflammations after a longer or shorter period. Abundant granulations are generally developed at the seat of suppuration, and sometimes proliferate so luxuriantly as to fill up the greater part of the canal and look like a polyp. At times also obstinate ulceration results.

As a rule, a circumscribed inflammation of the auditory canal remains limited to the soft structures, though perhaps new inflammatory centres may become developed. Under certain circumstances, however, the bones or structures of the cranial cavity may become affected, and a much more serious condition may then arise. This will be referred to later.

Propagation of the inflammation to adjoining structures is greatly favoured by certain anatomical or pathological conditions. Thus, towards the parotid gland its extension readily takes place by way of the fissures of Santorini, the tissues

filling which offer less resistance than the cartilage. The author possesses in his collection two adult temporal bones,[1] which exhibit congenital fissures along the entire upper and posterior aspect of the auditory canal, and communicate with the mastoid cells, as well as by the tegmen tympani, with the cranial cavity. An inflammatory process arising in the external auditory canal might in such a case easily spread to the cranial cavity and terminate fatally.

The *prognosis* is generally favourable, but the unusual tendency to recurrence should always be remembered. The possible results of the inflammatory process, such as gravitation-abscesses, must of course be taken into consideration when venturing an opinion upon the probable length of the disease. Otitis parasitica may run a protracted course, the fungus sometimes resisting treatment for a long while.

Treatment.—Since the introduction by the author into aural practice of medicated gelatine preparations,[2] he almost always begins the treatment with these, unless the patient has an abscess already mature or a parasitic otitis. In the early stage, in which severe pain is usually present, he employs "amygdalæ aurium,"[3] containing $\frac{1}{8}$ gr. of liquid extract of opium, or $\frac{1}{12}$ gr. hydrochlorate of morphia. The auditory canal is first thoroughly washed out with a warm 4 per cent. solution of carbolic acid; the gelatine-almond is then introduced deeply into the canal with the aural forceps, and the meatus closed with cotton-wool. The preparation gradually dissolves, and the pain is in this way generally very soon alleviated, and the inflammatory process cut short in many patients. The applications may be repeated as needed: sometimes one daily is sufficient; in other cases three or four may be indicated. In children half may be used.

The effect of these preparations is twofold—partly anæsthetic, partly antiphlogistic. The latter is to a certain extent explained by the loss of heat contingent upon the passage of the substance from the solid to the liquid state. The author can strongly recommend these preparations, on account of their value in appropriate cases, and from the simplicity of the treatment. If pus has already formed, their advantage is not so marked, though they are still very useful for the relief of pain until the abscess is evacuated. Such good results are obtained from this mode of treatment that the author no longer practises scarification, as was previously done

[1] *Prof. Zuckerkandl*, "Ueber eine typische Spaltbildung an der hinteren Wand des äusseren Gehörganges." Monatsschrift für Ohrenheilkunde, Jahrg. xii., 4.

[2] Compare Wiener Allgemeine medicinische Zeitung, 1878, Nr. 1 und 2.

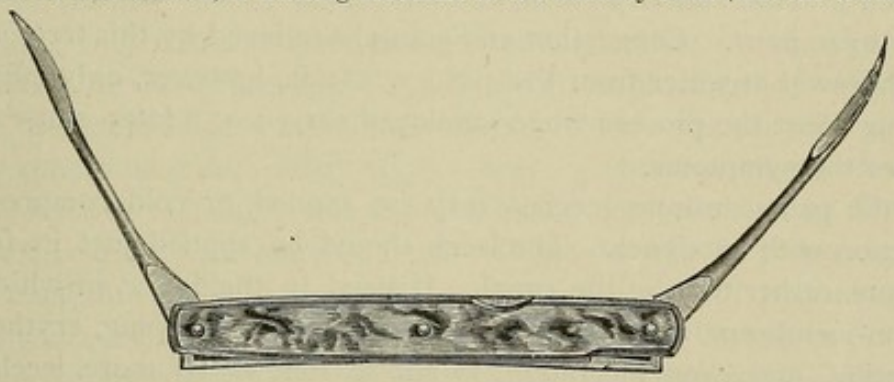
[3] These preparations consist of gelatine, with which is incorporated the medicament required. They are of a somewhat conical form, and at the translator's request have been recently made by Messrs. Bullock & Co., of Hanover Street, W., and named "aural ovoids." They may be obtained in two sizes, containing, as may be desired, ext. opii liq., morphia, zinci sulphas, aristol, or other substances. The effect of these preparations is very gratifying in cases of impacted cerumen, in which extreme sensibility of the meatus is present, and which obstinately resist syringing. The "aural ovoids" relieve the pain and sensitiveness, and soften the plug. They are particularly useful where a portion of the latter has been removed, leaving an excoriated state of the integument behind.—Eds.

almost without exception in the stage of hyperæmia before the establishment of suppuration.

For the purposes of scarification, or for the opening of abscesses, an instrument resembling a tenotomy knife, as represented in the accompanying figure, is most convenient. Scarification should be carried out by incisions from within outwards, from 1 to 2 *cm.* in length, through the inflammatory swelling, and also along the other parts of the canal. The reduction of the hyperæmia by the depletion may be maintained by careful injection of lukewarm water for the removal of coagula. In many cases the pain is alleviated by the diminution of tension thus brought about; and even suppuration obviated, if the incisions have been made sufficiently soon. The incisions should be deep enough to reach the perichondrium or periosteum. No ill result follows the wounding of these structures in this method of operation. It is well to apply afterwards a moderate degree of pressure

Fig. 99.

Instrument for scarification, or incising abscesses in the auditory canal (half the ordinary size).



to the parts by introducing a moist plug into the canal; but care should be taken that the compression is not so great as to cause pain. Sometimes the whole inflammatory process is curtailed by this treatment; no suppuration takes place, the swelling subsides, and the incisions heal by first intention.

As an abortive measure with the object of destroying the micro-organisms associated with the furuncular inflammation, *Hüter* and *Weber-Liel* recommend the subcutaneous injection of a few drops (two to four) of a 5 per cent. solution of carbolic acid. The puncture should be from 1 to 2 *mm.* in depth at the most prominent part of the swelling. According to *Weber-Liel*, the pain abates in about a quarter of an hour; and he advises instillations of spirit to be then employed in about three hours' time, and repeated every two hours. With more pronounced cases, or when several abscesses are present, the carbolic acid injections should be repeated. This may be done on the same day as the first, and with an 8 per cent. solution, if the pain has not been relieved. A severe smarting or burning

pain, which may last for an hour or two, arises after the stronger injection; but the inflammation then usually begins to subside, and a feeling of increased tension only remains, lasting usually for some days.

Schwartze[1] asserts that the inflammation may be arrested by a strong application of nitrate of silver to the walls of the auditory canal, as in the case of incipient whitlow. *Urbantschitsch* believes that the process may at an early stage be cut short by a kind of massage of the affected parts. For this purpose he recommends pressure to be exercised by means of friction or tampons, and the latter may be covered with a little ung. cinereum (*Schalle*[2]). Ordinary drainage tubing may also be employed instead of tampons (*Pomeroy*[3]).

If subcutaneous injection of carbolic acid is not adopted, *Weber-Liel*[4] recommends the following measures: The ear is first to be well bathed with a solution of bicarbonate of soda in spirits of wine (1 in 60); then dried with cotton-wool or brushes, and afterwards instilled with alcohol, to which a little perchloride of mercury may be added (1 to 1500). This is to be poured into the auditory canal, and allowed to remain there for from half an hour to an hour. Congestion and pain are relieved by this treatment by the withdrawal of water from the tissues. It is, however, only efficacious in cutting short the process when employed early; at a later stage it only mitigates the symptoms.

If the pain continue, leeches may be applied, or cold compresses in conjunction with anodynes. The leech should be applied just in front of the tragus, rather than in the canal. If used in the latter, in which case the drum-membrane must of course be protected by a plug, erythema or suppuration, and even ulceration, is apt to follow. If more leeches are considered necessary, some of them may be placed a little below the mastoid process, where a temporary depletion of the vessels in the region of the stylo-mastoid foramen will often have a beneficial result. The number of leeches applied, the duration of the bleeding after their removal, and the repetition of this treatment, are matters to be regulated in accordance with the particular circumstances of the case. In anæmic patients the use of *Heurteloup's* artificial leech may sometimes be advantageous; but, on the other hand, cases occur in which, on account of the extreme congestion and symptoms of cerebral pressure, even venesection may be indicated.

If the above treatment should fail to reduce the inflammation, it should be our aim to hasten the suppurative process, and to evacuate the pus. To this end, when the inflammation is deeply situated, it is advisable to

[1] "Die chirurgischen Krankheiten des Ohres," S. 89.

[2] "Bericht über die Ohrenstation des Garnisonlazarethes zu Dresden," Archiv für Ohrenheilkunde, xii. Bd., S. 11.

[3] "Transactions of the Amer. Otol. Society," New York, 1882.

[4] "Zur Abortivbehandlung der furunculösen Entzündung im äusseren Gehörgange." Deutsche medicinische Wochenschrift, 1880, Nr. 15.

introduce tepid emollient and anodyne solutions frequently into the auditory canal. The author usually employs a lukewarm decoction of poppy-heads with a little laudanum, as recommended by *Bonnafont*; or plain tepid water containing a little laudanum or morphia may be tried. They should be poured into the canal every half-hour, and allowed to remain there for some minutes, the meatus being afterwards plugged with cotton-wool.

If the disease be localised in the cartilaginous portion of the canal, the introduction of plugs of cotton-wool moistened with warm solutions is very grateful to the patient. The author employs usually a solution of acetate of lead and acetate of morphia (1 part of each in 500 of water). The cotton-wool soaked in this is inserted into the ear, and then covered up with a dry piece of wool. Every quarter of an hour or half-hour, when the application has become cool, it may be renewed. The use of hot vapours has been long and properly abandoned, as also the employment of poultices to the entire surface of the ear. From the latter, inflammation of the parotid gland and perichondritis in the mastoid region are very prone to result. These affections, which are very liable to occur in association with circumscribed inflammations in the canal, may, on the other hand, be easily prevented by the direct employment of cold applications at the commencement of the disorder. For this purpose a *Leiter's* cooling-apparatus is well adapted, as it may be constructed so as to leave the auricle free. If this is not at hand, a cold compress in the form of a horseshoe round the ear may be used. It should not be placed upon the auricle itself, but made to cover the parotid and mastoid regions. When the pain is very severe, narcotic preparations may be applied locally or administered internally. An ointment containing morphia acts exceedingly well (morph. muriat. 0·1—0·2 ad 10·0 vaseline). Veratrine in glycerine is also efficacious (1 to 100), or chloroform or sulphuric ether in ol. hyoscyami (4·0—10·0 to 20·0) may be rubbed over the skin in the vicinity of the ear. In very obstinate cases, when the pain is so severe as to prevent sleep at night, hypodermic injections of morphia may be given. Unfortunately, however, the pain is sometimes increased, from the nausea or vomiting which they occasionally produce.

Urbantschitsch states that the application of a strong induced-current for from five to ten minutes has a marked effect in allaying the pain. One pole should be placed on the tragus, the other on the neck. He also recommends, for the same purpose, the application of a few drops of a solution of morphia in glycerine to the inflamed portion of the auditory canal.

In certain cases, especially in otitis parasitica, the pain may be best relieved by an alcohol ear-bath. The whole auditory canal is filled with rectified spirits of wine, which is allowed to remain for ten or fifteen minutes. This treatment sometimes succeeds when the pain has defied the strongest narcotic remedies. Should all the above measures fail to

alleviate the pain, a blister may be applied beneath the mastoid process. The severest pain sometimes subsides from this treatment. The surface of the blister may be subsequently dressed with morphia. The introduction of small wedge-shaped pieces of well-soaked bacon has a very soothing effect, particularly at night-time.

Attention should be carefully given to the patient's general condition, and to the regulation of his diet and regimen. A saline purge, or purgative enemata, may be necessary, and with high fever the use of antipyrin and of mineral acids is indicated. Preparations of quinine or salicin should only be employed in case of necessity.

If suppuration be profuse, an attempt to diminish it may be made by the use of douches and other remedies. The author most frequently employs in such cases the "amygdalæ aurium" before mentioned, containing sulphate of zinc or borate of sodium; or, with a very copious discharge, sulphate of copper. For aural douches he is in the habit of using bichloride of mercury (1 in 5000), salicylic acid (1 to 2 parts in 1000), sulphate of zinc (3 parts in 1000 of water or glycerine), or borax. The various preparations of lead have long been employed in ear affections, the acetate especially (1 to 10 parts in 500). They are, however, less beneficial in cases of profuse otorrhœa than when much swelling is present with little suppuration. Solutions of tannin and of iron have the disadvantage of being often contaminated with insoluble matters, which may be deposited on the tissues. Alum (1 to 5 parts in 500) also is used when there is much exudation, but is best avoided, as experience tends to show that abscesses are apt to arise after its employment. If the discharge should be offensive, the above-mentioned remedies may be dissolved in some aromatic solution—*e.g.* orange-flower water. In many cases, especially when abundant granulations are formed, a solution of nitrate of silver is indicated (1 to 5 parts in 500). If excessive proliferation of the granulations take place, they may be brushed with a more concentrated solution (1 to 10 parts in 100 of distilled water); and should this not be effectual they may be touched with the solid nitrate of silver; or a silver wire may be dipped in nitric acid, and the layer of nitrate thus formed upon it may be similarly applied (*Pelletan*). The danger of the stick of caustic breaking is avoided by the latter method. Or, again, a little nitrate of silver may be fused upon a sound and used for this purpose. *Levi*[1] employs a concentrated solution of nitrate of silver (1 to 10). This solution is poured into the ear four days in succession. From the third day the ear is syringed with a carbolic solution (1 : 200). If the use of an astringent solution, in a case of profuse suppuration, has been persevered in for a long while unsuccessfully, the remedy should

[1] "Ann. des Mal. de l'Oreille, etc.," 2.

be changed. It sometimes happens that a substance thought to be less suitable acts better than the one employed. A weak solution also will sometimes check the discharge where a stronger one of the same substance increases it.

In cases of otitis externa unassociated with pruritus and eczema, tepid ear-baths with a 1 per cent. solution of sulphurated potash, during the intervals between the inflammatory attacks, are said by *Schwartze* to bring about a cure in the most obstinate cases. A patient, who suffered from furuncle 282 times between the years 1861 and 1878, remained free from any attack for four years by following this treatment.

If pain should still be present with a profuse discharge, great care should be used in employing stimulating applications; and if adopted at all, it is well to combine them with some anodyne. In many cases it is advisable to use plugs soaked in the required solution, especially when the canal is so narrowed by swelling that the ordinary instillation can with difficulty reach the deeper parts.

Before the introduction of any remedy into the auditory canal, this should be cleansed out as completely as possible. Immoderate syringing is however to be avoided, especially as neither patients nor their friends rarely understand how to do it properly and with discretion.

Inflammatory swelling of the structures of the auditory canal sometimes remains for a long time after the discharge has ceased. If it does not impede the conduction of sound, no interference is indicated; but if the hearing should be affected by the condition, an attempt may be made to promote absorption by the use of charpie plugs or laminaria bougies. After the inflammatory symptoms have disappeared, a more abundant formation of epidermis, as well as an increased activity of the ceruminous glands may be ordinarily observed. Secondary subjective symptoms may arise from an accumulation of such matters, but cease with their removal by simply syringing out the canal. It is well to call the attention of the patient to this point beforehand.

Voltolini[1] recommends the administration of *Fowler's* solution with the view of preventing recurrences; he further advises the external auditory canal to be painted over with a solution of nitrate of silver twice a week, and the use of cold baths in the summer, and cold frictions in the winter.

2. Diffuse Inflammation in the External Auditory Canal (Otitis externa diffusa).

Diffuse inflammation of the auditory canal is distinguished from the circumscribed form by the fact that it is not confined to the structures of the

[1] Monatsschrift für Ohrenheilkunde, xi. Jahrg., Nr. 7.

canal, but extends also to the tympanic membrane. Like the circumscribed inflammation, however, the diffuse process attacks simultaneously several histologically separate tissues, so that a classification upon a structural basis cannot be readily made. Erythema excepted (and that comes but seldom under treatment), an inflammation of the canal rarely occurs which does not affect several tissue-layers at the same time.

Etiology.—The causes which occasion an attack of otitis externa diffusa are similar to those which may bring about a circumscribed inflammation in the external auditory canal. Sometimes it is developed out of a circumscribed process, and very often the condition is associated with inflammatory attacks in the deeper structures of the ear, especially with purulent inflammation of the middle ear with perforation of the membrana tympani. The various acute and chronic exanthematous diseases, in which inflammatory processes extend by continuity to the auditory canal from the face or scalp, induce a diffuse more frequently than a circumscribed affection.

An opportunity often occurs in this way of observing the development of diffuse external otitis in the course of facial erysipelas, measles, scarlet fever, or small-pox. In syphilitic cases also such attacks may be frequently seen to follow the specific exanthem (papules). Individual peculiarities, especially a marked vascularity of the structures of the auditory canal, appear to determine in some cases the development of a circumscribed inflammation as a result of some injurious influence, which in others may, on the other hand, induce a diffuse otitis. In delicate children a primary diffuse inflammation is much more common than the circumscribed form, while in adults the latter is seen proportionately more frequently than the diffuse process. Fungi (aspergillus) induce diffuse more often than circumscribed inflammatory attacks in the ear.

Course.—The *subjective symptoms* are, as a rule, more severe when the inflammation is primary than when secondary or consecutive, and differ naturally in accordance with the intensity of the inflammatory process and with the parts affected. In general the symptoms do not materially differ from those associated with the circumscribed form of the disease, except that the disturbances of audition are usually much more pronounced, since the conduction of sound is more interfered with from the implication of the tympanic membrane. Hyperæmia of the deeper structures, being also greater, not only affects the hearing power, but also induces more readily the occurrence of subjective auditory sensations.

Those cases, in which a diphtheritic exudation appears, are attended by severe and constant pain. Fortunately they are very rare—indeed, some writers state they have never seen them. In such affections, the severe and almost unbearable pain is present without remission day and night,

accompanied by high fever, until the inflammatory process takes on another character.

The consecutive inflammations of the canal, especially those associated with suppuration of the deeper parts, are on the whole less painful. Many cases, particularly when they run a chronic course, often go on for a long time without any pain at all.

The *objective signs* in otitis externa diffusa vary from the first in accordance with its cause, severity, the structures implicated, and its origin, whether primary or secondary. In an idiopathic inflammation, the skin at the beginning appears reddened, more or less swollen, and the epidermis in places loosened or even lost (excoriation). The redness is usually most marked in the osseous part of the canal. The integumentary layer of the tympanic membrane appears likewise red and swollen—most so at its periphery and along the handle of the malleus. In this way, not only is the characteristic appearance of the membrane lost, but also its line of definition from the inner extremity of the external auditory canal. The lumen of the latter is changed to an irregular conical cavity with a rounded apex (tympanic membrane), on which either nothing can be recognised, or only indistinct traces of the hammer (*V. Tröltsch*). The light spot is generally absent from its normal position, while at various other situations reflexes are seen corresponding with the illumination. Even at this stage, excoriations are sometimes seen on the membrane ; and not infrequently its structure becomes in a few hours' time saturated with exudation associated with the intense hyperæmia.

It is seldom that the swelling is equable, even if the cutis only be affected. In most cases irregularities of the surface are present, which encroach upon the canal, but rarely to the extent of quite closing it. Such a condition is only apt to arise in very severe inflammation, and especially in cases where from the commencement the deeper layers of the tissues have been implicated. In such instances the swelling is often from the first so great that it may be impossible to introduce the smallest speculum into the auditory canal. It may be for a time difficult under such conditions to determine whether the inflammation be of a circumscribed or diffuse kind.

If the hyperæmia be very considerable, redness and swelling in the mastoid region readily occur, as well as œdematous swelling in the parotid region, and enlargement of the lymphatic glands in the vicinity of the ear.

In the further course of the disease, the objective appearances vary according as the inflammatory products are deposited on the surface or in the substance of the affected tissues, and whether diffusely or in several circumscribed centres. In the former cases a copious discharge is usually found in the auditory canal, at first sanguineo-serous, later purulent, which

sometimes flows away in a remarkable quantity. In the latter kind, the appearances are as already described in connection with the formation of abscesses in circumscribed inflammation of the canal.

Infiltration of the deeper tissues, with hyperæmia of the cutis and excessive desquamation of epidermic scales, is of rarer occurrence. The swelling in such cases is sometimes so considerable that the desquamation may completely obliterate the canal and occasion extreme deafness. Many authors (*Graf*,[1] *Wette*,[2] *etc.*) describe this form as *desquamative inflammation*.

Especially noteworthy in relation to diagnosis are cases of diffuse external otitis in which an abscess-formation occurs in the deeper part of the canal and on the tympanic membrane. Several centres of suppuration are usually formed in the structures of the membrane and auditory canal, and encroach upon the latter as rounded projections varying in size from that of a hemp-seed to that of a split pea. When fully developed the inflammatory swellings become denuded of epidermis and of a bright red appearance, and might then be easily mistaken at first for polypoid proliferations springing from the auditory canal or tympanic cavity. If a perforation of the membrane have occurred, and is made manifest by the so-called perforation-sound in the Valsalvan process of inflation, or in using the air-ball, an error in diagnosis may be still more readily made. Fig. 9, Plate I., represents a drum-membrane drawn by *Dr. Heitzmann* on the tenth day of the disease. The author saw the case from the third day. The development of the abscesses was observed, and also that of the perforation, which latter took place before the evacuation of the abscesses; and the light spot, often perceptible in the furrow between the abscesses, was distinctly seen to pulsate. Under suitable treatment the abscesses discharged, and the inflammatory symptoms disappeared. The tympanic membrane was left with some partial opacity and a movable cicatrix, whilst the hearing was notably impaired.

In diffuse external otitis the objective condition may from the beginning be modified by the cause of the affection. Thus in otitis parasitica, the entire canal may be from the first covered with epidermic scales containing fungi, or it may appear crammed full of such material. These or other foreign matters must be removed before a proper inspection can be made of other conditions present. Injuries again may influence the character of the objective appearances in accordance with the nature of the lesion.

Inflammatory states associated with *diphtheritic deposit* are extremely

[1] "Zur Casuistik der desquamativen Entzündung des äusseren Gehörganges." Monatsschrift für Ohrenheilkunde, xv. Jahrg., S. 204.

[2] "Ein Fall von acuter desquamativer Entzündung des Trommelfelles." Monatsschrift für Ohrenheilkunde, xvi. Jahrg., S. 33.

rare, and by many authors are not even mentioned. Such exudations appear to be never formed at the commencement, but undoubtedly are so in the later stages of certain inflammatory processes. It is usually strumous subjects who have been grossly neglected or badly treated in whom this condition may arise. In all the observed cases, after ordinary suppuration had gone on for a longer or shorter time, the white deposit made its appearance rapidly, with increased fever and pain in the ear The exudation adhered firmly to the inflamed structures, from which more or less hæmorrhage with greatly increased pain occurred on the slightest touch. The swelling was as a rule extreme, and the objective appearances in the vicinity generally accompanying a severe otitis were prominently marked.

Wreden[1] observed a diphtheritic inflammation of the external auditory canal, without a like implication of the middle ear, in two children, in whom *a diphtheritic inflammation of the pharynx and nasal passages made its appearance during an attack of scarlet fever.* In three adults he likewise saw the independent development of an otitis ext. diphtheritica. In every case the disease affected one ear only, and was accompanied by violent pain and extreme tenderness. The skin was œdematous, and covered with a white false-membrane. In two patients, the canal and tympanic membrane were affected, and the auricle was also included; and in one instance the auricle and cartilaginous portion of the canal alone were attacked, and became extensively ulcerated.

Bezold observed croupous otitis externa eleven times in the course of three years. According to him, the membranous deposit is limited to the osseous portion of the auditory canal and the external surface of the tympanic membrane. It rarely appears independently, but usually associated with a receding acute middle-ear inflammation, or with furunculosis of the canal. The pseudo-membranes can be detached from the surface by moderately strong syringing, and appear as tough casts of the osseous canal and membrana tympani.

In certain cases inflammations of the external ear assume a very dangerous character in delicate children, especially when ill-nourished, by the occurrence of gangrene of the soft tissues. Sometimes the inflammation is from the beginning very limited in extent, and gangrene sets in very rapidly. A more or less extensive slough is formed, which usually destroys all the soft parts down to the bone. The separate sections of the temporal bone, which during childhood are for the most part united by soft connective material, suffer displacement. The disease encroaches upon the soft structures in the neighbourhood of the ear, and often produces remarkable destruction of the tissues of the cheek, head, and neck. Paralysis of the corresponding side of the face is very apt to occur through destruction of the peripheral branch of the facial nerve, and the child presents a distressing appearance. Such an *otitis gangrœnosa* is mostly

[1] "Die Otitis med. neonatorum von anatomisch-pathologischen Standpunkte." Monatsschrift für Ohrenheilkunde, ii. Jahrg., 7-11.

developed among assemblages of children in public institutions, if gangrene should accidentally be present. But under insanitary endemic or epidemic conditions, the disease may appear in private houses, even without overcrowding, and in spite of good nursing and attention. In adults the author has never observed a case of gangrene following on an external otitis, while amongst children it is not at all infrequent. There is no doubt that in them the peculiar anatomical relations of the external auditory canal have some influence upon its occurrence.

Inasmuch as in otitis externa diffusa the tympanic membrane is affected as well as the auditory canal, so all the objective appearances may be observed that occur in inflammation of the membrane. They will be fully described later in treating of myringitis; but it may here be observed that the usual result is perforation.

As with inflammations of other structures, an external diffuse otitis may from various causes—chiefly unhealthy constitutional states and improper treatment—assume a *chronic character*. The fever and pain usually cease, while the other symptoms remain, or may even become intensified. In this way profuse otorrhœa may result, with development of much granulation-tissue (polypoid proliferations). Sometimes such a chronic course may be prognosticated from the outset, as when in individuals of marked morbid diathesis the affection comes on very slowly, accompanied with little or no pain, and with an early tendency to the formation of exuberant granulations.

Prognosis.—This question has to be considered in the first place in reference to the course and termination of the inflammatory process as such; and secondly in respect to the probable result on the functional capacity of the ear as a sensory organ. In regard to the latter, we have to bear in mind, not only the various circumstances which may influence the result in a circumscribed external otitis, but in this case also the condition of the affected tympanic membrane. Thus the inflammation of the membrane may bring about such great loss of substance as to render its satisfactory cicatrisation a matter of doubt. Or, again, the infiltration into its substance may be so considerable that its complete reabsorption is uncertain. These and other matters make great caution necessary regarding the prognosis. The general result of experience in cases of diffuse external otitis in healthy subjects is that recovery takes place in from three to eight weeks, and without any notable loss of hearing, even though a perforation of the membrana tympani have occurred. Indeed partial thickenings of the membrane produced by the inflammatory infiltration do not appear to materially affect the hearing power. On the other hand, certain cases occur in which, where the thickening of the membrane is extremely slight or even imperceptible, more or less deafness remains after all inflammation has ceased. In the great majority of cases,

however, these inflammations, if properly treated, pass away without any disturbance of audition.

Complications and sequelæ, such as periostitis in the mastoid region, or suppuration of neighbouring glands, will naturally have their influence on the general prognosis.

The prognosis in *chronic external otitis* in regard both to duration and results is unfavourable on account of the debilitated or morbid constitutional condition which usually exists in these cases, rather than on account of the degree or extent of objective changes, such as excessive proliferation of granulation-tissue or great loss of substance in the tympanic membrane. Especially is this the case with weakly, ill-nourished children, in whom destruction of the tympanic membrane with permanent disturbance of function may remain after the termination of the inflammatory process.

In the highest degree unfavourable, both as to their course and termination, are those cases in which a diphtheritic exudation becomes developed. The disturbance is generally very considerable, and even if the inflammation is overcome, the functional capacity of the organ permanently suffers through the tissue-destruction. The same may be said respecting the gangrenous otitis of children, which in the greater number of instances ends fatally.

Treatment.—The remedial measures to be adopted in otitis external diffusa are very similar to those previously indicated in otitis circumscripta. Any irritating matters which may be present—as foreign bodies, fungi, etc. —should be carefully removed. The treatment must in general be guided by the symptoms. All irritating applications should be avoided in the first stages of the disease. If the case should come under observation in the stage of hyperæmia, scarification of the soft structures is usually very beneficial, both in respect to the subsequent course of the affection and also in relieving pain. If suppuration has already set in in the deeper structures, possibly with a state of the integument offering an obstacle to the discharge of the pus, the operation becomes still more advisable, and even imperative. The imprisonment of the pus may entail most dangerous consequences, not only in regard to the integrity of the hearing capacity, but even to the life of the patient.

It is specially necessary to keep open the auditory canal as wide as possible, so as to prevent the collection and retention of inflammatory products. A drainage tube is best for this purpose, but where it cannot be introduced, the soft structures should be incised. If abscesses have been formed in or near the tympanic membrane, they must be evacuated as soon as possible, and the case subsequently treated as described later on under myringitis.

The objective appearances in diffuse as in circumscribed otitis are apt

to persist longest in the vicinity of the anterior and posterior tympanico-squamosal fissures, and thus favour the development of a chronic inflammation with profuse otorrhœa and immoderate growth of granulation-tissue. In such cases the application of nitrate of silver, solid or in strong solution, is of service. In otitis parasitica, the previously described mode of treatment should be followed.

CHAPTER VII.

AFFECTIONS OF THE MEMBRANA TYMPANI.

I. Injuries.

The tympanic membrane is in great measure protected against injury from without by its position and connections. It is not rigidly stretched at its attachment at the inner margin of the auditory canal, but is capable of excursions of a certain amplitude, and can thus evade to a certain degree the effect of strong concussions. Through its connection also with the malleus it derives some support against external violence. With reference to its strength, it is to be remarked that injuries of the healthy membrane come comparatively seldom under observation. Solutions of continuity of its structure are, it is true, very frequently the subject of treatment, but they are usually either the result of primary inflammation of the membrane itself, or are the consequence of morbid processes in the neighbouring tissues, by which the drum-membrane becomes secondarily affected. Such lesions will not be discussed at this juncture, but will be described later, with the diseases wherein they may occur.

Among the injuries which may arise from external violence may be mentioned the superficial excoriations produced by instruments introduced by patients for cleansing the auditory canal, or for other purposes. These injuries are most frequently found on the upper wall of the canal and on the upper half of the tympanic membrane, chiefly on the posterior segment —results due to the direction of the auditory canal from behind forwards, inwards, and downwards; to the curvature of the anterior wall of the osseous part of the canal; to the innermost part of the upper wall curving a little downwards towards the tympanum; and also to the oblique position of the membrane itself.

Such slight excoriations usually cause severe momentary pain without further disturbance, and require no treatment. Injuries, however, which penetrate the membrane throughout entail severe symptoms, and require special notice.

Minute lacerations of its structure, with slight extravasation of blood, occur occasionally in connection with various hyperæmic states of the membrane, as

well as in certain general affections, such as scurvy. They are of little practical moment, and call for no special treatment.

A healthy tympanic membrane may either be penetrated from without by some instrument, or it may be ruptured or lacerated by indirect violence, as by a strong concussion. Cases of the former kind are of frequent occurrence, and are produced by hair-pins, ear-spoons, pieces of straw or paper, pencils, matches, etc.

The author has seen many cases of penetration of the drum-head caused by an accidental thrust with a penholder. In a case in which a man was pushed down, and fell with his right ear on a bundle of straw, the tympanic membrane became pierced by a stalk, and the author found a portion of the wheat-ear, fifteen years later, still embedded in the front part of the membrane. Upon its removal, the reddened lining of the tympanum could be seen through a perforation, through which the patient could expel the air by Valsalva's process. (The membrane is depicted in Fig. 4, Plate I.) In a girl of twenty, again, he found a piece of rice-straw, which had been sticking in the ear for nearly ten years.

With such injuries of the membrane there may be associated fractures of the auditory ossicles, especially of the malleus; and injuries also of deeper structures. *Menière*[1] relates the case of a gardener, in whom a branch of a pear tree penetrated the ear as he fell, and caused fracture of the handle of the malleus. *Von Tröltsch* recognised a united fracture of the handle of the hammer, the history and appearances leaving no doubt as to the nature of the case. A man was for some time under the author's observation whose left ear exhibited a united fracture of the handle of the malleus close to a cicatrix in the posterior superior segment of the membrane. The lower fragment of the malleus formed a right angle with the upper part. The injury had occurred ten years previously by a fall upon the head from a scaffolding. *Hyrtl*[2] describes having observed a united fracture of the neck of the malleus in a prairie dog.

The *healthy* tympanic membrane is comparatively rarely ruptured as a result of concussions, although patients not uncommonly attribute the presence of a perforation to an indirect injury of this kind. It will, however, generally be found on investigation of the facts, and a careful examination of both ears, that the membrane in which the perforation exists gives evidence of having been previously affected in some way.

The resisting power of the healthy membrane is very great, and is, according to *Schmiedekam*, greater in man than in most animals. In a preparation of the human ear, which had been for some weeks in spirit, he found that a pressure of 143 *cm.* of mercury was required to produce rupture of the drum-head. The line of rupture was straight, and parallel to the lower three-fourths of the anterior line of attachment of the handle of the malleus. Another tympanic membrane, in which,

[1] Gazette médicale de Paris, 1856, Nr. 50.

[2] "Zur pathologischen Anatomie des Gehörganges." Wiener medicinische Wochenschrift, 1862.

however, evidence of former inflammation was present in the form of false membranes, was not ruptured until under a pressure of 168 *cm.* of mercury. In this case also the rupture was in the anterior segment.

The author made some experiments on the power of resistance of the membrane in the following manner:—A fresh preparation from the cadaver, in which the membrana tympani was normal, was used. An aural catheter with a bulbous end was introduced into the Eustachian tube, and fastened there by means of a suture. The catheter was then connected with a force-pump and receiver containing air at a pressure of from four to five atmospheres, which was allowed suddenly to pass through the catheter into the tympanum. Similarly, an india-rubber plug was fitted tightly into the external auditory canal, the plug being bored for the passage of a tube, the outer end of which could be connected with the force-pump apparatus. The compressed air was allowed to pass suddenly through the tube into the auditory canal, between the plug and the tympanic membrane. In neither of these experiments could the membrane be ruptured, though they were often repeated: the indiarubber plug was always expelled forcibly from the canal.

It must be admitted, however, that the membrane may be ruptured as a result of comparatively slight concussions[1] as well as from violent ones, as from artillery fire, gunpowder explosions, etc. Still such cases are very rare, and are, as the author believes, due to some defect or peculiarity of the membrane. This view is supported by the fact that during his aural practice in the military hospital in Vienna for several years, including the war time in 1864 and 1866, not more than one patient came under observation with rupture of the tympanic membrane in whom that structure could be supposed to have been normal before the injury. This was the case of an officer near whom a grenade exploded at the battle of Königgrätz, killing three men and leaving him senseless on the ground. On recovering consciousness he had no pain, but his head felt heavy, and he had a violent noise in the left ear. He noticed later that he was perfectly deaf on this side; the auditory canal was moist; and on blowing his nose, the air passed through the ear with a hissing sound. The same day, and especially in the course of the night, severe pain came on, and an acute inflammation developed itself. He was seen by the author for the first time three weeks afterwards, and then exhibited on the anterior inferior segment of the inflamed membrane a roundish perforation about a line and a half in diameter and with a clear margin, within which a pulsating reflection of light could be seen. The other ear, as well as the pharynx, was quite healthy, and both Eustachian tubes were pervious.

The deafness in various degrees which is frequently found among artillerymen cannot well be referred to the occurrence of previous rupture of the membrana tympani, since the objective appearances do not bear out such a supposition. Traces of former injuries to the membrane are extremely rare in such cases. Even if the statements of patients to

[1] In two cases observed by the author, the rupture was caused by a kiss on the ear.

the effect that blood flowed from the ear after the concussion be assumed to prove the occurrence of a rupture of the membrane, it would not demonstrate the previous healthiness of that structure. In the patients examined by the author, the auditory defect was always to be referred to an affection of the nerve apparatus; and if the drum-head showed signs of injury, it was also seen to be deteriorated by previous morbid processes, usually by a chronic catarrh of the middle ear. The slightest cause sometimes suffices to produce a rupture of the membrane in such cases—*e.g.* a slight blow near the ear, or even simply coughing, straining, sneezing, or blowing the nose. The author has seen several instances in which a perforation with an immediate muco-purulent discharge from the tympanic cavity resulted from a simple sneeze. The fact that the discharge follows at once upon the rupture, and continues in large amount, offers in itself strong ground for surmising the existence of a previous affection of the ear.

As an example of injury to the ear from a blow, without rupture of the drum-head resulting, a case of *Bürkner's* may be cited.[1] The patient was knocked down and rendered senseless by a blow from the fist over the ear. On recovering consciousness, two hours later, he had a loud buzzing in the ear, with pain on moving his head to the same side, uncertainty in walking, and dizziness, increased on closure of the meatus. The tympanic membrane was depressed, but otherwise uninjured. All the symptoms disappeared in ten days under treatment by the *Politzer* process. *Bürkner* ascribes the symptoms to displacement inwards of the membrane and auditory ossicles, especially the stapes, subsequently remedied by inflation.

The point is of forensic importance, as this is a common kind of assault on the part of many inconsiderate and reckless persons.

The opinion that in whooping cough the membrane may be ruptured by violent expulsion of air through the Eustachian tube is in opposition to experiment and to the facts just recounted. *Gibbs*[2] states that he has seen the occurrence of hæmorrhage from the ear from laceration of the drum-head, in four instances out of about two thousand cases of pertussis. It is, however, evidently possible that the blood may have come from the superficial vessels of the external layer of the membrane, congested, like others of the head and neck, as a result of the prolonged cough. The membrane also may possibly be so weakened from the congested condition that a comparatively slight concussion might produce a rupture of its structure. That, moreover, the hæmorrhage may be brought about as a simple result of the congestion attendant on whooping cough, is shown by the ecchymoses of the conjunctivæ, etc., which are sometimes observed; as well as from the hæmorrhages from the mucous membrane of the tympanum, and into the labyrinth.

The cases of rupture of the membrane from hanging, reported by *Wilde*, were similarly instances merely of ruptured vessels due to the distended state of the vessels of the head.

[1] "Zur Casuistik der traumatischen und entzündlichen Mittelohraffectionen." Archiv für Ohrenheilkunde, xv. Bd.

[2] Brit. Med. Journ., 1861, Nr. 43.

Ruptures of the membrana tympani may naturally be associated with other head injuries, as fracture of the temporal bone and of the base of the skull. Extensive fracture of the skull, even of the petrous portion of the temporal bone, may, however, occur without any injury to the drum-membrane. The author had once the opportunity of examining during life a man who, as the result of a head injury, had a fissure running through the base of the skull, and implicating the petrous portions of both temporal bones. The tympanic membranes were quite intact. He was, however, deaf, and suffered for six weeks from inflammation of the brain. An unfavourable prognosis was given as to the hearing, and indeed the patient soon afterwards died.

Ruptures of the membrane brought about by so-called contre-coup are particularly noteworthy. The author has seen several such cases in Vienna. A young lady, leaving the room, struck her forehead against the door-post, and ruptured her left tympanic membrane: it healed in the course of a week. A young man, while diving, struck his forehead against the bottom of the bath, and ruptured the left drum-head; a severe inflammation was set up, and it was some weeks before it had quite disappeared. *Williams*[1] observed a fracture through the external auditory canal, with rupture of the membrane, in a boy who fell on the back of his head. *Eitelberg*[2] reports a case in which a perforation below the malleus, with fracture of its handle, were said to have resulted from a blow upon the ear with the fist: both lesions healed. *Kirchner*[3] saw several cases of this kind. In a man of sixty, who fell with the side of his head against a beam, fracture of the osseous portion of the auditory canal, with rupture of the membrane and fracture of the handle of the malleus, took place. In another case there was fracture of the temporal bone and of the hammer: in this instance the patient had been run over by an engine. He also observed a case where the os tympanicum was broken by the force of the lower jaw in a fall from a considerable height. On recovery, a deep furrow was seen on the anterior and lower surface of the osseous part of the auditory canal, extending as far as the membrane, and a fissure on the posterior wall 1½ *mm.* long: the membrane also was ruptured. *Krakauer* saw a fracture of the handle of the malleus which was due to examination of the ear with a sound under a bad light. In the author's collection is a preparation in which, besides a fissure parallel to the long axis of the petrous bone through the whole of the tegmen tympani, there is a tear through the tympanic membrane, with fracture of the handle of the malleus: the head of the malleus is likewise dislocated from the crown of the incus, the latter being untouched. The case was that of a man who fell upon his head from a third-floor flat.

The symptoms associated with an injury to the membrane may be very various, and dependent upon its condition and that of the deeper structures, as well as upon the nature of the lesion, *e.g.*, whether from a rupture or a stab.

[1] "Ein Fall von Fractur des äusseren Gehörganges durch Contre-Coup mit Zerreissung des Trommelfelles." Zeitschrift für Ohrenheilkunde, xiv. Bd.

[2] "Bruch des Hammergriffes durch Schlag auf's Ohr." Separatabdruck aus der Wiener medicinischen Presse.

[3] Jahresbericht der Würzburger otiatrischen Poliklinik 1884-85; ferner, Bericht aus der otiatrischen Section der 59. Versammlung deutscher Naturforscher und Aerzte, Berlin, 1886."

Very severe, if momentary, pain accompanies an injury of the healthy membrane. Extensive lacerations may, however, occur without any pain at all. In such cases the drum-membrane usually gives evidence of a previous morbid state; commonly a fatty degeneration of the membrana propria. On the other hand, instances occur in which rupture of an altered membrane causes as much pain as in the perfectly normal structures. The acuteness of the pain, with the feeling of alarm, sometimes causes fainting, even though the deeper structures are uninjured. In a patient who pierced her drum-membrane with a knitting needle, the fainting was repeated several times during the next twenty-four hours, although no further pain was felt, and the wound healed without any inflammatory symptoms.

Occasionally convulsions and other nervous seizures make their appearance, especially in hysterical subjects. Not infrequently more or less dizziness results from such lesions: this, however, lasts usually but a short time. If no inflammation follow the injury, the pain quickly disappears; if, however, inflammation should set in, the usual symptoms of myringitis become established.

Besides the pain usually attendant on an injury of the membrane, symptoms related to the function of the auditory nerve may be observed. *Subjective auditory sensations* may make their appearance, and the *hearing-power* may become affected. In regard to subjective sounds, they may be of the most varied kind and duration. Generally the patient perceives a violent noise or crack with the injury, but this soon ceases, or is replaced by a weaker sound; and with the changes occurring in the course of any inflammation present, the noise itself frequently undergoes variations. The causes of these subjective sensations are very diverse. The loud noise simultaneous with the injury depends directly upon this, to which it corresponds in character. The continual noises which make their appearance later may be due to effusion of blood into the cavity of the tympanum, encumbering the structures of the fenestra ovalis and fenestra rotunda; to continuous vibration of the base of the stapes; to simultaneous hæmorrhage into the labyrinth; or to concussion of the nerve elements in the labyrinth. If inflammation should be established later, the changes consequent thereon may obviously also occasion tinnitus; or further complications in connection with the auditory nerve or the brain may equally induce the phenomenon.

With regard to the perceptive power of the auditory nerve for external stimuli, an injury to the membrane may affect it either in the direction of increase or diminution of sensibility: there may be either hyperæsthesia acustica or deafness. This seems to depend upon the condition of the tympanic membrane, as well as upon possible simultaneous complications, and the nature of the injury. The author has frequently

treated patients who immediately, and for some time, even weeks, after the injury, had hyperæsthesia either for all sounds, or for those of a certain kind—*e.g.* the rattling of carriages. They were obliged to stop up the ear to avoid the otherwise disagreeable sensation. Sometimes the hyperæsthesia changed with respect to particular tones and noises; so that there were, whilst recovery was taking place, certain sounds only, the perception of which was exaggerated.

As a general rule, however, the hearing power becomes more or less depreciated in consequence of injury to the drum-head, if this structure was previously in a normal state. It is rare for a healthy ear to become so deaf in this manner as to make it necessary to bring a watch into direct contact with it in order that it may be heard. If, however, the deafness should be so marked as this, or perhaps such that the watch is not heard even on contact with the side of the head, it may not unreasonably be conjectured that, besides an injury to the membrane, pathological changes in the deeper structures are likewise present.

Strange as it may appear, it is nevertheless a fact that the hearing power sometimes becomes even improved after an injury to the membrane. This may perhaps occur where previously existing tense cicatrices or adhesions, which may act prejudicially in regard to the sound-conduction, are torn through. If the injurious influence exercised by such abnormal conditions of the tympanic membrane upon the position and function of the auditory ossicles be removed, the hearing capacity may in this way become improved. In many persons a loss of perception of the direction of sounds results from injury to, not necessarily rupture of, the drum-head. The derangement usually disappears in a short time, often long before recovery from the lesion. *A. Fick* refers the symptom to a temporary loss of tactile sensibility in the membrane.

The *objective appearances* are very variable, according to the nature of the injury and to the complications which may occur. In some cases of simple perforation with a needle-like instrument, incised wounds with sharp instruments, or ruptures, there is often nothing to be seen from first to last but a scanty, more or less dried extravasation of blood on the site of the lesion, while the rest of the membrane may be quite normal. In other instances the edges of the wound are separated more or less by retraction of the tissues, and the hiatus thus formed is either free or filled up with a blood-clot. This coagulum may adhere so firmly that it cannot be detached even by a strong air-current with the Valsalvan process, and the perforation is only to be seen after syringing it away.

Sometimes, especially in cases of rupture, the rent is in the posterior segment of the membrane, quite close and parallel to the handle of the malleus. If the edges of the wound are not retracted, and the extravasation scanty and not dried up, the tear may be overlooked from

its resemblance to the normal appearance of the blood-vessels in this situation.

In certain interesting cases described by the author[1] the edges of the different layers of the wounded membrane are unequally retracted, the appearance being like that of steps or stairs. Wounds of the membrane with irregular edges are caused as a general rule by blunt instruments, and in such cases the bleeding is usually slight. The hæmorrhage is, on the other hand, more copious as a rule when caused by sharp instruments; here, as elsewhere in fact, the difference is that of incised and lacerated wounds. The blood-clot found near the edges of the rupture is ordinarily insignificant, unless there has been copious hæmorrhage—always a very rare incident.

If inflammation should follow the injury, the symptoms are those described farther on under myringitis.

The *prognosis* depends on the nature of the lesion, on the complications which may be present, and upon the constitutional or other condition of the patient. In a large number of instances wounds of the membrane heal by first intention—not only where the structure is healthy, but even when its condition is deteriorated.

Further considerations in this connection will be discussed in the chapter on loss of substance in the membrane.

Treatment.—If seen immediately after the injury, the ear should be carefully examined, and any foreign matter or blood-clots present removed with the greatest care. Syringing the canal with this object should, if possible, be avoided; or, if necessary, should be performed only with the smallest quantity of an antiseptic solution. Hyperæmia of the membrane is increased by the injection, and the liquid flows into the tympanic cavity, where it may produce injurious effects. The author has seen a severe inflammation of the middle ear follow on a mere slight syringing with tepid water in a case of this kind, even when it has been performed with every precaution. It is better, if it be found sufficient, to wipe out the canal and the surface of the membrane with a piece of cotton-wool, introduced with a pair of ear-forceps. The coagulum between the edges of the wound is usually so inconsiderable that its presence is unimportant.

The auditory canal and membrane being clean, the parts should be protected by a loose plug of iodoform-gauze or wool, or other antiseptic material. Nothing further is necessary, if no other indications be present. In very plethoric persons, and especially if the deeper structures of the ear be hyperæmic, it may be well to apply leeches in front of the tragus and below the mastoid process, with the view of warding off the possible

[1] "Beiträge zur praktischen Ohrenheilkunde." Allgemeine Wiener medicinische Zeitung, 1868.

occurrences of inflammation. A saline purge may also be administered. The main point, however, is that the patient should have perfect quiet, and avoid everything which might tend to induce congestion of the head. If inflammation of the drum-membrane should nevertheless ensue, the treatment should be conducted on the lines indicated in the following section.

2. Inflammation of the Tympanic Membrane (Inflammatio membranæ tympani: Myringitis).

Inflammation of the membrana tympani readily arises consecutively to inflammation originating in the regions of the external and middle ear, between which it is placed. Primary inflammation of the membrane is, on the other hand, a rare affection, to which *Kramer* first called attention long after the introduction of the aural speculum.

Myringitis may be either acute or chronic in its course. Chronic myringitis is usually associated with a chronic inflammation of the middle ear, to which it is generally secondary. It occurs at all ages, though it is relatively more common in children than in adults. Most often one membrane only is affected; according to *Bonnafont*, the left more frequently than the right. Cases, however, are met with in which both membranes suffer simultaneously from the first. Occasionally also the opportunity presents itself for observing partial inflammations of the membrane, but these are usually, though not always, of traumatic origin.

Etiology.—Myringitis usually results from some intense direct irritation of the membrane. Amongst the most common of such causes are: injuries; cold, especially from introduction of cold water; and the application of irritating substances, such as the nostrums frequently used by the ignorant for toothache or earache. The various quack remedies advertised so universally, and under the most plausible names, are undoubtedly responsible for a large contingent of the cases of inflammation of the ear coming under treatment. According to *Rau*, the misuse of electricity and galvanism is also answerable for certain cases of inflammation. It has been already mentioned that fungi growing in the auditory canal may set up a myringitis (micro-myringitis, *Wreden*).

Inflammation of the tegumentary layer of the membrane may likewise become developed in connection with the acute exanthemata, with erysipelas, and with papular and pustular syphilitic affections in this region.

a. Acute Myringitis.

Course and symptoms.—In response to some injurious influence, and without any particular premonitory symptoms, the patient is suddenly

seized with a very severe stabbing or tearing pain in the ear. It usually comes on first in the night, and very soon spreads over the same side, or even over the whole of the head, so that the patient can no longer define the exact situation of the malady. He may suppose it to be in the teeth or elsewhere, until later on a discharge from the ear makes its appearance, or marked deafness supervenes. More or less deafness is usually present from the first, but is apt to be disregarded on account of the violent pain. The subjective auditory sensations which commonly appear also at this time are more noticeable than the deafness.

In a few hours the violent pain not unfrequently abates in a considerable degree, generally in association with the appearance of a very scanty, somewhat serous discharge, with partial desquamation of the epidermis. The pain, however, begins again soon, and is usually so severe during the night-time as to entirely prevent sleep, so that the patient's strength is apt to be rapidly reduced. According to *Schwartze*,[1] the pain may be assuaged by firmly closing the ear with the finger; perhaps through a possible diminution of the hyperæmia of the membrane thus induced.

Fever, though sometimes set up at the commencement, is generally established only after the pain has gone on for some hours. Children, particularly if delicate, and plethoric individuals, sometimes become delirious. The former may remain in a state of unconsciousness, with slight intermissions, for whole days. They may also be attacked with convulsions—a circumstance of importance which may lead to errors in diagnosis. The febrile symptoms generally continue until the discharge from the ear comes on, and then abate; but may be again intensified with aggravation of the disorder.

The pain is as a rule increased by pressure on the structures of the auditory canal, such as is caused by movements of the lower jaw in speaking or in mastication. It is also worse in the pre-exudative stage when the patient lies with the affected side of the head undermost; though when the discharge becomes established this position gives relief on account of the increased facility offered for its escape.

The deafness varies in accordance with the intensity of the morbid processes going on in the tympanic membrane, and in dependence also upon other changes accompanying them. The same may be said of the noises, which are seldom absent. These are differently described by patients, but have no special characteristics. The stimulation of the auditory nerve to which they are due is brought about chiefly in consequence of the great hyperæmia of the deeper structures which is associated with inflammation of the membrane. It is in part caused also by the pressure exercised by the inflammatory products upon the membrane, and thence

[1] Die chirurgischen Krankheiten des Ohres, S. 118.

transmitted through the chain of the auditory ossicles. Spasmodic contractions, again, of the tensor tympani muscle may set up a special tinnitus in acute myringitis, to which *Lincke* drew attention as being described by patients to resemble the fluttering of butterflies. In a case of this kind the author was able to recognise movements of the inflamed membrane in association with the tinnitus. When at the beginning of the disorder the pain is very intense, the deafness and tinnitus are apt to be more marked only at a later stage. The deafness begins to decrease only with diminution of the discharge; and the internal noises often continue to be present for a long time, even after all traces of inflammation have disappeared from the membrane.

The *objective appearances* are so characteristic that the fact of the affection remaining unrecognised until recent times can only be attributed to the imperfect methods of examination formerly employed. With regard, however, to the question as to the primary or secondary nature of the inflammation, when other structures are likewise involved, it must be admitted that inspection often fails us; nor does the history of the case always afford satisfactory evidence in coming to a conclusion on this point.

The appearances will vary considerably according to the causes of the inflammation; as well as, and chiefly, in dependence on the previous condition of the membrane. If the membrane can be examined at a very early period, the nature of an injury, if this be the cause, may as a rule be easily recognised. One may, for instance, distinguish between an excoriation; a punctured, incised, or lacerated wound; a rupture; and perforations, simple or multiple. When, however, some time has elapsed before an examination can be made, the diagnosis as to the origin of the inflammation may be very difficult, and it may be even impossible to say with certainty whether it be due to injury or is secondary in character.

The inflammation ensuing upon an injury is sometimes *partial* in extent. The tissues in the vicinity of the lesion are then reddened and swollen, the more distant parts being normal in appearance. Very soon, perhaps after twenty-four hours, the edges of the wound acquire a yellowish border, indicating the commencement of the formation of a cicatrix. In most cases of injury, however, and especially with ruptures and lacerated wounds, the myringitis which follows is diffuse, extending over the entire membrane; and in its further course resembles more or less an idiopathic inflammation of the part.

When a previously healthy membrane is attacked with inflammation, it becomes in a few hours dull, lustreless, more or less livid, and loosened in texture. The livid grey appearance does not extend over the entire surface: those parts in which the large blood-vessels are found are more swollen and of a deep red colour, and thus the outlines of the structures (hammer, external auditory canal) connected with the membrane appear

indistinct. This intensely red area corresponds to the arrangement of the tissues in the immediate neighbourhood of the handle of the malleus, being of a triangular shape, with the base upwards and the rounded apex downwards. It is more swollen up than the surrounding grey region, and almost entirely obscures the malleus. The short process of the malleus is usually perceptible only as a small, yellow, pointed body, about the size of a millet-seed; and sometimes even this trace of the handle soon disappears. The outline of the triangular area just described is not sharply limited, but the whole surface has from the beginning a diffuse reddish appearance. With such a condition of the membrane, light thrown upon it is not reflected in the ordinary way: the normal bright-spot is in most cases altered in shape and position, or may be altogether absent; or other reflexes may appear in the most diverse situations.

The appearances above described are, however, but seldom to be observed. In the majority of cases an opportunity for examination does not occur until a later period, when the entire membrane has already become highly congested. It then presents a livid red appearance, the epidermis lost in some places, while in others in their vicinity larger or smaller patches with a dull white colour, due to the loosened but still adherent epidermis, are visible. The surface of the membrane appears moist and flattened, or even somewhat convex, with larger or smaller depressions of a darker tint. Its boundary, too, can no longer be definitely made out, and the reflex of light is irregular. The handle of the malleus cannot ordinarily be recognised at all, or at most only a trace of it, either as a narrow furrow or as a thin crest extending for a short distance upwards. Its short process also, though still visible at the beginning of the affection, likewise disappears soon, and the membrane then comes to present more or less the appearance depicted in Plate I., Fig. 5. The auditory canal in the immediate vicinity of the inflamed structure is also hyperæmic in a greater or less degree, and in extremely rare instances a pulsating movement of the entire tympanic membrane may be observed. In the further course of the affection the epidermis becomes more and more completely cast off, and the secretion from the surface more copious. It is at first sero-sanguineous, later purulent, and flows abundantly out of the canal; some, however, accumulating upon, and more or less obscuring, the membrane.

If the inflammation now recede, the morbid appearances usually disappear in the reverse order of their development. The region adjacent to the lower portion of the handle of the malleus is the first to recover its normal aspect, while the redness and swelling are still visible at the periphery. The triangular band of tissue descending from the upper wall of the external auditory canal, and conveying to the membrane its principal blood-vessels, is visible longest as a congested area, in which the

short process of the malleus gradually reappears (Plate I., Fig. 6). At this period an appearance may be noticed which seems to depend upon the peculiar histological structure of the membrane. A number of whitish lines may be observed radiating from the handle of the malleus towards the periphery (Plate I., Figs. 6 and 7). On close inspection they are seen to be due to prominences, and are undoubtedly caused by the greater degree of swelling of bundles of fibres of the radiating layer. As the inflammation goes on diminishing, they also gradually disappear, the bright spot regains its normal position and shape, and after more or less of the epidermis has been thrown off from the surface, the membrane once more assumes its natural aspect (Plate I., Fig. 8).

Figs. 5, 6, 7, and 8 on Plate I. represent various stages of an inflammation of the drum-membrane, as observed by the author in a patient who came under his treatment on the fourth day of the affection. Fig. 5 was taken on the fourth day of the inflammation, Fig. 6 on the twentieth day, Fig. 7 on the twenty-sixth day, and Fig. 8 on the forty-second day, at which time the patient had recovered his hearing perfectly.

It is rare for the morbid process to run so simple a course as that above described, in which the tegumentary layer of the membrane mainly suffers, while the deeper layers remain unaffected. Thus the pus, instead of wholly discharging itself from the surface, may infiltrate the membrane, either diffusely or in one or more circumscribed centres, to form small abscesses. If the purulent infiltration be diffuse, the membrane may still present a greyish-red appearance resembling the simply hyperæmic integument. When, on the other hand, it accumulates in one or more places, forming abscesses, these become visible as protuberances of varying size and shape. In the majority of instances of myringitis, purulent infiltration of the membrane takes place together with exudation on the free surface, whereby a copious otorrhœa is established besides swelling of the structure. Not unfrequently the abscesses develope just on the periphery, as in the case represented in Fig. 9, Plate I., in which several were formed simultaneously; or as in Fig. 12, Plate I., which was drawn just after the abscesses had been evacuated, and shows the pus as it flows away from them. The hyperæmia persists over the whole membrane until after the evacuation of the abscesses, when several of these co-exist, and in some cases also where only one is present. On the other hand, it sometimes happens that with a single abscess the surrounding structures present a more normal appearance when it has reached its highest development. Figs. 11 and 12, Plate I., represent a case of this kind. Even when a purulent infiltration of the membrane, whether diffuse or circumscribed, has already taken place, it is possible for the inflammation to pass away without leaving any change in its structure which is perceptible to the naked eye, and even without any disturbance

of function. It is nevertheless well established that it is just in such cases that morbid structural changes in the membrane are left behind which may call for treatment at some later period.

More or less extensive perforations almost always occur in the course of an acute myringitis. They are seen more often on the lower than on the upper half of the membrane, and sometimes in several situations at the same time. Most commonly the perforation takes place at about a third of the distance from the handle of the malleus to the periphery; only in rare cases near the outer margin of the drum-head, one such being depicted in Fig. 13, Plate I. It may develope either as the outcome of a circumscribed suppurating process in an already excoriated site; or, as the result of an ulcerative process in the inflamed and thus degenerated tissues; or, lastly, it may be occasioned by some accidental and perhaps insignificant external cause, such as sneezing or blowing the nose, which may then easily produce a laceration in the weakened structure. Sometimes a pulsating bright-spot makes its appearance at the point at which the membrane is just about to become perforated. Once formed, the perforation appears as a round or oblong, more or less irregular, aperture or cleft. If the opportunity should occur of watching from the commencement the development of a perforation due to an ulcerative process, a depressed spot of darkish appearance about the size of a millet-seed is first visible. If a little secretion has collected in this depression, there is also a distinct light-reflex, usually pulsating. In this condition the membrane is already perforated, though the aperture is so small that light does not pass through it in sufficient quantity to illuminate the tympanic cavity. The perforation, however, very soon enlarges, partly through the continued destruction of tissue, and partly on account of retraction of the edges, so that in some cases it may in the course of a few days involve perhaps as much as two-thirds of the whole membrane. Frequently, however, the aperture is a large one from the commencement, appearing as a roundish or oval darkened space with an irregular margin, through which the hyperæmic mucous membrane of the tympanum is visible (Plate I., Fig. 14). In this space a distinctly pulsating light-spot may often be observed.

When the inflamed membrane has been lacerated as a result of some injurious external influence, the rupture is usually bounded by irregular edges due to the unequal contraction of the surrounding tissues. The fringed margin of the perforation, however, soon smooths down, and a more regular aperture is then presented.

Abscesses of the tympanic membrane, if left to themselves, may either become reabsorbed and disappear; or the pus may undergo fatty degeneration, or calcification; or, finally, they may cause destruction of portions of the membrane, with or without perforation. When such a

disintegration takes place, the pus accumulated between the lamellæ either breaks through the membrane externally into the auditory canal, or internally into the cavity of the tympanum, or in both directions at the same time. Usually the last occurs; but sometimes the abscess evacuates itself only in one or the other direction, in which cases the diagnosis is not difficult, provided the Eustachian tube be patent; being based upon the absence of a "perforation-sound" when the Valsalvan process is practised, or the air-ball employed to inflate the tympanum. It may happen, however, that in the process of inflation the force of the air may break through the remaining wall of the abscess, and thus convert it into a perforation.

The walls of an abscess which has ruptured externally may undergo further disintegration, and form in this way a large ulcer, the base of which is constituted by the mucous-membrane layer, with perhaps some of the membrana propria adhering to it. The same may, as intimated, occur in the other direction, in which case the tegumentary layers of the membrane will form the base of the ulcer.

Such conditions as these may to some extent remain present after the inflammatory process has ceased, and thus produce anomalies of the membrane to which reference will be made later. In by far the greater number of instances, however, the abscess breaks through the membrane both inwards and outwards, either simultaneously or nearly so. There arise, then, total perforations, with variously formed boundaries, and the passage or canal may have various courses and directions in different cases. For instance, the external and internal openings may be so placed that air inflated by way of the tympanum may penetrate the inner aperture but find no outlet; the canal may be funnel-shaped in either direction; and so forth. Those portions of the abscess-wall which were at first little affected, may undergo later on a further ulceration, with the result that the edges of the ultimate perforation become more or less smooth, as represented in Figs. 14 and 15, Plate I.

Inflammatory processes in the membrana tympani may lead to considerable loss of substance. The entire membrane may be destroyed, and the malleus then become necrosed in consequence of the withdrawal of its main blood supply. Such a condition is, however, extremely rare, some portion at least of the membrane being generally left attached to the margin of the inner end of the auditory canal.

A case like that represented in Fig. 18, Plate I., in which only a small part of the original structure remains at the upper border, with scanty remnants attached to the handle of the malleus, is so rare as to be a curiosity. Here one looks directly upon the reddened mucous membrane covering the promontory, on the posterior and inferior part of which is indicated the fenestra rotunda. In such instances the malleus

is drawn inwards by the tensor tympani muscle, and its lower extremity may in this way readily come into contact with the promontory, especially if the latter be strongly developed. If this contact should continue long, or should a considerable pressure of the malleus upon the mucous membrane of the promontory be present from strong contraction of the tensor tympani muscle, it may happen that the epithelium becomes gradually lost; and an adhesive inflammation is set up, resulting in permanent union of the two structures. The remains of the membrane may be also thus drawn inwards, and if coming into contact with other structures, may likewise become adherent to them.

The characteristic signs by which a perforation is recognised may now be briefly described. If, on inflation by the air-ball or by the Valsalvan process, the so-called "perforation-sound" were invariably heard, nothing further would be needed for the diagnosis. Since, however, this is not always the case, we are then dependent on ocular examination. When the perforation is small, and the tympanic cavity is not visible through it, the presence of a pulsating light-spot is sufficient to establish a well-grounded suspicion of its existence. In such a case air-vesicles will nearly always make their appearance in the fluid collected at the spot when the Valsalvan inflation is practised, and the escaping air produces a characteristic noise. If no fluid is contained in the aperture; or if the fluid, though present, is not inter-penetrated by the air, then no air-vesicles are formed, but the characteristic perforation-sound is still audible. This, however, necessarily implies the permeability of the Eustachian tube. If it be impervious, the diagnosis of the perforation will rest on the interpretation of the objective appearances in the membrane. It may thus happen that in certain cases the most practised examiner will be unable to obtain absolutely reliable data for determining the question.

With more extensive losses of substance, the diagnosis is in general easier. The inner wall of the tympanic cavity may then as a rule be seen through the aperture in the membrana tympani, and the more distant the margins of the opening are from the internal wall of the tympanum, the more easy is it to recognise the perforation. Since, however, the inflamed drum-membrane is usually very red, and the handle of the malleus frequently invisible, the edges of the perforation can only with difficulty be detected if the membrane is so much drawn inwards as to touch the reddened promontory. The case may then be mistaken for that of an inflamed membrane without perforation; or it may be thought to be the deep red and swollen mucous membrane of the promontory; or a polypus springing from the cavity of the tympanum. It will thereupon become necessary to investigate the relations of the doubtful structure to the inner margin of the external auditory canal. An inflamed drum-membrane will

form with the latter a continuous surface; while, if the questionable structure be a polypus or the promontory, an interruption of continuity can be made out at some place between it and the margins of the canal. Moreover, if it be a perforated membrane, traces of the edge of the aperture will usually be discoverable on minute inspection, and occasionally at some spot or other a suggestion of distance from a surface behind. If with these conditions a perforation-sound be audible when the air-ball inflation or the Valsalvan process is practised, the demonstration of a perforation becomes conclusive; while if the auscultatory sign be absent, the presence or absence of a perforation cannot always be confidently asserted.

Syringing of the auditory canal will in many instances afford information, as when some of the injected fluid passes into the throat through the Eustachian tube. An inverse application of the air-douche, in which the air-ball is emptied into the external auditory canal, and one end of the otoscopic tube placed in the patient's nostril, may also be employed for recognising a perforation. A small probe may be used under a good illumination in doubtful cases to clear up the point, but great care should be exercised in doing this. *Siegle's* speculum may also be of service, as the tympanic membrane is drawn outwards by its aspirating action, and the presence of a perforation is thus more readily recognised.

An error in diagnosis may be most easily made where, though the external layers have been destroyed to a considerable extent, the mucous-membrane layer is still left. In such a case the latter structure is brought either very close to, or completely into contact with, the inner wall of the tympanum, partly in consequence of the external atmospheric pressure, and partly from the contraction of the tensor tympani muscle. On inspection, a loss of substance in the membrane with a well-marked border will present itself, with a background which from its position and appearance resembles the promontory or some other part of the inner wall of the tympanic cavity. The most experienced observer may then be unable to say at the first glance whether the loss of tissue implicates the whole thickness of the membrane, or whether certain layers only have been destroyed as above described. If the Eustachian tube be patent, inflation of the tympanum will decide the question by the presence or absence of the perforation-sound. Should the mucous-membrane layer be still present, and either intact or with only a small perforation, the tympanic membrane will be pushed outwards by the inflated air, and the aspects of the structure, including its colour and light-reflex, will alter. A comparison of the appearances before and after the inflation then suffices to decide the question. Such a case is represented in Figs. 21 and 22, Plate II., in which all the layers, with the exception of the mucous-membrane, were destroyed. Fig. 21 was drawn before, and Fig. 22 after, inflation of the tympanic cavity. When the Eustachian tube is impervious, or inflation

is for other reasons impracticable, *Siegle's* speculum may be employed to draw out the drum-membrane.

Special interest attaches to a perforation of the membrana flaccida, known as *foramen Rivini*. It occurs most frequently as a result of inflammation of the middle ear, but may also be due to a primary myringitis. Inflammation in this situation may be present alone, or in conjunction with that of adjacent structures on the upper wall of the external auditory canal. *A. Buck*[1] has reported such cases. In very few of these can a perforation-sound be recognised on inflation of the middle ear, as that part of the tympanum which is bounded by the membrana flaccida does not communicate directly with the Eustachian tube.

In diffuse infiltration of the membrane its structure is likewise altered in various ways. The tissue elements not only undergo changes in their relative position, but also suffer disintegration. The infiltration is very rarely quite symmetrical; in the majority of cases the inflammatory products are unequally distributed, so that the surface of the membrane becomes uneven in appearance. Its posterior segment is usually infiltrated to a greater degree than the anterior portion; in consequence of which the anterior appears somewhat more deeply situated in the canal. In acute inflammations of the membrane, infiltration is apt to take place to a less extent than in the sub-acute and chronic forms.

Acute myringitis, as already mentioned, generally leads to perforation. The power of regeneration inherent in the drum-membrane is nevertheless considerable, so that healing is the rule. Not only are small losses of its substance renewed, but often, even though half the membrane has been destroyed, a cicatrix forms which replaces the lost tissues. The restoration, however, is governed by certain conditions, which may so modify the regenerative process that the renewal is either altogether in abeyance, or takes place slowly, or in such an unsatisfactory manner as to ultimately depreciate the function of the membrane. Among other injurious influences in this connection is the presence of foreign matters, which should be most carefully removed.

Regeneration of the lost tissue takes place more readily when the latter is confined to the membrane proper than when perhaps the margin of the auditory canal or the malleus is implicated in the perforation. Previous degeneration of the membrane is likewise a bar to perfect cicatrisation. The extent, too, of the loss of tissue obviously influences the process and its duration.

Solutions of continuity in the inflamed membrane without perceptible loss of substance may heal in a very short time by simple adhesion of the edges of the wound. Many incised or punctured wounds causing a partial myringitis go through this process. Sometimes a perforation heals while inflammation of other parts of the membrane is still going on. The author

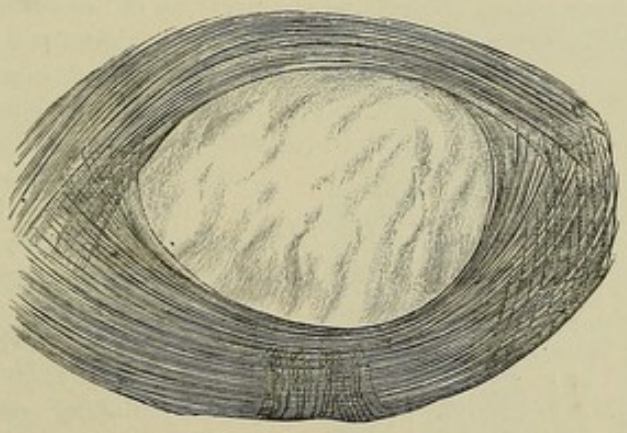
[1] Report of the First Congress of the International Otological Society, New York.

has frequently observed that during the course of a myringitis the patient could by inflating the middle ear by the Valsalvan process press air-bubbles through a perforation; while on the following day this could not be effected, nor was the lesion discoverable at any later time in the course of the affection. In some cases of this kind no trace of a cicatrix can be afterwards perceived.

If the solution of continuity be associated with loss of substance, recovery may take place in various ways. Under favourable circumstances a membranous cicatrix is developed which entirely replaces the lost tissue. It is formed from the tegumentary and mucous-membrane layers of the drum-membrane; the membrana propria, containing no vessels, takes no part in the new formation. If an opportunity should offer itself of following the regenerative process from the commencement, it will be

Fig. 100.

Cicatrix in the tympanic membrane (magnified 100 times).



observed that excessive vascularity of the tissues in the immediate vicinity of the perforation is by no means favourable to the formation of a cicatrix. On the contrary, a loss of substance is most speedily restored in situations where no large vessels are found. So long as the inflammation is still acute, cicatrisation does not commence. When, however, the inflammatory process begins to decline, an abundant formation of cells and nuclei takes place from the edges of the perforation. Blood-vessels are gradually developed between the newly formed cell-elements, partly from the matrix furnished by them, and partly by outgrowth from the already existing vessels of the membrane. The same process occurs in the case of nerve fibres, and the new cell-formation becomes gradually developed into a new membranous structure, covered externally by epidermic cells, and internally with epithelium.

The author has never been able to discover in the cicatrix fibres resembling those of the membrana propria; but, on the contrary, the

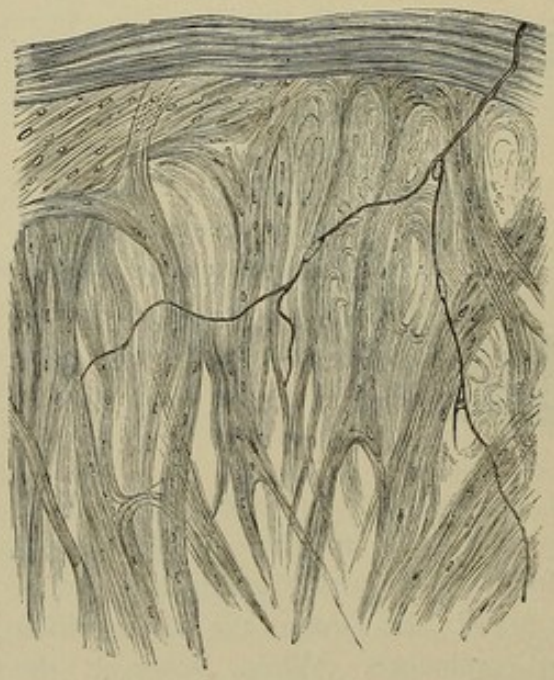
latter is usually sharply defined in the neighbourhood of the cicatrix, as shown in the adjoining figures.

The newly formed cicatrix must be thus, under the conditions of its development, necessarily thinner than the surrounding tympanic membrane, and its surface appears deeper. Further, since in virtue of its delicate structure more light passes through it than through the normal membrane, it looks somewhat darker than the latter—a fact which may cause it to be mistaken for a perforation.

Further details on this will be found in the author's work, "Ueber Narbenbildung im Trommelfelle," Monatsschrift für Ohrenheilkunde, 1869. The development of cicatrices in the drum-membrane of frogs has also been studied by the author; as in these animals the structure, which, as in man, consists of three layers, is superficially placed, and thus convenient for examination. The depression of the surface of the cicatrix beneath that of the surrounding membrane has been attributed to its more readily yielding to the external atmospheric pressure. No ground exists, however, for such an explanation: the pressure from within is as great as that from without. Its depressed appearance depends simply upon the absence of the membrana propria, at the level of which it is placed. That this is so, is at once seen by looking at the internal surface of such a cicatrix, which appears as though pressed outwards, and not inwards.

Fig. 101.

Cicatricial tissue in the tympanic membrane (magnified 450 times). Above are seen fibres of the membrana propria; beneath are bundles of connective-tissue fibres, crossed obliquely by a newly formed nerve.



The result in regard to the hearing power after healing of a perforation is not always beneficial. If the tension of the new tissue be too great or too little, the hearing may be worse than before. Reference has been previously made to the retraction of the perforated tympanic membrane by the contraction of the tensor tympani muscle. In this way the margins of the perforation may be brought close to, or into contact with, the promontory or some other structure of the cavity of the tympanum. Such a structure may then even project beyond the margins of the perforation into the external auditory canal.

In association with an inflammation and perforation of the membrane the tissues of the tympanic cavity become hyperæmic, and the more readily

so from its intimate vascular relations with the drum-membrane. Its structures are more exposed to injurious external influences, and subject also to irritation from the continued presence of purulent secretions. Under such conditions proliferation of the mucous membrane is readily set up, and it may thus happen that adhesions are brought about between the borders of the perforation and various parts of the wall of the tympanum or its contained structures—as, *e.g.*, the auditory ossicles or tendon of the stapedius. If the development of the cicatricial tissue takes place in an inward direction towards the deeper structures, rather than in the plane of the membrane, an indirect union of the parts implicated occurs. In either of these cases a thin superficial cicatrix, whether free or adherent to the underlying parts, may extend across the perforation. Generally, however, this is not what occurs, but the structure to which the drum-membrane has become adherent simply fills up the aperture; and the mucous membrane which finally is formed over it undergoes a condensation, or sclerosis. In this manner the most varied conditions may come about, known generally as *synechiæ*.

See Plate I., Figs. 26 and 27. Fig. 26 is from a case of myringitis, in which the promontory is adherent to and fills up the middle of the three perforations. Fig. 27 shows considerable loss of substance, with calcareous deposits in the membrane: the anterior edge of the perforation was connected with the promontory by delicate cicatricial tissue.

The different conditions which come about in perforations as above described may be variously combined. Thus the margin of a perforation may be partly adherent to the inner wall of the tympanum by long bands of cicatricial tissue, while at another point there may be direct adhesion between the two structures, and at yet a third place the edge of the perforation may be simply covered with integument, a communication thus remaining between the external auditory canal and the tympanum.

The presence of a cicatrised perforation with irregular adhesions is usually more detrimental to the hearing capacity than if the perforation had remained unhealed, and so it may become advisable to separate or divide them.

Another, though infrequent, outcome of perforation, and one likewise unsatisfactory in regard to the hearing power, is that in which the margin alone is covered simply with the integument. These are the so-called *permanent or dry perforations* (*perforatio obsoleta*), and are rarely found in their typical form without other complications. It is usually very large perforations, circumscribed partly by other tissues than the tympanic membrane, in which this condition arises. The fibrous tissue of the membrane surrounding the perforation is increased by a new connective-tissue formation, and the edge finally covered over by epidermis. The membrane in the immediate vicinity of the perforation is thus thickened and semi-tendinous,

and therefore less capable of regenerating the tissue. If such a perforation be very extensive, subsequent alterations, such as commonly arise in exposed mucous surfaces, take place in the tympanum, by which its lining membrane becomes sclerosed, and assumes a yellowish, dry appearance.

If the formation of an abscess has been associated with the myringitis it does not always discharge itself. In not a few cases the pus is either not evacuated at all, or imperfectly so; and the contents of the abscess cavity undergo complete or partial calcareous metamorphosis. *Calcareous deposits* are then formed, surrounded by more or less degenerated tissue-elements, as well as by newly formed connective tissue. Such deposits may be single or multiple, and appear in varied shape and extent—sometimes as an irregularly disseminated material (Plate I., Fig. 32), sometimes with a more defined arrangement (Plate I., Figs. 33, 34, 35). They usually arise on the site, and after destruction, of the membrana propria; or where the fibres of this structure have been partly dislodged from their position during the abscess-formation; in which case the tympanic membrane in the vicinity will be found to be thicker than elsewhere. Externally and internally the chalky deposits are lined by the tegumentary and mucous-membrane layers of the new tissue respectively. If therefore they be touched with the sound, abrasions may readily occur. They generally appear somewhat elevated above the surface of the membrane, especially if closer to the dermoid than the mucous-membrane layer, and resemble macerated bone in colour. They very seldom extend over the entire surface of the tympanic membrane; the author has, however, often seen cases in which partial calcification extended to the border of the auditory canal or to the malleus—a condition which by some writers is said not to occur.

Even an acute inflammation sometimes leads to alterations in the membrana tympani, resulting either in an *attenuation* (*atrophy*) or in a *thickening* (*opacity*) of its structure. This thinning is due to a molecular disintegration, with subsequent absorption of the degenerated material, and may occur either with a circumscribed or a diffuse infiltration. A circumscribed atrophy of the membrane is liable to be confounded with a cicatrix, but may be distinguished from this by its border being less sharply defined. There may be one or many such places in the same membrane, and they are usually sequent to a chronic myringitis. (See Plate I., Figs. 30 and 31.) The *thickenings*, or *opacities*, result from a localised tissue-hypertrophy, or from the presence of heterogeneous matters in the substance of the membrane, and are as a rule likewise due to a chronic inflammatory process. Further reference will be made to these later.

The *prognosis* in inflammation of the membrance is on the whole favourable. If the course of the affection be not influenced injuriously by constitutional or other conditions, and if the loss of tissue be not very

extensive, the patient commonly recovers his ordinary hearing capacity, even though perforation has taken place, and any other troublesome symptoms present also disappear. Still much caution is necessary in the prognosis, especially as regards the hearing. The result is apt to be unfavourable if the myringitis appear simultaneously with inflammation of the deeper structures; and in strumous children, when it commences with very acute symptoms, it is liable to assume a chronic form in spite of the most careful treatment, and to lead to secondary consequences functionally detrimental to the organ.

Treatment.—In acute myringitis antiphlogistic measures should be employed in the pre-exudative stage. All bodily and mental exertion should be avoided, and the ear protected, as far as possible, from injurious external influences. Any foreign matters present in the auditory canal, to which perhaps the inflammation may be due, should be carefully removed. Epidermic accumulations, especially those which contain micro-organisms and are firmly adherent, should be loosened and syringed out. The diet ought to be regulated, and the general condition looked after. Salines are often useful at the commencement, and saline purgatives administered if specially indicated, as for instance if congestion of the head should supervene.

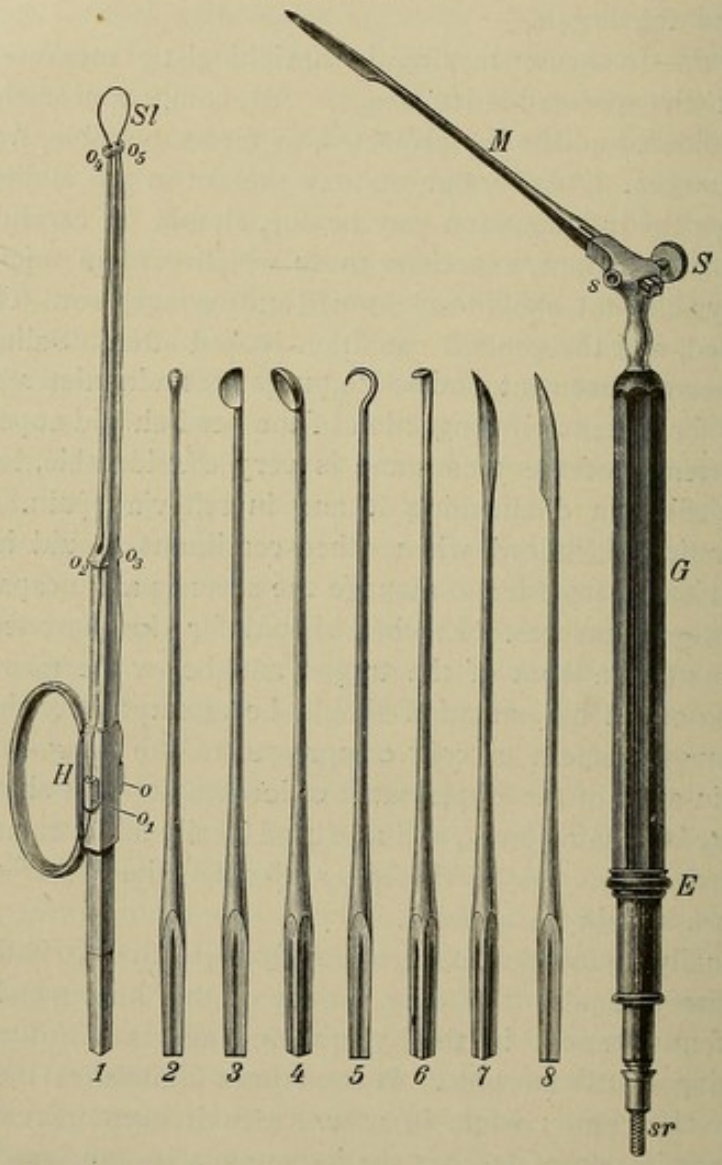
If hyperæmia of the membrane is very considerable, local bleeding has a good effect in diminishing it and in relieving pain. Bleeding is sometimes indicated, indeed, when other conditions would have perhaps made it inadvisable, in order to assuage the severe pain incapable of being relieved by other measures. Leeches should for this purpose be applied in suitable number in front of the tragus and below the mastoid process, and limitation of the inflammation should be attempted by the application from the commencement of cold compresses to the mastoid and parotid regions. If in spite of the employment of leeches the pain should continue, anodynes may be administered, and also used locally in the manner described under external otitis. As in the latter affection, the use of poultices and warm vapours should be avoided.

It is equally injudicious to introduce from the first irritating solutions into the auditory canal. The only remedy of this kind which the author has found of any benefit in the hyperæmic stage is a dilute solution of lead containing a little morphia. It sometimes diminishes the hyperæmia, and so the violent pain; while in other cases it even increases the pain. If after the application of leeches the hyperæmia be not lessened, and the swelling of the drum-membrane be considerable, it is advisable, particularly if the auditory canal be much congested, to make a few superficial incisions through the skin of the latter. They should be from 2 to 3 *mm.* long, and made under a good light with a myringotome (Fig. 102, *ME*), parallel to the boundary of the membrane, and in its immediate vicinity. The blood-vessels supplying the membrane are in this way divided, and the direct

depletion thus effected has much better results than the indirect one produced by leeches, and is always to be preferred with individuals who are not afraid of the trivial operation. The pain sometimes abates considerably, and the further course of the affection is frequently favourably influenced.

Fig. 102.

Instruments for the performance of various operations in the deeper parts of the auditory canal.



Schwartze[1] even recommends paracentesis of the membrana tympani "in certain cases of acute inflammation of this structure, in which in a very short time an extreme swelling of the generally dark bluish-red tissue occurs, chiefly in the posterior upper segment, and the patient, despite remedies which always otherwise relieve the pain, still suffers intensely."

[1] "Die Paracentese des Trommelfelles." Halle a/S., 1868.

In Fig. 102 *E G S* is the handle. The part at *S*, at an obtuse angle to the handle, has a groove into which the different instruments fit, and are fixed by an adjusting screw. The lower part of the handle, which can be detached from the upper part at *E*, is so arranged that it can be used as a caustic-holder. At the lower extremity of the handle, *sr*, is a screw for attachment to a mirror, so that the handle may also be used for the reflector. *M* is a myringotome, for incising the tympanic membrane, scarifying the deeper structures, etc. This, and the other instruments which can replace it, stand at an obtuse angle to the handle, in order that the hand of the operator may not interfere with the illumination of the canal. 1 represents a snare for removal of polypi from the deeper parts of the ear, or from the nasal cavities. It is drawn of the ordinary size, and consists of a metal shaft and a moveable outer case, to which a ring is fixed at *H*. The projections at $o, o^1, o^2, o^3, o^4, o^5$, are pierced longitudinally to carry the wire, which is of silver or well-annealed iron. The loop, *Sl*, is tightened by drawing back the outer casing by the ring *H*. 2 is a blunt-pointed silver sound or probe: it may be used likewise for cauterisation by fusing a little nitrate of silver on the end. 3 and 4 are sharp spoons; 5 a small hook, frequently useful. 6 is a so-called synechotome, devised by *Wreden* for division of adhesions of the membrane; the cutting edges are at the extremity, which is bent at right angles to the shaft. 7 represents the author's tenotome for division of the tendon of the tensor tympani muscle. 8 is a very useful form of myringotome with a concave edge.[1]

If exudation has already appeared on the surface, its amount, as well as the state of the drum-membrane, will determine the further treatment. A free use of astringent and other topical applications is inadvisable. Excessive zeal in their employment is likely to do more harm than if they are too sparingly used, and the inflammation is often increased in this way. With very profuse suppuration, and with great swelling of the membrane, astringent solutions may be used if the pain have abated. If, on the other hand, pain be still present, the greatest caution is necessary, or both this and the inflammatory process will probably be augmented. Simple warm instillations, however, are useful for the relief of pain in the exudative stage. In this way may be explained the statement of many patients that the introduction of warm oil gives momentary relief; though in these cases warm water, or the lead solution with morphia, previously mentioned, are preferable. The author finds a weak *solution of boric acid*, with a few drops of tincture of opium, be very beneficial (boric acid, 1 part; distilled water and glycerine, of each 40 parts; tincture of opium, 1 to 2 parts).

[1] *Reiner* of Vienna makes a pocket-case according to the author's instructions, containing everything needful in most cases. It contains a reflector—the handle above described, a forehead-band with clamp for fixing the reflector if it be desired to have the hands free, four ear specula, two Eustachian catheters, a pair of ear forceps, small ear forceps with catch, small pair of scissors, a bistoury, a director, and a tuning-fork, a thermometer, some needles and other requisites.—A very convenient operating case has been furnished for the translator by the same maker, containing a common handle differing from that described above in having at *E* a similar arrangement to that at *S*, but with a square instead of a round bore. By this means instruments with square hafts may also be employed, and thus those of various operators and makers may be fitted into one case. Reflector, scissors, bistoury, etc., are omitted, as being cumbrous and liable to injure the remaining contents. This case can be obtained from *Mayer* and *Meltzer*, Great Portland Street, W.—Eds.

If perforation has taken place, the introduction of astringent solutions is still more objectionable. If the Eustachian tube be patent, the irritating liquid may easily enter the tympanic cavity, and the hyperæmia of the middle ear be increased. The author therefore avoids this method of treatment as much as possible in myringitis, substituting, when necessary, that of painting the drum-membrane over with the required medicament. The result is much better, though it entails the disadvantage that the patient cannot carry out the treatment himself.

The before-described gelatine preparations may also be used, especially where a more continuous action is desirable. If the introduction of astringent solutions be considered necessary, only a small quantity should be employed at a time. Three or four drops will be quite sufficient to cover the membrane, if the head be held in the proper position. The parts should previously be well cleansed, and this is sometimes much better done with a little cotton-wool introduced by means of the aural forceps than by syringing out the auditory canal. If the discharge be so far lessened, that a thin layer only is found on the drum-membrane, it is best to do as little as possible further in this direction, otherwise the instillations may again increase it.

The application of iodine ointment over the mastoid region, and elsewhere in the vicinity of the ear, is sometimes beneficial even during the stage of otorrhœa. In syphilitic subjects, unguentum hydrargyri may be employed, either alone or combined with some other ointment. Though the effect of such applications is not generally very striking, yet it cannot be said that they are of no value at all. They are particularly indicated in myringitis with infiltration, in which thickening of the membrane is most apt to be left. The troublesome eczema, described by another writer as "the only result" of these inunctions, may be with care easily avoided, if directions be given that the application is not to be made repeatedly on the same part if this has become distinctly reddened. The inunction should then be made in another situation, or else discontinued for a few days.

If a myringitis should be associated with some definite morbid constitutional state, the direction of the treatment will be guided by this consideration.

When an abscess has developed in the membrane, it should be evacuated as soon as possible with a cataract-needle, or the myringotome represented in Fig. 102 (*EM*). Afterwards a little tepid unirritating antiseptic fluid should be used to cleanse out the canal. The operation should not be postponed too long, or a permanently injurious result to the ear may ensue from calcification and fatty degeneration of the pus, or from ulceration of the walls of the abscess cavity.

If perforation takes place during acute myringitis, some precautions

are necessary in regard to the middle ear. Some of the discharge from the membrane usually finds its way into the tympanic cavity through the perforation, and produces irritation of the mucous membrane, as well as morbid subjective symptoms. For this reason it is sometimes necessary to clear out such matters from the tympanum, and this is best done by means of the air-douche. The inflation should be made as sparingly as possible. The method recommended by the author is eminently suitable for this purpose. If the loss of substance in the membrane be not great, nothing further is required. The perforation closes up, and there is often scarcely a trace left of the former lesion. With more considerable losses of tissue, cicatrisation proceeds slowly. The edges of the perforation may then be touched with nitrate of silver, either solid or in solution. If the regeneration should still remain sluggish, the process may be stimulated by the introduction of an artificial drum-membrane, impregnated or smeared with some appropriate medicament. Further details of this procedure will be given in the description of artificial tympanic membranes.

If the margins of the aperture be drawn inwards to a considerable extent, perhaps so much so as to be in contact with the inner wall of the tympanic cavity, efforts should be made to prevent possible adhesion between the two structures. To this end frequent employment of the air-douche is indicated, or the edges of the perforation may be separated from the underlying parts by a thin probe, the end of which is bent at a right angle and passed through the opening. With very large perforations unfortunately the prevention of such adhesions is rarely successful. Mention will be made further on of this as well as other sequelæ sometimes resulting from myringitis.

(*b*) *Chronic Inflammation of the Membrana Tympani.*

Chronic myringitis may become developed out of either a primary or a secondary acute process—a result dependent sometimes upon some constitutional dyscrasia, such as struma, tubercular disease, or syphilis; sometimes upon extraneous causes. The presence of micro-organisms especially may keep up the morbid process, unless they be duly recognised and rendered innocuous. A secondary inflammation of the membrane consequent on a chronic suppurative process in the middle ear will usually run a chronic course. The constant irritation caused by the discharge of purulent matter through a perforation will obviously tend to the continuance of the disease. Such chronic forms of myringitis are, from the commencement, characterised by absence of the severe pain associated with acute inflammation; while on the other hand symptoms referable to deranged function of the auditory nerve assume

a greater prominence. The deafness is apt to be considerable, in accordance with the greater or less extent of morbid change going on in the deeper structures.

The chief *objective appearances* to be found in cases of chronic myringitis are those which have been described in connection with the acute form of inflammation with single or multiple perforation and infiltration of the tympanic membrane. But in addition to these, other conditions may often be met with in the chronic varieties. Thus, larger or smaller masses of granulation tissue may be observed either on a limited area, as in Fig. 19, Plate I., or over the entire surface of the membrane, as represented in Fig. 20. The appearances may vary during the progress of the affection. The inflammatory products undergo different alterations in different places, with the result that at certain spots the inflammatory process has terminated, leaving behind more or less obvious changes of structure, whilst at other parts it may not only be still active, but even exhibit more acute signs. In this way are to be explained the diverse appearances which may be observed on the same membrane during the progress of the affection. On the anterior segment, for example, the membrane may appear cloudy or quite normal, while over the posterior region considerable proliferation of granulation-tissue has taken place; or, as seen in Fig. 19, Plate I., the membrane in the immediate neighbourhood of the malleus may be almost normal, while a calcareous deposit resulting from an abscess is present in the anterior segment; and on the posterior, granulation-tissue is still in course of development.

The growth of granulation-tissue in these cases becomes sometimes so extensive as to take on the appearance of polyps, which project for a considerable distance into the auditory canal, and may even quite obscure the view of the deeper parts. The nature of such cases might be mistaken, or remain in doubt, without recourse to the history and to an investigation of the condition of the middle ear. Further details on this subject will be given in the chapter on Polypi.

Nassiloff[1] found in a man of sixty-five, who had suffered from an otorrhœa for twenty years, that the mucous membrane of the cavity of the tympanum was much thickened, and the drum-membrane of a uniform yellowish-brown colour, dull, and thickened. The mucous surface of the tympanic membrane was smooth, the external surface uneven, while its substance was spongy, being permeated by canals which could be partly recognised with the naked eye, and under the microscope exhibited a lining of pavement-epithelium. The membrana propria was for the most part destroyed, a remnant only existing by the malleus. The drum-membrane was constituted chiefly of tolerably vascular connective tissue; the epidermis, with the rete Malpighii, was destroyed, while in its place villi of varying length and thickness, and covered with stratified pavement-epithelium,

[1] "Ueber eine neue Form von Entzündung des Trommelfelles." Centralblatt für medicinische Wissenschaften, xi., 1867.

were distributed over the entire surface. They were made up of a connective-tissue matrix and fibres, and contained a capillary loop.

Prognosis.—This is in every way more unfavourable than in acute myringitis. In the latter a complete recovery as regards the structure of the membrane, with restoration of the impaired hearing capacity, may be considered as the common course. In the chronic forms, on the other hand, whether sequent to a primary or a secondary inflammation, such perfect results can hardly be proposed as attainable. There generally remains behind either a permanent perforation of the membrane, or such conditions as thickening, calcareous deposits, atrophy, synechiæ, or cicatrices, which are usually found more or less combined in the same drum-membrane.

Figs. 16, 17, and 29, on Plate I., represent some changes remaining after chronic inflammation of the membrane. In Fig. 16 is seen a large loss of substance, and in the portion left at the periphery are some chalky deposits; the malleus, with the adjacent part of the membrane, is drawn strongly inwards. Fig. 17 depicts a case where almost the entire membrane had been lost by chronic inflammation, only the posterior superior segment remaining and adhering to the descending process of the incus. Fig. 29 exhibits thickening of the inferior segment and atrophy of the other parts of the membrane. Fig. 30 represents partial thickening, together with atrophy. In both Fig. 29 and Fig. 30 the atrophic portions are seen depressed towards the tympanic cavity. Figs. 33, 34, and 35 show calcareous deposits in the drum-membrane. Fig. 35 presents a cicatrix with light-reflex above a calcareous deposit on the posterior segment. Figs. 21, 22, 23, 24, 25, 26, 27, and 28 represent various forms of cicatrices. In Fig. 26 were three perforations: that in the superior anterior segment was replaced by a membranous cicatrix; the margin of the perforation in the anterior inferior region was adherent to the promontory; while on the posterior segment was a dry perforation. Fig. 27 shows a large cicatrix in the anterior segment, with thickening of the adjoining parts and displacement of the malleus. Fig. 28 exhibits a rare result of chronic myringitis, in which the greater portion of the membrane was destroyed, as well as the outermost part of the roof of the tympanic cavity, by concurrent caries; the head of the malleus and the crown of the incus were loosened by inter-articular suppuration, and were visible through the external auditory canal.

Treatment.—The treatment of chronic myringitis is to be conducted on the principles laid down in the previous chapter. Particular attention should be given to other possible ear disease present in association with the inflammation of the membrane, and any special constitutional state ought also to have careful consideration.

The local treatment must of course be guided by the actual conditions. Polypoid proliferations should not be permitted to remain long present: if they do not disappear in a few days under astringent applications, more effectual measures are indicated. Nitrate of silver may be used as above described. *Politzer* recommends the application of a small quantity of ferric perchloride to the granulations. It is said to act more rapidly, and with less pain; but both as regards this substance and sulphate of copper the author's experience is such as to lead him to prefer nitrate of silver

for this purpose. *Schwartze* recommends painting over with a chromic acid solution for profuse and prolonged superficial suppuration (chromic acid 1 part to distilled water 2 parts).

In chronic myringitis associated with otitis media, the medicated gelatine preparations are very efficacious. Granulations may also be painted over with tinctura opii; or, in cases of syphilis, with a solution of corrosive sublimate (hydrarg. perchlor. 1 to 5 parts to spirit. rectif. 200 parts); or with a mixture of equal parts of tincture of iodine and tincture of opium. If such measures have no result, it is best to destroy the small granulations with the galvano-cautery; the larger ones may be removed either with a cold-wire snare or a galvano-caustic loop. Diverse modes of treatment are not seldom requisite in the same case to insure the best result.

CHAPTER VIII.

ON CERTAIN SECONDARY RESULTS OF INFLAMMATION OF THE EXTERNAL EAR.

The various changes which may result from inflammatory affections of the external ear have been for the most part already referred to in describing these disorders. It will nevertheless be advantageous to give a more special account of some of these consequences, in so far as they admit of beneficial treatment.

1. Partial or Total Defect of the Auricle.

Acquired absence of the auricle is sometimes due to inflammation, but is most frequently the result of gangrene, and occurs for the most part in early childhood. If such a defect be not associated with some affection of the deeper structures, the hearing power is not notably impaired, and does not call for any treatment, except in so far as this may be desired for the sake of appearances. Operations have been planned for the restoration of a part or of the entire auricle, but the results have always been unsatisfactory. This is not surprising, considering the construction and complicated form of the organ. If therefore the patient persist in having something done, it will be better to recommend him to wear an artificial auricle. Such appliances are made of papier maché or gutta-percha, and are, by means of a spring contrivance, either fitted in the auditory canal or attached to the side of the head.

2. Fistulous Passages in the neighbourhood of the Ear.

Of these the most important are such as are associated with more or less extensive loss of substance in the bone resulting from caries or necrosis. Abnormal communications are in this way established between the passages and cavities of the ear and the exterior. They terminate usually behind the auricle in the mastoid region, presenting as it were the appearance of another external auditory canal. Most frequently these fistulæ occur in individuals with some morbid constitutional condition, as struma or tubercle, in whom an abscess communicating with the external auditory

canal has become developed in the region during the course of an external otitis, and they are to be treated on ordinary surgical principles. Fistulous openings associated with caries will be referred to later on.

3. Permanent Narrowing (Stenosis) and Occlusion (Atresia) of the External Auditory Canal.

Stenosis and occlusion of the canal generally owe their origin to previous primary or secondary inflammation, and arise from the associated local or diffused hyperplasia of the implicated structures.

Extreme narrowing is usually found in old patients who have suffered a long time from inflammation of the canal. Atresia, on the other hand, occurs chiefly in the earliest years. The proximate cause of the narrowing lies in the hypertrophy of all the different structures, from the skin down to the bone and cartilage; more rarely of the skin only; and cases are also observed in which the stenosis is entirely dependent upon a limited or diffuse new formation of bone. The new bone may develope not only in the osseous, but even in the cartilaginous portion of the canal, and may produce an increase in its length as well as in the thickness of its walls. The new formation has been sometimes proved on examination to extend indeed almost as far as the orifice of the canal.

Acquired atresia arises most commonly in infancy when the osseous portion of the canal is not yet fully developed, and is thus usually a consequence of adhesion of the soft structures. If, however, the occlusion be complete, and remain so for a long time, the further development of the osseous portion of the canal will be impaired in such a way that either no osseous canal at all, or only a most irregular one, becomes ultimately formed. It thus may happen on examination with the probe in later years, that the canal is found occluded by osseous tissue covered by the integument. Such long-standing cases are comparatively not at all rare, and the author has in them never been able to find that the atresia was limited wholly to the soft parts. Bony material could always be found in the deeper region; indeed, in most instances outgrowths of bone with more or less irregular rounded surfaces confronted the view; while in cases of recent occlusion, the canal presented the appearance of a concave cone with a rounded-off apex.

In adults the author has observed that these osseous formations which quite occlude the canal sometimes proceed even from its cartilaginous part. In a case in which the canal measured only 6 *mm.* the obstructing mass was of bony hardness, and in intimate connection with the cartilage of the canal, appearing to grow out from its wall, with the convex surface towards the opening. The integument lining the canal was continuous with the structure covering the new formation.

Stenosis of the canal seldom induces marked symptoms. The lumen may be considerably reduced without notable effect upon the hearing. If deafness be present, it generally depends on some secondary cause, such as accumulation of cerumen or epidermis, or accidental swelling of the soft structures. By such conditions the narrowing may very easily become a complete occlusion, and so induce deafness and other phenomena.

Complete atresia always causes very considerable deafness, from the imperfect sound-conduction. Other subjective symptoms are only apt to occur if pathological changes in the deeper parts are likewise present.

Prognosis.—Inasmuch as both narrowing and occlusion of the canal are generally secondary consequences of inflammation arising out of the most varied primary processes; and as further they may be present in association with diverse morbid changes affecting the deeper structures, the diagnosis must necessarily be rendered very difficult in many cases. Consequently the prognosis must obviously be given with the greatest caution. It will demand more particularly a special consideration of the material basis of the stenosis or occlusion, as well as of the condition of the internal structures of the ear.

If the narrowing be due only to hypertrophy of the soft parts, the prospects are more favourable than when it is mainly dependent upon a new bone-formation.

In atresia likewise the prognosis will be better when it results merely from adhesion of the soft structures. It must, however, be remembered that such occlusions are commonly followed by an irregular formation of new osseous material, and that this makes the condition much worse.

Treatment.—Stenosis from hyperplasia of the soft tissues is best treated by pressure. The readiest method of applying it is by means of a drainage tube inserted into the canal; but this is only suitable where the narrowing is due to simple inflammatory swelling. Pledgets of lint or properly-shaped pieces of compressed sponge are more efficacious, but perhaps laminaria tents adapted to the auditory canal are most appropriate. They should be cone-shaped, and provided at the base with a silk thread for their more easy removal.

Any accumulations of masses of epidermic scales or foreign matters in the narrowed canal must of course be removed, and the laminaria bougie or other appliance should be smeared before its introduction with vaseline, or with some ointment with which may be incorporated, if desired, any substance designed to promote absorption. During its introduction the patient should keep his mouth open. The length of time it should be allowed to remain in the canal will depend chiefly upon the sensibility of the patient. Sometimes severe pain from the pressure comes on in half an hour, or even sooner; while other patients can bear its presence for as long as twenty-four hours. A renewal of the process also will depend

upon the patient's condition, and if judged advisable a larger-sized bougie will naturally be required. If it be wished, the interior of the canal may be painted over, before using the bougies, with any substance from which absorption may be expected; as a mixture of iodide of potassium, iodine and glycerine (pot. iod. 100 parts, iodine 1 part, glyc. 1000 parts), or iodine ointment (pot. iod. 200 parts, iodine 3 parts, vaseline 1000 parts), or with mercurial ointment.

If the narrowing be very great and the further presence of bougies cannot be tolerated for any length of time, and perhaps suppuration be going on simultaneously in the deeper parts, the soft structures may be incised in the longitudinal direction. The renewed introduction of bougies may then be more successful.

When a new-formation of osseous tissue is the cause of the stenosis, but a very slight effect at the best can be expected from painting over with any absorbent. In most cases such measures are quite useless.

With complete occlusion of the canal, the indications for operative interference will depend on the condition of the deeper parts. If a well-grounded suspicion exist that suppuration is going on beneath, an operation must be devised at all hazards, otherwise grave destruction of the deep structures may take place, or dangerous gravitation-abscesses may form,—conditions which may possibly threaten the life of the patient. Complications of this kind may soon come about in delicate children; and as in them the atresia depends at the commencement only upon adhesion of the soft structures, an operation can be more readily undertaken.

If on the other hand no suppuration be present on the other side of the occluded region, and the main object of treatment be simply improvement of the hearing power, the case is different. It will then, as in cases of congenital atresia, become necessary to determine whether any hearing power still exist, and if so whether amelioration may be looked for from an operation. Should either of these questions be decided in the negative, any operative interference will be contra-indicated, experience having shown that under such circumstances the occlusion takes place only after extensive destruction of the drum-head and the deeper structures

Should an operation be decided upon, and the atresia be due only to adhesion of the soft tissues, these should simply be divided by a crucial incision, and the wound filled up with iodoform gauze. Later on, dilatation should be carried out—preferably by a laminaria tent. If the atresia be occasioned by a bony formation, it will be necessary to remove this. The author has repeatedly performed the operation by means of a small gouge, but most often with the galvano-cautery. The latter is simpler, and operating with it in the deeper parts is safer. The hæmorrhage also is less.

Moos[1] operated with a drill upon a bony mass 7 *mm.* in thickness, the result of an inflammatory process of ten months' duration, which brought about occlusion of the canal.

4. Permanent Apertures in the Tympanic Membrane (Dry perforation: Perforatio obsoleta).

Although perforations with loss of substance of varying extent may result from a primary myringitis, as well as from a secondary inflammation of the membrane arising in connection with an inflammation of the middle ear, the latter is of much more frequent occurrence than the former.

The development of these perforations, the changes occurring in them afterwards, and the conditions governing their regeneration, have been already described. We must, however, once more advert to the fact that the subjective symptoms due to them are not always the same, even with equal losses of substance in the same region of the membrana tympani. The importance of a given section of the membrane in reference to the conduction of sound varies according to the state of the remainder of the membrane, to the position and mobility of the auditory ossicles, and to the condition of the rest of the sound-conducting apparatus. Thus in one case a simple perforation in association with a high degree of deafness may be observed, while in others there may be considerable loss of substance without perceptible impairment of hearing. It would appear as though in many instances the condition of other structures, chiefly of the auditory ossicles, may become improved in relation to the conduction of sound, by a solution of continuity of the drum-membrane; the depreciation of function resulting from the perforation being more than compensated by the new conditions of transmission.

Not only is it the impairment of the hearing power which makes the healing of a perforation very desirable, but other troublesome concomitants of the lesion sometimes ensue. Among these may be mentioned the inflammatory attacks which are apt to arise upon the slightest external irritation, from absence of the protection naturally afforded by the intact membrane to the mucous lining of the tympanic cavity. The sclerosis of this lining membrane which takes place at a later period may also be detrimental both to the hearing capacity and to the general condition, and especially so in regard to the occurrence of subjective auditory sensations.

In certain rare cases, again, patients with dry perforations suffer from severe vertigo, which, however, ceases if the external auditory canal be stopped up. The author can recall a patient who, whenever he

[1] "Ueber einen Fall von Anbohrung des in Folge von Entzündung knöchern verschlossenen äusseren Gehörganges." *Virchow's* Archiv, lxxiii., S. 154.

happened to forget to insert in his ear the cotton-wool plug which he otherwise always used, had so much uncertainty in standing or walking that he had to take hold of objects as a precaution against falling. He could never venture into the street without his plug of cotton-wool. Another patient, who was likewise subject to attacks of extreme giddiness, and was thus much hampered in his business, completely lost these on an artificial drum-head being adapted.

Obsolete perforations without other associated morbid changes are rare in proportion to the frequency of solutions of continuity of the membrane, and thus seldom come under observation.

Prognosis.—The success which may attend any local measures of treatment will depend on the extent of the loss of substance, the state of the remaining part of the membrane, and of the other aural structures, as well as upon the constitutional and other conditions of the patient. Restoration of the lost tissue is least to be expected when the surrounding parts are degenerated, perhaps calcified; or when the perforation is bounded by other structures than those of the tympanic membrane, as, *e.g.*, the malleus or the margin of the auditory canal; although membranous cicatrices are, it is true, formed often enough in such situations.

If once the margins of the perforation are skinned over, restoration of a large loss of substance takes place with great difficulty, even with artificial stimulation. This is remarkable, if it be considered that the regenerating power of the membrane is so marked that, if even larger portions of its structure be removed by incisions, this very restoration of the excised part cannot be *prevented*. The extreme difficulty which attends efforts to heal up old perforations should be borne in mind, in order to avoid the pain and trouble connected with failure in the matter. It is therefore eminently advisable to try certain methods first, which are not only quite painless, but from which in many instances a more beneficial result follows than even from the formation of a cicatrix; *e.g.* the use of the artificial drum-heads introduced into practice by *Toynbee* upon the basis of the observation made by *Yearsley*, that certain patients with perforation of the membrane heard better in a marked degree when the auditory canal was stopped up with a cotton-wool plug.

Toynbee's artificial drum-membrane consists of a thin disc of vulcanised indiarubber, into the centre of which is fixed a wire of the length of the auditory canal. The disc is of the size and thickness of the normal tympanic membrane, and the outer extremity of the wire is curved round into a ring (Fig. 103).

Although this artificial membrane of *Toynbee* is, as regards its adaptability and results, a great advance upon the cotton-wool plug, many disadvantages nevertheless attach to it, and the recognition of these by aurists has for a long while stimulated attempts to improve upon it.

Among such drawbacks may be mentioned the conspicuousness of the conducting-wire when in position in the canal, as well as the liability to injury of the deeper parts which it may readily cause—this last especially when the patient lies on his side with the deaf ear undermost. The apparatus likewise may easily become unserviceable by separation of the disc from the wire. Finally, its expense makes it unsuitable in poor practice.

Fig. 103.
Artificial drum-head.



The commonest substitutes for *Toynbee's* drum-head are the cotton-wool plugs recommended by *Yearsley*, and the artificial membrane without conducting-wire which was introduced by *Toynbee*, but afterwards abandoned. This was again introduced into practice by the author ten years ago, and will be described directly. *Hassenstein*[1] devised the small forceps depicted in Fig. 104 for holding the cotton-wool plug. It is intended to remain with the plug in the auditory canal. *Hartmann* recommended as a substitute for an artificial membrane a small, thin rod of whalebone enveloped by cotton-wool. Thus with both these appliances, as with *Toynbee's*, the instrument necessary for the introduction remains behind in the auditory canal. *Schalle* recommended the employment of a simple plug of charpie as an artificial drum-membrane.

Fig. 104.
Hassenstein's forceps for holding the cotton-wool plug.



The cotton-wool remains fixed between the ends by means of the movable ring *R*.

The artificial membrane introduced by the author can be made by the patient himself. He has designed the apparatus represented in Fig. 105, by means of which it may be most readily constructed. The vulcanite case contains the necessary materials—viz. needles, silk thread, and a suitable sheet of gutta-percha tissue. At the end of the vulcanite case a punch is fixed in (*A*), which corresponds to the size and shape of the normal tympanic membrane. By this instrument a disc may be punched out of the piece of gutta-percha, and threaded with silk through the centre.[2]

For introducing this artificial drum-membrane, the simple instrument drawn in Fig. 106 is employed. It is a wire curved round to form a small ring, which is bent over at a right angle to the shank, as at *o*. The other end of the wire is bent to form a larger ring (*F*), or is simply rounded off. To insert the disc the thread is passed through the small ring and along the wire, being held in contact

[1] "Beitrag zur Lehre von der Wirkung des künstlichen Trommelfelles." Wiener medicinische Wochenschrift, 1869.

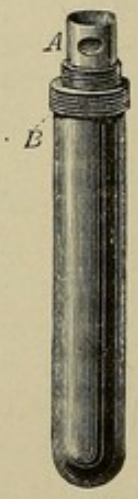
[2] If necessary the punch may be discarded, and the disc of gutta-percha cut out with a pair of scissors.

with this by the finger. When the disc has been properly adjusted in situ, the thread is released and the wire withdrawn, leaving the disc in the canal.

The forceps drawn in the adjoining figure may also be used to introduce the artificial drum-head. The branches of the forceps cross, and are kept pressed against each other by their own elasticity, being separated by compressing the handle. They hold the thread of the disc, which has been passed through a ring-loop *o* at the extremity of one of them, which is much longer than the other, and made of steel or vulcanite. These

Fig. 105.

Vulcanite case with punch for making the artificial drum-membrane.



The cover of the case can be screwed on to *B*, leaving the punch, *A*, free.

Fig. 106.

Contrivance for introducing the arificial drum-membrane.



During introduction the artificial membrane, *T*, lies immediately upon the ring, *o*, through which the thread passes.

forceps are especially advantageous for use by the aurist himself, as they do not prevent proper illumination of the membrane.

Experience has shown that the cotton-wool plug not uncommonly gives better results than the gutta-percha disc. Many patients hear better when a drop of water is brought into the proper situation on the membrane, as after syringing the ear, than by any other artificial aid. In many instances, again, the application of a little powder has been attended by improvement in the hearing. Thus, benefit resulted in a case of *Kosegarten's*,[1] when he applied a little powdered alum to the inner wall

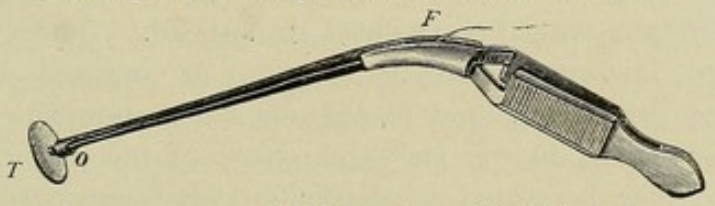
[1] "Ueber eine künstliche Hörverbesserung bei grossen Trommelfellperforationen. Monatsschrift für Ohrenheilkunde, xvii. Jahrg.

of the tympanic cavity. *Lichtenberg*[1] extols particularly the application of collodion as an artificial drum-membrane. In the case of a very deaf patient of the author's, none of the ordinary appliances improved the hearing in the least; while by the introduction of a thin paper plug which he himself made, and turned up at a right angle at the end placed nearest to the membrana tympani, his hearing was so much better that he could follow conversation without effort. This is in accordance with *Blake's* observation of the success attending the introduction of small paper discs.

On the basis of these facts, the author has also tried various materials for use as artificial membranes. Those made from linen, or from silk, as suggested by *Czarda*, sometimes accomplish more than the others. The linen drum-heads appear to be better in certain cases on account of their more intimate contact with the tympanic membrane.

Fig. 107.

Forceps for inserting the artificial drum-membrane.



At *o* is seen the thread of the artificial membrane *T*, which is drawn through and fixed at *F* between the unequal branches of the forceps.

Wiethe's account of a case treated in the hospital practice of the author is instructive. The patient, aged thirty-eight, had perforation of both membranes, due to a double median otitis from which he had suffered from childhood, when it arose from scarlatina. The membranes were very red, and thickened over the posterior superior segments. The Eustachian tubes were both pervious, and the characteristic perforation-sound was heard on inflation of the middle ear. The watch was audible on contact on both sides; tympano-cranial conduction was better on the left. Without knowing anything about artificial drum-membranes, this patient made one for himself by rolling up a piece of paper into a thin cylinder and enveloping it in cotton-wool. When this was inserted into the canal, he heard the watch at 5 *cm.* distance on the left, and at 6 *cm.* on the right side. Conversation also, which previously was no more to him than a confused jumble of sounds he now heard so as to understand the words, and could even recognise friends by their voice. Trials were now made with various artificial tympanic membranes. *Toynbee's* produced no effect, nor did that recommended by *Politzer*, consisting of a piece of indiarubber with a wire attached. *Hartmann's* appliance improved the hearing distance on the right side to 7 *cm.*, on the left to 5 *cm.* With *Delstanche's* drum-membrane the hearing distance was increased to 12 *cm.*; and with *Hassenstein's* it was 12 *cm.* on the left, and on the right 22 *cm.* The linen drum-membranes of the author gave an improvement amounting to 25 *cm.* on the right, and 21 *cm.* on the left. With the gutta-percha disc the distances were, on the right 32, on the left 23 *cm.* The silk membrane did not give such a good

[1] Wiener medicinische Presse, xx. Jahrg., Nr. 37.

result. A piece of indiarubber drainage tube, introduced so as to lie upon the descending process of the incus, but which did not cover over the perforation, improved the hearing distance to 23 *cm.* on the right side.

Zaufal's[1] statement that the drum-membranes recommended by the author are more difficult to insert than those of *Toynbee* is correct. Nevertheless, experience teaches that patients very soon learn to manipulate them. It is found also that *Toynbee's* drum-heads are very easily displaced from their proper position by the movements of the lower jaw. The slight displacement, too, is so disagreeable to the patient that *Giampietro*[2] has even introduced a modification of the conducting wire to remedy this defect. It is divided at the outer end into two branches, which by their spring action are supported against the walls of the canal, and thus fix it. *Graf's*[3] statement that the author's membranes irritate the parts more than others is quite without foundation.

Before introducing an artificial membrane, the auditory canal and middle ear must be freed from any foreign matters which may be present. For this purpose the canal should be syringed out, and the middle ear inflated by the air-ball or the Valsalvan process. The Eustachian tubes also should be made clear as far as possible, as better results are then got with the artificial drum-head. The latter should then be dipped in some antiseptic solution, or smeared with vaseline or an antiseptic ointment, and placed upon the tympanic membrane, without further regard to the size and shape of the perforation. The hearing should now be tested to determine what improvement, if any, follows. Experience shows that in certain cases the artificial membrane gives better results when applied in its entirety, while in others greater improvement is gained when it is cut according to the loss of substance present. If, therefore, no benefit is to be recognised when it has been introduced intact, it should be removed, trimmed with the scissors, and tried again. The process should be repeated in the same way until a good result is obtained. The author has observed that in certain instances the best effect has been obtained when the disc was even smaller than the perforation, and was pushed on into the tympanic cavity. Artificial membranes constructed of different materials should also be tried in order to find out which suits the case best. When it has been satisfactorily introduced, a short sound is perceived at the moment of application, which is also audible to the observer. The improvement in the hearing, if any, is at once recognised by the patient. If the artificial drum-head does not lie properly in situ, discomfort is felt, and he will instinctively execute movements of the lower jaw in order to accommodate the disc to a more suitable position on the tympanic membrane.

[1] Böhm. Corr. Blatt, Nr. 26.

[2] "Du nouveau tympan artificiel et de son usage dans la pratique." Monatsschrift für Ohrenheilkunde, etc., Jahrg. xv., S. 7.

[3] "Zur Frage vom künstlichen Trommelfelle, insbesondere vom Wattekügelchen." Zeitschrift für Ohrenheilkunde, xi. Bd.

Hackney[1] advises that where the Eustachian tube is patent, the artificial membrane should completely cover in the perforation; but that when the tube is not pervious the disc should be arranged so as only to partly close the aperture in the membrane. According to this author the improvement in the hearing sometimes does not appear until several hours or days after the introduction of the artificial membrane. This statement, so far as the author can say, has not been corroborated by any other observer.

The benefit resulting from the use of artificial drum-membranes is limited mainly to the improvement in the hearing, and it is only in isolated cases that other abnormal symptoms are removed or alleviated. They are very seldom efficacious in the relief of subjective auditory phenomena; indeed, in many instances, a tinnitus already present is increased, or even makes its appearance when nothing of the kind had previously existed; though this, it is true, usually disappears again soon. The author has known cases in which the patient, for this reason, had to forego the use of this appliance. It must, however, be insisted on, that the material of which the artificial membrane is made plays a part in the result, and that in such cases different kinds should be tried.

The improvement in the hearing is in many cases limited only to speech, or to certain tones or noises. Patients who heard conversation better with the artificial membrane, but in whom no improvement in hearing for the watch was perceptible, have frequently come under the author's observation. He has also, on the other hand, frequently seen individuals in whom, as it were, an auditory hyperæsthesia was in this way produced for noises, without any noticeable improvement in the hearing capacity for spoken words. There is, in the opinion of the author, nothing remarkable in the occasional apparent improvement in the sound-conduction by the cranial bones on use of the artificial drum-heads. This is explained by the fact that in the customary method of testing the bone-conduction the tympanic-conduction cannot be eliminated. If in any case the ordinary sound-conduction by way of the tympanum becomes strikingly better by the use of the artificial membrane, the watch will also be heard better when in contact with the side of the head, because some of the sound-waves find their way into the neighbouring auditory canal. We see the same in connection with certain other morbid changes. Thus, with collections of cerumen in the canal, it may sometimes be observed that if extreme deafness come on, the watch cannot be heard on contact with the mastoid process. Directly, however, the plug of cerumen is removed from the auditory canal, the sound is at once perceived.

Artificial drum-membranes sometimes serve as a very suitable pro-

[1] "Ueber die Anwendung des *Toynbee*'schen künstlichen Trommelfelles." Zeitschrift für Ohrenheilkunde, ix. Bd.

tection to the deeper structures in perforated membranes with or without an associated otorrhœa. In cases in which they are well tolerated, the author considers them more advantageous than cotton-wool plugs, because they not only may improve the hearing, but do not impede to such an extent the return of blood by way of the external auditory canal. Often, however, their presence cannot be borne from the irritation and increased otorrhœa which they cause.

From what has been already said, the employment of artificial drum-membranes will be indicated under the following circumstances :—

1. In dry perforations, for the relief of the deafness, as well as of other morbid symptoms, such as tinnitus and vertigo.

2. In cases of atrophy and cicatrices of the membrane, producing displacements of the sound-conducting structures, or associated with discontinuity of the auditory ossicles, particularly of the incus-stapes articulation, and occasioning thus certain morbid subjective manifestations.

3. As protective media for the structures of the tympanic cavity.

4. As means for the application of remedies in inflammation of the membrane or of the deeper structures.

In comparison with the frequency of occurrence of the conditions in which the use of artificial membranes may be tried, the number of cases in which they actually bring about an improvement in the hearing is unfortunately not very large. Sometimes their presence cannot be tolerated at all, or only after a wearisome probation. Usually they have to be discarded on account of the otorrhœa which they re-establish, perhaps after none has been observed for years; or they may set up a painful inflammation where none has previously existed. Though in such cases their use must of course be stopped, still it does not necessarily follow that all idea of their re-employment must be abandoned. After the active symptoms produced by them have disappeared, an attempt may perhaps be made at a later period to habituate the structures in a methodical manner to tolerate their presence. Thus, at first they should only be permitted to remain a very short time in situ, and then by degrees this time may be increased. In this way one may ultimately succeed in some cases in which even painful inflammatory symptoms were set up on their first introduction.

Moos[1] treated a patient in whom almost the entire tympanic membrane had been destroyed in each ear. *Toynbee's* artificial drum-heads were inserted, and immediately afterwards a sensation of numbness came on in the border of the tongue on both sides, which continued for an hour after the artificial membranes were removed. Solid food seemed smooth on the tongue, and liquids of different flavours could not be distinguished. *Moos* explains the phenomenon by the pressure exercised by the artificial drum-membrane upon the chorda tympani.

The probable efficacy of the artificial drum-membrane in any particular case can never be predetermined with certainty. Neither the size and shape of a perforation, nor other perceptible objective appear-

[1] "Ueber Störungen des Geschmacks- und Tastsinnes der Zunge in Folge von Application des künstlichen Trommelfelles." Archiv für Augen- und Ohrenheilkunde, i., S. 207.

ances, furnish trustworthy data for this purpose. According to the author's experience, most benefit is derived from it in losses of substance on the posterior segment of the membrane, especially if the posterior superior section has been implicated. Yet even in these cases no improvement may occur. It is only after trials that anything definite can be said about the matter. In some instances the result obtained is a surprisingly good one, even when the perforation has completely cicatrised, and particularly when the loss of substance has been in the posterior superior quadrant, and the healing process has left the articulation between the incus and stapes quite free, or covered only by a very thin irregular cicatrix. When also, as is not seldom the case, a discontinuity has been brought about between the descending process of the incus and the head of the stapes, in consequence of previous inflammation, the effect of the artificial drum-membrane may be still more remarkable.

In certain cases of extreme atrophy of the membrane, in which the very thin structure was in contact with the inner wall of the tympanum, to which it was partly adherent, the author has also found the artificial membrane useful in improving the hearing power and in relieving other symptoms. As much may be said even of such cases in which the membrana tympani was entirely destroyed by inflammation, and irregular adhesions between the auditory ossicles were brought about by a new formation of cicatricial tissue.

We are unable to enunciate a generally valid hypothesis of the manner in which the artificial drum-membrane acts in improving the hearing capacity. The result cannot be simply referred to the closure of the aperture in the membrana tympani. This, as *Wiethe*[1] remarks, is easily refuted by the occurrence of great defects in the membrane without any marked deafness, as well as by the fact that their closure is not seldom unattended by any benefit. It may also be sometimes observed that, when an improvement does follow, it is only when the perforation is not completely covered. Neither can the good result be always explained by the greater quantity of sound-waves transmitted to the labyrinth on account of vibrations of the artificial membrane itself; nor by the conjecture of *Lucæ*, that the appliance increases the intra-labyrinthine pressure, and thereby intensifies the sensibility of the auditory nerve. *Erhard* thinks that the artificial drum-head serves to improve the conducting power of the chain of auditory ossicles by closing them up together more thoroughly; and *Knapp*[2] is of opinion that the good effect is to be ascribed more particularly to pressure upon the processus brevis, which is situated over the plane of rotation of the malleus; this pressure leading in some cases to a slackening, in others to a tightening, in the connection of the chain of ossicles. *Politzer*'s[3] view is that the improvement may be due to restoration of the

[1] "Ueber das künstliche Trommelfell." Allgemeine Wiener medicinische Zeitung, 1883, Nr. 46.

[2] "Das Baumwollkügelchen als künstliches Trommelfell." Intern. Med. Congress, London, 1881.

[3] Lehrbuch der Ohrenheilkunde, S. 566.

normal arrangement of the nodal lines in the vibrating membrane, which the perforation had deranged. None of these explanations, however, can be accepted as satisfactory in all cases.

It cannot be denied that all the above-mentioned factors may possibly serve to contribute more or less in bringing about the beneficial effect of the artificial drum-membrane, as, indeed, may perhaps many others—for instance, changes in the resonance-conditions of the middle ear attendant upon closure of a perforation. It may perhaps be affirmed that only under the rarest circumstances is it possible to attribute the result to the operation of any one of them alone, but that in any given case it will probably be produced by a combination of several.

Various modes of treatment have been recommended with the object of closing up very old perforations. If the margins have become covered by integument, cauterisation with nitrate of silver will be useless. In such cases the edges must first of all be freshened; and if this be unavailing, other measures will have to be employed. The author recommends the application of an artificial drum-membrane made of emplastrum anglicanum (court-plaster). It should extend for a certain distance beyond the border of the perforation. In the course of four-and-twenty hours, sometimes later, hyperæmia is set up, which increases until a circumscribed, sometimes even a diffuse, inflammation becomes developed. The epidermis is cast off from the edges of the perforation, and the process may result in cicatrisation of the aperture. The inflammation must of course be carefully watched, and treated on the same lines as an ordinary myringitis. If the desired process fail, it may be repeated with the addition of some slightly stimulating substance spread on the artificial membrane. For this purpose the author usually employs a linen drum-membrane with an ointment containing potash or soda (carbonate of potash 1 part, vaseline 50 parts), or nitrate of silver (1 to 100 parts). If no marked action follows, the application may be repeated. With smaller losses of substance, the author has had good results from numerous incisions $\frac{1}{2}$-1 *mm.* in length, made quite close to one another and at right angles to the margin of the perforation. The pain which this produces is trivial, and the hæmorrhage slight. Small perforations often close up in this way, even though of long standing, and larger ones diminish in size; but with very large or unfavourably situated apertures the method is usually unsuccessful. The author has also tried, with good effect, the removal of a portion of the tissue bordering on the edge of the perforation to the extent of $\frac{1}{2}$ *mm.* At first this was done with the knife; later by the galvano-caustic method.

Berthold[1] recommends the transplantation of a small piece of skin, or of a piece of the membrane lining an egg-shell, for closing a perforation.

[1] Tagblatt der Versammlung der Naturforscher und Aerzte in Cassell, 1878; ferner, "Das künstliche Trommelfell und die Verwendbarkeit der Schalenhaut der Hühnereier zur Myringoplastik," Wiesbaden, 1886.

All otorrhœa must have ceased, otherwise the discharge will wash away the transplanted tissue. The edges of the perforation are to be first freed from epidermis, for which purpose *Berthold* uses a piece of court-plaster. The piece of cutis to be transplanted should be larger than the perforation over which it is applied. The auditory canal is afterwards to be plugged. When the egg-membrane is employed, a very fine glass pipette, bent at an angle of 125°, and fitted with an ordinary piece of indiarubber tubing closed at the farther end, is used for the introduction. The mouth of the pipette is dipped in white of egg, and a small piece of the egg-skin aspirated on to it with the moist inner surface outermost. The skin sticks to the mouth of the pipette, and can be then conveniently trimmed into shape. It is now conveyed to the required position on the tympanic membrane, to which it is made to adhere by compressing the indiarubber tube. It will, according to *Berthold*, grow to the edge of the perforation, if properly applied. *Tangemann*,[1] after having failed in transplanting a piece of cutis from the arm in a case of perforation, succeeded by using several smaller pieces, which he introduced one by one to close the aperture, and then plugged the canal with cotton-wool smeared with oxide of mercury ointment. After forty-eight hours a narrow strip of tissue was visible across the aperture, dividing it into two parts, the lower of which closed up within seventy-two hours of the operation. The upper opening also became smaller, but the patient went away before it had quite closed; "the tympanic membranes had, however, completely regained their functional capacity, $\frac{48}{48}$." The author, although he has done this operation on three patients—once according to both methods—has unfortunately met with no success, the transplanted tissues failing to unite with the membrane. He would not, however, discountenance it; and, indeed, intends repeating it in suitable cases.

5. Thickening (Opacity) of the Tympanic Membrane.

The condition known as thickening of the membrane, and sometimes as opacity,[2] is one of the commonest consequences of inflammation of that structure. It occurs more frequently as a result of chronic than of acute myringitis, although it may take place in a high degree in connection with the latter form. Chronic myringitis, as previously mentioned, is mostly associated with inflammations of the middle ear. It is therefore as a sequela of the latter affection that thickenings of

[1] "Ersatz des Trommelfelles durch Hauttransplantation." Zeitschrift für Ohrenheilkunde, xiii. Bd., S. 174.

[2] The term "opacity of the drum-membrane" is often misapplied, being employed as the equivalent of "thickening." The condition, as *Schwartze* observes, may exist even with atrophy of the membrane, whilst thickening implies hypertrophy. The word should only be used to mean diminished transparency.

the membrane are usually developed. The different forms of such a condition will be described later when middle-ear inflammations are discussed. In the present connection only those varieties will be referred to which depend directly upon myringitis, and are not further influenced by the course of the middle-ear disease.

The thickenings in question may be *circumscribed* or *diffuse*. The former may be either single or multiple; so numerous, indeed, that the membrane is sometimes spotted all over with them. According to their site, should be distinguished:—

(*a*) *Epidermoid thickenings*, produced by accumulations of epidermis either in the form of small patches, or spread in layers over the entire membrane. The most extensive of such changes are found in eczematous and erysipelatous inflammations, in which masses of epidermic elements, usually in well-marked layers, often adhere very closely to the membrane and produce considerable thickening. The membrane presents a whitish or dirty whitish-yellow appearance, with the surface uneven and broken up. The malleus may, under these circumstances, not be visible. On syringing out the canal with tepid water, the membrane may again look normal if the epidermic masses all come away. If they do not, the thickened parts appear looser in texture, and usually of a lighter colour; while the blood-vessels over the malleus and its vicinity are congested from the irritation caused by the injection.

Urbantschitsch[1] gave the first description of certain well-defined pear-like masses, about as large as a pin's head, which were seen on the tympanic membrane and in the external auditory canal after a diffuse external otitis. They did not remain fixed in the same spot, but changed their situation, and were hard to the touch. One of these accumulations, on being removed, exhibited under the microscope a soft mass of epithelial flakes without cholesterin, enclosed in a compact cortical layer. Later on these masses disappeared without leaving any trace. The author has observed similar collections in various, often quite irregular, forms after inflammatory processes. After remaining a longer or shorter time, during which they also changed their position, they broke up into fragments again.

(*b*) *Dermoid thickenings*.—These depend chiefly upon new formation of skin; but sometimes also certain organic and inorganic masses, partly crystalline, partly amorphous, are present, which contribute to produce the thickening. Like epidermoid thickenings, their extent varies very much. They are to be seen most often, and in their highest development, in situations where the integumentary layer is normally more abundant, as in the neighbourhood of the malleus. The membrane loses its normal surface relations, and also its natural colour and lustre. It presents a

[1] "Ueber eine eigenthümliche Form von Epithelialauflagerung am Trommelfell und im äusseren Gehörgange." Archiv für Ohrenheilkunde, x. Bd.

whitish or yellowish appearance over the thickened area; and where this is adjacent to the malleus, that bone may be unrecognisable.

(*c*) *Thickenings due to hypertrophy of several or of all the layers of the membrane.*—Thickenings of the dermic layer alone are of rare occurrence. The hypertrophy usually involves also the membrana propria. When the thickening is very great and due to new connective-tissue formation, the membrane acquires a parchment-like appearance, and often appears somewhat uneven on account of the irregularity of the growth in different parts. On microscopic examination an accurate demarcation cannot be made out between the membrana propria and the tegumentary layer: the newly formed connective-tissue fibres run in the most irregular manner between the two layers, and the collections of amorphous material are irregularly deposited amidst their structures. With a high degree of thickening, the mucous-membrane layer has likewise no distinct limitation from the rest of the membrane, which is made up of irregularly intermingled structures interspersed with variously shaped amorphous or crystalline masses of fat, pigment, and inorganic matters.

(*d*) *Thickenings due to hypertrophy of the mucous-membrane layer.*—These likewise are of rare occurrence alone, and are almost without exception the result of a myringitis associated with an otitis media.

Particular mention must be made of that form of thickening of the membrana tympani dependent chiefly upon deposit of calcareous matter (*calcareous degeneration, chalky deposit*). It is almost always due to calcareous metamorphosis of the products of inflammation, and is present either in patches (abscesses) or in a diffused manner. These chalky deposits are found interspersed either between the histological elements of the tissues, or much more often between the layers themselves—generally between the layers of the membrana propria, from which they can be more or less turned out. One or other of these layers is often destroyed to a greater or less extent by the inflammatory process, so that the calcareous material is then covered only by the tegumentary layer of the membrane; or if the disintegration affects the circular fibres, then by the mucous-membrane layer only. Sometimes the deposit occurs in the dermoid, or in the mucous-membrane layer alone, or even, as *Lucæ* observed, merely in the epidermis.

The chalky matter may be met with either in a limited spot or in several places in the same drum-membrane. It appears for the most part in somewhat large, more or less crescentic patches, before or behind the handle of the malleus; or sometimes as horseshoe-shaped deposits on the lower segment of the membrane at some distance from, and round about, the handle. More rarely the deposits are seen close to the malleus, and scarcely to be distinguished from it. Sometimes they are found in one or numerous small patches, scattered irregularly, or arranged in a linear

manner. Their margins are almost invariably very distinctly defined, and usually project somewhat beyond the level of the membrane, which over them is sometimes uneven. In colour they resemble macerated bone. When due to a myringitis, they are almost without exception confined to the substance of the tympanic membrane, and scarcely ever touch the border of the auditory canal, as is very frequently the case with such as are consequent on inflammation of the middle ear.

They consist in the main of calcareous matter, with which is mingled variously shaped masses of fat, pigment, and granular substance (detritus).

Politzer and *Wendt* found bone-corpuscles in a calcified drum-membrane taken from a cadaver; and the author has also found them in great number in a piece of calcareous matter which he removed from the membrane of a patient. No osseous trabeculæ and cancelli are to be observed, however, and the presence of bone-corpuscles is extremely rare.

The *subjective symptoms* which may be associated with thickenings of the membrane vary very much. Sometimes diffuse thickening may co-exist with normal or but slightly deranged hearing power; while in other cases a very limited thickening may be attended with perceptible deafness. The result will naturally be influenced by the extent of the morbid changes in the deeper structures so commonly present after a myringitis associated with inflammation of the middle ear. Not only marked deafness, but also subjective auditory sensations, may be direct consequences of thickenings of the membrane. The deafness is probably only to be ascribed to the thickening in very exceptional instances. If the degree and extent of the structural change be very considerable, possibly the hearing may be depreciated by reflection of the sound-waves from the surface. In most cases, however, the symptoms are due to excessive tension of the membrane, which brings about changes in the position and pressure of the auditory ossicles, and in this way influences the condition of the labyrinthine structures.

Course.—Thickenings of the drum-membrane sometimes disappear spontaneously, even after having existed for years. The author has seen instances in which actually an atrophy was present where there had previously been thickening—a result to be attributed to fatty degeneration with disintegration and successive absorption of the tissues. As a general rule, however, this does not happen, but the thickening remains, and often even becomes greater, entailing also increase of the deafness and of other subjective symptoms.

Treatment.—Epithelial accumulations should first be removed in the way previously described. With superficial interstitial thickenings—*e.g.* of the integumentary layer—if they be not of too long standing, and if the existence of consecutive changes have not indicated an operative procedure, an attempt may be made to bring about absorption. For this

purpose the membrane may be painted over with preparations of iodine (pot. iod. 100 parts, iodine 3 parts, glycerine 800 parts); or brushed with a nitrate of silver solution (1 in 10); or one of corrosive sublimate (1 in 50). The application should be made every day until some effect is apparent, and then omitted for some days. The treatment is to be repeated according to the requirements of the case; and if after two or three repetitions no improvement is noticed, nothing further is to be looked for in this direction.

In many cases a beneficial effect in regard to the symptoms may be gained by inflation of the middle ear with the air-ball, and by methodical rarefaction and condensation of the air in the external auditory canal. The result is to be referred to reduction of excessive tension of the membrane. This method of treatment must be conducted with much caution, otherwise an injurious relaxation may be brought about in the healthy portions of the membrane, and the condition be thus rendered still worse.

The operative measures which may be indicated in thickenings of the membrane, as well as those which may be undertaken in anomalous conditions of tension resulting from unfavourable cicatrisation, will be spoken of later, after inflammations of the middle ear and derangements of the drum-membrane consequent thereon.

CHAPTER IX.

NEW FORMATIONS OF THE EXTERNAL EAR.

The neoplasms found in the external parts of the ear are either primarily developed there, or, taking their origin in the deeper structures or in the neighbouring region, encroach upon the external ear in the course of their further growth. They are usually non-malignant in character, occasioning merely deformities ; or else, by bringing about narrowing and occlusion of the auditory canal, or by their injurious effect upon the tympanic membrane, they may produce auditory derangements. Subjective auditory sensations—*e.g.* vertigo,—may perhaps likewise be caused by their indirect influence upon the deeper aural structures. Subsequent metamorphoses taking place in the new formation may also occasion certain symptoms, just as in the case of inflammatory processes in the external ear. Such symptoms may be readily connected with the objective conditions on which they depend, and will consequently need no further description in relation to any particular kind of growth.

Malignant neoplasms may also occur in this region ; and they may not only produce the previously mentioned symptoms, but may likewise lead to results threatening the life of the patient, to which in certain cases he may succumb. Secondary (metastatic) new formations in the outer ear are of very rare occurrence.

The varieties of new growths found here will now be described.

1. *Fibromata.* Larger or smaller fibroid tumours are sometimes met with just in front of the auricle. They are usually known as molluscum benignum (fibroma molluscum, or cutis pendula). The author has frequently removed such growths. In one case the tumour was about the size of a pea, and attached by a narrow pedicle to the upper border of the helix, from which it hung down.

Hyperplasia of connective tissue consequent upon inflammation may frequently be observed in the auricle, but tumours, in the ordinary sense of the term, are seen there comparatively seldom.

The commonest kind of neoplasm is that which arises on the lobe of the ear as a result of its being pierced ; concerning the pathogeny of which some obscurity still exists. In certain persons on whom this

operation has been performed, a new formation becomes gradually developed in the passage, usually after an interval of some months. The discomfort produced by the narrowing of the canal by the new growth leads sooner or later to the earrings hitherto worn being removed. If the ear be seen at this stage, distinct signs of inflammation will be noticed in the lobe, which is usually firmly infiltrated; and occasionally small granulations may be observed projecting from the orifices of the punctured canal. If the earring be removed the inflammation generally subsides very soon, the canal closes up, and when the lobes are examined later a new formation is perceived on the surface where the canal ended—firm to the touch, and usually somewhat prominent. In many instances things remain in this state, and the lobes are again pierced, to be followed again by inflammation and further development of the new growth. With every fresh attempt a similar result ensues. New formations developed in this way often increase in size after the passage has closed, so that they sometimes become as large as a walnut. They usually form thus in both lobes in persons prone to their growth.

According to *Billroth*, they consist chiefly of spindle-cells and connective tissue, and may be considered simply as examples of cicatricial hypertrophy. It is interesting to note that such a hyperplasia is more uncommon after incised wounds on the lobe; and we thus find that a recurrence rarely takes place after excision; while, on the other hand, repeated piercings give rise to multiple new growths. These neoplasms are always non-malignant, and only call for treatment when they produce marked disfigurement; otherwise, if they have ceased to grow, they should be left alone.

If removal become necessary, the mode of operation will depend upon their size and the condition of the lobe. If the tumour is not large, the author excises a triangular piece of the lobe, including the growth, by two incisions, which meet above (*Roosa*). The edges are then brought together by interrupted sutures introduced so as only to transfix the skin: the first stitch should be inserted at the margin of the lobe to prevent the edges curling up.

In one case in which the growth was as large as a hazel-nut the author had to remove the entire lobe. An incision was first made all along the free margin of the lobe, and the skin dissected up off the tumour, which was then removed from the underlying tissue. A wedge-shaped piece was next excised from both skin-flaps, the integument being more redundant than that of the other lobe, and the parts finally brought together. During the six months that the patient, a girl of nine, remained under observation, no recurrence took place. The new formation exhibited under the microscope, dense connective tissue with abundant connective-tissue corpuscles, and very few blood-vessels.

Knapp[1] removed from a negress, aged twenty-two, a tumour of the size of a hen's egg from the right lobe, and another as large as a hazel-nut from the left one. The patient had had her ears pierced two years previously, and during one year had worn heavy earrings. The lobes swelled up, and the earrings had to be taken out. The tumours were enucleated, and the incisions united by interrupted sutures; healing taking place by first intention. Four months afterwards a recurrence occurred on the right side, the growth attaining the size of a cherry, and it was again removed. The tumour had the characters of a fibroma. *Knapp* thinks that the new formations which develope superficially in the puncture may be considered as hypertrophies of cicatricial tissue, but that those arising in the fibrous connective tissue of the lobule must be regarded as true fibromata.

Steinbrügge[2] examined a tumour of the size of a nut which was removed by *Moos* from the lobe of the ear of a girl of eighteen, and was caused by wearing an earring of base metal. He found a confused network of fibres, with clusters of irregular cells. The fibres were most abundant round the puncture-canal; the adipose tissue was pushed towards the periphery, and, like the adventitia of the veins, exhibited distinct cell-proliferation.

According to *Dr. Langaard*,[3] tumours of this kind are particularly common among the negroes in Brazil, and among their immediate descendants, and may attain an enormous size. They are said to become developed most often after injuries to the skin, and usually after piercing the ear. *Kramer*[4] mentions also *Bramley's*[5] statement that a tumour situated in the lobe of the right ear, which may become very large, is often to be seen among the inhabitants of the village of Neel-Khent, at the foot of the Shepoarie Mountain, in the valley of Nepaul. These growths are said to be sometimes absorbed, so as to leave behind only an irregular mass of thickened skin. They are probably similar to those before mentioned.

Dr. Saint-Vel[6] states that fibrous tumours of the lobe of the ear, caused by the great dragging of very heavy earrings, may often be observed among the negroes of the Antilles.

2. *Chondromata.*—Cartilaginous neoplasms of small size are occasionally observed in the auricle, and also in the cartilaginous portion of the auditory canal. They are not attended by any noteworthy symptoms, and are without clinical interest, except when existing in the canal as independent tumours of large size; in which case they may produce functional and other disturbances.

In the external auditory canal the author has met with chondromata as roundish tumours varying from a hemp-seed to a hazel-nut in size, and attached by either a somewhat broad or a more pedunculated base. They are seen also in the form of spiny excrescences of varying size. In a case in which he operated, the tumour grew from the posterior wall of the osseous section of the canal towards the external opening, and was of a mushroom-like shape.[7]

[1] Archiv für Ohrenheilkunde, v. Bd., S. 215.
[2] Zeitschrift für Ohrenheilkunde, ix. Bd.
[3] "Ueber eine eigenthümliche Hautgeschwulst der Neger," von *Dr. Moritz Kohn.* Wiener medicinische Wochenschrift, 1869.
[4] "Die Erkenntniss und Heilung der Ohrenkrankheiten." Berlin, 1849, Seite 209.
[5] Transactions of the Med. and Physiol. Society of Calcutta, vol. vii.
[6] Tumeurs fibreuses du lobule de l'oreille. Gaz. des Hôpit., 1864.
[7] Wiener medicinische Presse, 1880, Nr. 7 und 9.

Chondromata are found both in the cartilaginous and in the osseous portions of the canal, and sometimes co-exist with similar growths in other parts of the body. The new formation may originate in the parotid gland, and spread from this into the auditory canal. Its surface is generally smooth, with the superjacent skin very thin, and of varying vascularity. The structure of the new growth is usually complex, the microscope showing the different varieties of cartilage in different parts of the same tumour. Cartilage cells are found together with various forms of connective-tissue cells amidst a more or less abundant, mostly scantily vascular connective-tissue matrix. Calcification is very frequently seen in different parts of the growth, as well as ossification with perfectly formed bone-corpuscles.

In a very interesting case of the author's, large exostoses were present in the auditory canal in combination with chondromata on various parts of the body. There was in particular a large chondroma on the horizontal ramus of the pubic bone, which interfered a good deal with movement. The patient stated that the growths in the ear became developed at the same time as those in the other parts of the body. The exostoses were of importance only in the right auditory canal: in the left also three such were present, but they did not greatly interfere with a view of the membrane. There is no doubt that this was a case of chondromata of the canal in which ossification had taken place.

So long as the new growth does not greatly narrow the lumen of the canal, no symptoms are apparent. If, however, the canal should be occluded, or considerably narrowed, marked disturbances may occur. When, for example, a suppurative inflammation of the deeper parts is also present, the tumour may, by interfering with the free discharge, become very dangerous, and its removal will then become imperative. Such a necessity, however, applies not to chondromata only, but to all tumours blocking up the meatus.

Small chondromata in this region are best excised, or destroyed by the galvano-cautery. If larger, the author employs the chisel and hammer for their removal.

3. *Osteomata.*—Besides the osteophytes, which are developed in the course of chronic inflammatory processes, the osseous new formations known as *exostoses* are found in the external auditory canal.

They present themselves as rounded or oval-shaped tumours, with either broad or pedunculated bases, and vary from a hemp-seed to a hazel-nut in size. They are quite hard to the touch, and covered with more or less sensitive integument. Sometimes they become so large as to touch the opposite side of the canal ; or, if several are present, they may be in contact with one another. The lumen of the canal may be so encroached upon by them that nothing can be seen of the deeper structures. Such a condition was present in a patient suffering from syphilis affecting the bones, who

besides exostoses of the shin bones exhibited several in his auditory canals, of which those on the right side are represented in the subjoined figure (Fig. 108).

They are by no means uncommon in this region, which according to *C. Weber*, is a favourite seat for them. They may be present alone or combined with other ear affections, ordinarily with chronic inflammation of the middle ear and its sequelæ. The author has observed several cases in which exostoses of the canal were associated with occlusion of the Eustachian tube; and he is inclined not to regard the combination as a merely accidental one. Probably in such cases bony neoplasms exist also in the tubes.

Exostoses may be either *single* or *multiple*, and in one or both canals. They develope most frequently upon the posterior wall; rarely on the anterior. They occur more often in men than in women: a fact attributed by some writers to the effect of alcoholic drink (*Toynbee*, *Von Tröltsch*). According to *Welcker*,[1] they are more common on the American continent than our own,[2] and *Delstanche fils*[3] speaks of heredity as a cause.

Fig. 108.

Exostoses in the auditory canal of a patient who had been affected with osseous syphilis.



They may consist of firm bone with few vessels (eburnated exostoses), or may exhibit a more spongy structure. Their development takes place either from the periosteum, or directly from osseous tissue; and they are generally of slow growth, remaining for the most part stationary after attaining a certain size. According to *Virchow*, the degree of compactness of the bony substance stands in relationship to the stage of development of the growth.

Their cause cannot usually be ascertained. *Toynbee* referred them to the gouty-rheumatic diathesis; and although this cannot be absolutely repudiated, it cannot be shown to be present in the majority of cases. In opposition to the opinion of *Von Tröltsch* and others, the author considers them to have an undoubted relation to syphilitic disease, and he has observed them with comparative frequency in patients who either still suffered from syphilitic bone affections, or had been successfully treated for them. They may sometimes, moreover, be the product of inflammatory processes, as shown by an interesting case detailed by *Hedinger*,[4] in which

[1] "Ueber knöcherne Verengerung und Verschliessung des äusseren Gehörganges." Archiv für Ohrenheilkunde, i., S. 163-74.

[2] *Seligmann's* statement also corroborates this view. (Sitzungsbericht der k. Akademie der Wissenschaften in Wien, 1864, S. 55.)

[3] Contribution à l'étude des tumeurs osseuses. Bruxelles.

[4] "Ueber einige eigenthümliche Exostose im Ohre." Zeitschrift für Ohrenheilkunde x. Bd.

an exostosis became developed in the course of a chronic inflammation in the ear. The tumour was operated upon, and the chiselled-out portion showed on microscopic examination that the substance of the neoplasm did not stand in connection with other bone, but resulted from ossification of areas of connective tissue (osteoid metamorphosis).

The differential diagnosis between exostosis and an inflammatory or other neoplasm is facilitated by examination with the probe, and by the history of the case. With other projections which may be present as accidental malformations in the auditory canal, they are not easily confused. In the situations corresponding to the two extremities of the future tympanic ring, small bony prominences are sometimes found which might be readily mistaken for small exostoses: their position, however, and their stationary condition, so that they appear quite the same on repeated examination, sufficiently determines their character.

Exostoses are unattended by pain in their development. If, however, their growth proceeds until they come into contact with other exostoses or with the wall of the auditory canal, then pain may be present as a result of the pressure. Nor is the hearing notably impaired so long as the canal does not become occluded. Any deafness, and perhaps subjective auditory sensations which may appear in connection with them, are usually due to accompanying morbid changes in the ear, or to other contingencies, such as obstruction of the narrowed passage by cerumen or epidermic accumulations.

Osteomata may also develope in the immediate vicinity of the meatus, in the mastoid region, and on the squamous portion of the temporal bone. The author is in possession of three specimens of this kind, one of which is represented in Fig. 109, and for this he is indebted to the anthropological investigations of *Prof. Zuckerkandl*; another is a spiniform osteoma about 1 *cm.* long on carious bone above the external auditory canal; the third specimen is the half of an osteoma operated on by *Prof. Weinlechner.* It was situated on the mastoid process, measured about 30 to 33 *mm.* in its longest diameter, and weighed 463 grains.[1] A similar formation was observed by *Vandervoot*[2]: it grew from the mastoid process, and was as large as a nutmeg.

The *prognosis* and *treatment* of exostoses of the canal are in their leading features the same as those of chrondromata.

Local applications, as well as the method of compression by laminaria tents, are as a rule quite without result, or at the most bring about only a temporary diminution by pressure upon the soft parts covering the exostosis.

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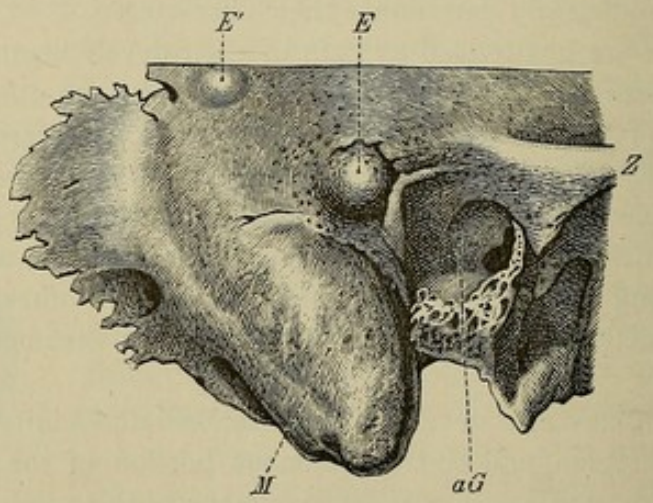
[1] *Weinlechner*, "Osteoma in der Warzengegend durch Operation entfernt. Eröffnung der Warzenzellen. Consecutive eiterige Mittelohrentzündung mit Durchlöcherung des Trommelfelles. Heilung." Monatsschrift für Ohrenheilkunde, etc., xx. Jahrgang, Nr. 11.

[2] Annalen für Augen und Ohr, iii., Bd. 2, S. 11.

In certain very rare instances, however, the author has observed a reduction of the growth on the employment of stimulating applications. *Moos*[1] also reports the disappearance of an exostosis by galvano-caustic treatment; granulations being at the same time developed on the adjacent parts. Tincture of iodine, or iodine with iodide of potassium in glycerine, are mostly used as absorbents (iodine 1 part, pot. iod. 100 parts, glycerine 500 parts). The tumour should be painted over twice a day until the skin shows signs of irritation. The treatment should then be stopped for some days until the irritation has disappeared, and may then be recontinued.

Fig. 109.

Temporal bone with two osteomata; the walls of the auditory canal much thickened.



M, Mastoid process; *aG*, external auditory canal; *Z*, zygomatic process; *E*, *E'*, osseous new formations.

If after three weeks of this treatment no effect be noticed, its continuance will be useless. With cases of syphilis, preparations of iodine may be administered concurrently. Painting with solutions of corrosive sublimate (1 or 2 parts in 20 of rect. spirit.) and of nitrate of silver have likewise been recommended, but they cause more pain and are less efficacious than iodine. Compression to any considerable degree cannot be tolerated. The most effective treatment is removal with a chisel and hammer. A small gouge is employed, and very carefully worked into the deeper parts. Where the exostosis is situated very deeply in the auditory canal, *Schwartze* recommends that the auricle and the cartilaginous portion of the canal should be first of all detached from behind, so as to get at the growth more easily. If antiseptic precautions be taken, no

[1] Zeitschrift für Ohrenheilkunde, viii. Bd., S. 148.

particular danger is connected with this procedure. *Bremer*,[1] *Schwartze*,[2] *Knapp*,[3] and *Lucæ*,[4] have all operated in this manner.

Pedunculated growths may sometimes be simply broken off (*Syme*). *Schwartze* communicates a case treated by *Weitz*, in which such an exostosis was broken off. It weighed about five grains, and showed signs of being worn down where it had been compressed against the opposite side of the canal.

Bonnafont[5] bored through exostoses with a small trephine, after destroying the superjacent cutis with nitrate of silver. The operation took ten days to complete. *Mathewson*[6] used for the same purpose a dentist's drill. He considers this less dangerous, as it works with a very light pressure. *Delstanche*, *Aynes*,[7] and others have operated in a similar manner.

4. *Angiomata.*—Both simple and cavernous angiomata are found on the external ear, either arising there primarily or spreading from the neighbouring structures. They are seen as single or multiple, more or less elevated patches of various size (vascular nævus); or in the form of cavernous tumours. According to *Schwartze*, one-fourth of the angiomata occurring on the head are found on the auricle or in its vicinity, and are situated chiefly in the cutis, though they encroach also upon the subcutaneous tissue, and even upon the cartilage. They are sometimes congenital, and remain stationary without undergoing any further enlargement. On the ear their most frequent site is the anterior surface of the auricle, or the helix; much more rarely the posterior surface. Instances occur, however, in which the growth originates in the auditory canal, and either remains limited to this, or extends thence to the adjoining parts.

Particular attention is to be drawn to the occasional existence of these formations in the auditory canal, where they can with difficulty be seen—*e.g.* in a depression in the wall. If hæmorrhage should then take place from the canal, its cause may be readily overlooked. In the case of a boy whom the author saw in his hospital practice, the telangiectasis was on the left auricle, and extended along the upper wall of the auditory canal to the tympanic membrane, where it was spread over the posterior superior segment. The boy's father, who accompanied him, had an exactly similar condition in his own ear on the same side.

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[1] Annal. des mal. de l'oreille, etc., iv., 6.

[2] Die chir. Krankheiten des Ohres, S. 101.

[3] "Totale Entfernung einer Elfenbeinexostose, die den Gehörgang ganz ausfüllte. Heilung." Zeitschrift für Ohrenheilkunde, xv. Bd.

[4] "Casuistische Beiträge zur Bedeutung und zur operativen Entfernung der Exostosen des äusseren Gehörganges." Archiv für Ohrenheilkunde, xvii. Bd.

[5] "Observation d'un cas *de surdité complète* de l'oreille gauche, due à l'obstruction du conduit auditif externe par une tumeur osseuse (exostose) *siégeant près de membrane du tympan*, guérie par la trépanation." Gaz. des Hôp., 64, 1868.

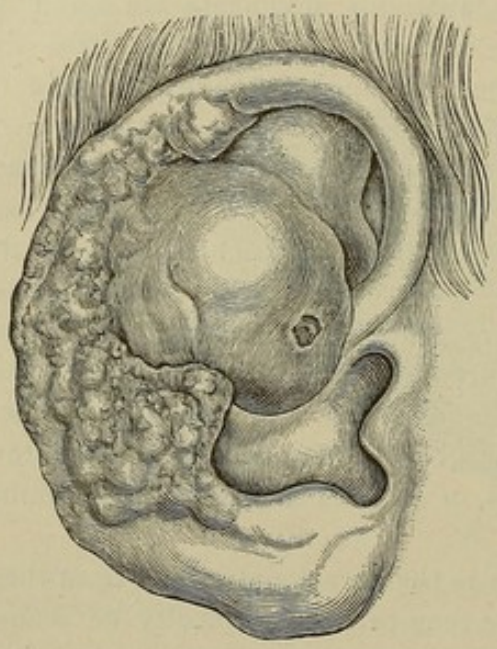
[6] Report of the First Otological Congress.

[7] "Exostosen des äusseren Gehörganges." Zeitschrift für Ohrenheilkunde, xi. Bd.

In certain cases an angioma presents at first sight the appearance of an othæmatoma. It may, however, be distinguished from the latter by the history of its development, and by the presence of smaller new formations in the immediate vicinity of the larger one. The adjoining figure (Fig. 110) exhibits such a form: it occurred in a shepherd's boy, seventeen years of age.

Vascular neoplasms in the region of the ear, on the auricle, and in the external auditory canal, are often present for years without producing any troublesome symptoms, though they sometimes grow to such a size as to cause considerable disfigurement. *Schwartze*, however, observed severe reflex cough in a case of angioma in the canal. If their presence narrows the canal to a marked degree, they may occasion considerable deafness; and sometimes patients complain of various subjective auditory sensations. The latter phenomena are either consequences of secondary changes in the deeper structures, or depend chiefly upon the sounds produced by the blood circulation in the vessels of the new growth, in which case they may also be perceived by the observer.

Fig. 110.
Angioma of the auricle.



Much more important than these symptoms are the hæmorrhages which sometimes take place. They may be of the most serious character, and may necessitate ligature of the vessels, even perhaps of the carotid.

Jüngken had to tie the common carotid on account of hæmorrhage from a ruptured congenital angioma in the neighbourhood of the ear. Seven years afterwards the hæmorrhage recurred and terminated fatally.

The author has frequently removed small angiomata with the galvano-cautery. The last case he successfully treated in this way was that of a woman with five vascular growths on the auricle, each as large as a lentil, from some of which severe hæmorrhage repeatedly occurred. With larger growths compression suitably applied may be employed, or they may be submitted to electro-puncture. If these means are unsuccessful, then removal is indicated, during which it may be necessary to sacrifice larger or smaller sections of the auricle and auditory canal. In the case represented in Fig. 110, after other modes of treatment had failed, amputation

of the auricle was performed by *Prof. Weinlechner*. Inoculation of the tumour with vaccine lymph has also been recommended for small angiomata. *Zeissl* used for vascular nævus a plaster containing tartar emetic. Injection with perchloride of iron should be avoided on account of a possible embolism (*Schwartze*).

Aneurysms are sometimes found both on the auricle and behind it, on the posterior auricular artery. They develope very slowly, and produce similar symptoms to the angiomata. The author observed an aneurysm of the size of a pea on the anterior surface of the auricle of an opera singer. After having existed for years without causing any trouble, hæmorrhage suddenly took place from it while he was performing in an opera at Bayreuth. Various modes of treatment were tried without success, and finally the common carotid was ligatured by *Prof. Weinlechner*. In this way a radical cure resulted, and the patient still pursues his vocation.

Another vascular condition which deserves mention, and which has only once come under the author's observation, is that presenting an appearance resembling a telangiectasis, and is dependent upon a vaso-motor paralysis brought about by the intemperate use of morphia. In the case referred to, the patient had for years injected morphia in large quantities. Torpid ulcers were present on various parts of the body, and extensive cicatrices due to the needle punctures. Then darkish, irregularly defined, livid patches somewhat raised above the surface, made their appearance on both auricles. Their colour momentarily disappeared on pressure, and at once reappeared on its removal. This condition came on about six months before the man was seen by the author; first of all on the upper half of the left auricle, especially on the helix; somewhat later on the right auricle; and from there spread over the anterior and posterior surfaces without causing any particular discomfort. The deeper aural structures were healthy. The phenomenon was no doubt attributable to a paralysis of the vaso-motor nerves. No similar changes were to be seen on other parts of the body. As soon as the patient understood that the affection was recognised to be due to his abuse of morphia, he disappeared and did not return.

5. *Papillomata.*—The hard or horny and soft or fibrous varieties are both met with in this region. Among the first kind are the warts, which are found either single or multiple both on the auricle and in the cartilaginous portion of the auditory canal. In the soft papillomata, which are more or less vascular, considerably hypertrophied cyst-like dilated follicles, the contents of which are occasionally calcified, are sometimes found (Fig. 111). These growths may become so large as to quite occlude the auditory canal, and thus impair the hearing. They may also become inflamed and very painful as a result of mechanical or other irritation, or by infection. In this way hæmorrhages often take place. Transformation of papilloma into epithelioma has been frequently observed, although in itself it belongs to the non-malignant new formations.

Excision of the papilloma, with cauterisation of the wound with nitrate of silver, may bring about a radical cure. When situated on the auricle, the growth is most conveniently removed with curved scissors.

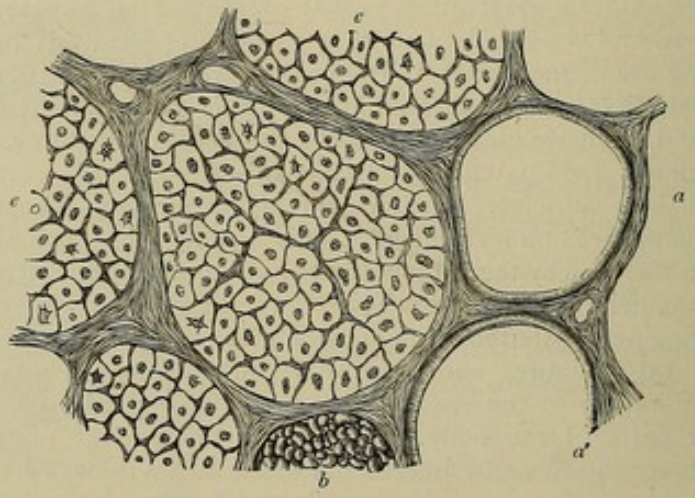
The sharp spoon is best for this purpose when they grow from the wall of the auditory canal. The galvano-cautery may also be employed; and the author has operated on a considerable number of cases in this way with good results.

In the case of a papilloma occurring in a woman aged sixty-five, the growth commenced to ulcerate, and caused severe pain. Recurrence took place after operation, with reappearance of the pain. The operation had to be repeated on several occasions, but finally recovery took place.

In a case reported by *Bing*,[1] in which the papilloma measured 4 *cm.* by 1 *cm.* by 1½ *cm.*, and grew from the lower part of the concha, narrowing the meatus, the

Fig. 111.

Section of a papilloma from the posterior wall of the cartilaginous part of the auditory canal. (Magnified 300 times.)



e, *e'*, Inter-papillary spaces filled with epidermic cells; *a*, *a'*, cyst-like cavities; at *b* the contents are partly calcified.

surgeon, to facilitate its removal, had first to cut through the upper wall of the canal.

6. *Adenomata.*—A true new formation of gland-tissue may undoubtedly occur in the external auditory canal. The author has, however, never observed such a growth, except as a sequel to a long-existent inflammation of the canal which was usually associated with chronic inflammation of the middle ear. Adenomata occur for the most part as mixed tumours (adenoma fibrosum, myxomatosum), with single or divided peduncles, growing sometimes from the auditory canal, or from the mucous lining of the tympanic cavity. The capsule of the growth is not uncommonly very firm, and covered near its attachment with ciliated

[1] "Ueber Warzen und Papillome am äusseren Ohrtheil." Wiener medicinische Blätter, 1885.

cylinder-epithelium. In the interior are sometimes found cysts with mucous contents. Several adenomata are occasionally present in the same auditory canal.

7. *Sarcomata.*—These tumours are developed primarily in the auditory canal, and extend from there to the neighbouring structures, or they take the opposite direction in their growth. They are of rare occurrence in the ear, being usually seen in children and young persons. Round-celled sarcomata are found in the region, and also tumours with large cells and an abundant connective-tissue stroma (fibro-sarcoma). The latter grow slowly, and may exist for years without causing any particular symptoms. The small-celled or round-celled sarcoma, on the other hand, grows with great rapidity, and is generally attended with striking manifestations. The pain associated with this very rapid development becomes sometimes most severe, especially if the sensory nerves become implicated, or if inflammatory processes are set up in neighbouring structures, as is sometimes the case in the parotid gland or the mastoid process. The neoplasm spreads very quickly through the inflamed tissues, producing the greatest distress.

The objective conditions may be very various. Sometimes the new formation presents itself as a circumscribed tumour, firm to the touch, and covered with healthy cutis, and without any suppuration in the ear. Sometimes, as a result of ulceration, it is bathed with a foul-smelling, more or less sanguineous discharge.

The growth may exist in the auditory canal without any attendant signs of its presence in the neighbourhood, not even swelling of the glands. In other cases, a high degree of infiltration of the glands and soft parts, with enlargement of the bones, especially of the mastoid process, as well as fluctuating swellings and destruction of tissue in various degrees, may be observed. In its further course, aural symptoms following upon metastatic formations may become developed ; and severe hæmorrhage sometimes takes place in consequence of ulceration of the new growth.

The *diagnosis* is only to be made with certainty from a microscopical examination, though in many cases the general characters and appearances of the neoplasm afford pretty distinct evidence of its nature. The inflammatory symptoms in the auditory canal, or in the vicinity, may, however, so mask the character of the principal disease as to lead to its being mistaken for a case of inflammation only, until later its rapid and fatal course discloses the true condition.

Fibro-sarcomatous tumours generally take a mild course. So long as they do not occlude the auditory canal or ulcerate, no notable symptoms appear. But the round-celled sarcoma, as already stated, spreads through the structures with great rapidity, and invades the cavity of the cranium ;

or metastatic foci become developed in vital organs. Inflammation also of the deeper aural structures may supervene, and terminate fatally by extension to the cranium. Not uncommonly paralysis of the facial nerve occurs in the course of the disease.

The *prognosis* will depend upon the character of the new growth, its generalisation, and other changes in the ear itself and neighbouring organs. So long as the growth remains small, it may be completely extirpated, and this should never be delayed. A *partial* removal is always to be avoided as far as possible; experience showing that the remaining portion grows still faster after the operation. Cases, however, occur where even a partial excision must be undertaken, on account of the obstacle offered to the escape of discharges from the external auditory canal, and the extension of inflammation to the cranial cavity which is thereby threatened. Firmer fibrous sarcomata are best removed from the auditory canal by a galvano-cautery snare. Soft sarcomata may be removed with the ordinary polypus-snare or a sharp spoon. In a radical operation, the wound should be afterwards seared with the galvano-cautery, with the view of preventing a recurrence of the growth.

Particular caution must be exercised in opening the fluctuating swellings in the neighbourhood, which sometimes accompany these tumours. Such apparent abscesses frequently contain cyst-like masses of the softened growth; incision of which may be followed by severe hæmorrhage, very difficult to arrest.

8. *Epitheliomata* (cancroid).—These neoplasms may occur primarily on the auricle and in the external auditory canal (*Kessel*,[1] *Brunner*, *Lucæ*,[3] *Delstanche*,[4] and others); or they may spread to these structures from the neighbouring regions. The author's experience accords with that of *Schwartze*, that the greater number of epitheliomata of the external ear are seen in patients who have suffered for a long period from purulent otitis.

In the case of a man from whom *Arlt* removed the left eyeball for this disease, the growth reappeared seven years afterwards on the left auricle, which it destroyed rapidly as far as the lobe, and extended thence to the mastoid region, where a large ulcer of characteristic appearance formed. After extirpation of all the diseased tissue, healing took place, and the patient has continued well for four years.

The disease begins either by a gradual alteration in the character of warty growths, which have already existed perhaps for a long while as such; or by the appearance in the skin or subcutaneous tissue of

[1] Archiv für Ohrenheilkunde, iv. Bd., S. 284.
[2] *Ib.*, v. Bd., S. 28.
[3] *Ib.*, xiv. Bd., S. 127.
[4] *Ib.*, xv. Bd., S. 21.

one or several hardish nodules. Fissures soon form on the surface of the infiltrated tissues, and develope by degrees into ulcers with hard, prominent edges, and uneven, more or less granular base, out of which altered plugs of epithelium can be easily pressed. While at one part of the growth degeneration is going on, at another it is extending and implicating more and more of the healthy structures. In this way not only the entire auricle and the deeper parts of the canal, but also the neighbouring structures, may be destroyed to a considerable extent, so as to involve even the cranial bones. The disease is in many instances not attended with any pain for a long period; but sometimes, on the other hand, violent lancinating or constant pain is present. If the growth extend to the deeper structures, and especially if the orbit or pterygoid fossa have been invaded, the pain is apt to become most intense. Symptoms referable to the auditory nerve will be dependent upon the same conditions as may be brought about by other new formations in the ear.

Though epithelioma must be considered a malignant neoplasm, numerous cases have been recorded in which the patient survived extirpation of the growth for many years without a recurrence. If the disease prove fatal, this results either from its encroachment upon the brain, or from the formation of metastatic growths in organs important to life, or from extension inwards to the brain and its membranes of inflammation of the deeper structures of the ear, or from septicæmia.

Early excision of the diseased parts is particularly indicated with the auricle, as experience shows that even after its complete amputation the wound heals tolerably quickly, and that the operation generally results in a radical cure. After amputation of the auricle at its root, the healing of the wound must be carefully watched, so as to prevent a possible adhesion of the parts, with occlusion of the auditory canal. If the growth be situated in the canal itself, and be strictly circumscribed, the diseased part may be taken away with the sharp spoon, or destroyed with the galvano-cautery; a certain amount of the surrounding healthy structures being likewise burnt away at the same time. When, however, a complete extirpation of the diseased tissues cannot be carried out, it is better not to operate at all, since this would only be followed by increased rapidity of growth in the parts left behind. Even the application of escharotics, such as fuming nitric acid or chromic acid, has only an injurious effect, according to the author's experience. In such cases the only thing to be done is to keep the ulcerated parts clean with some suitable, if necessary, deodorising lotion, and to treat such symptoms as may arise. If severe pain be present, anodyne remedies may be employed externally, and also used internally if required. Antipyrin may be serviceable in such cases.

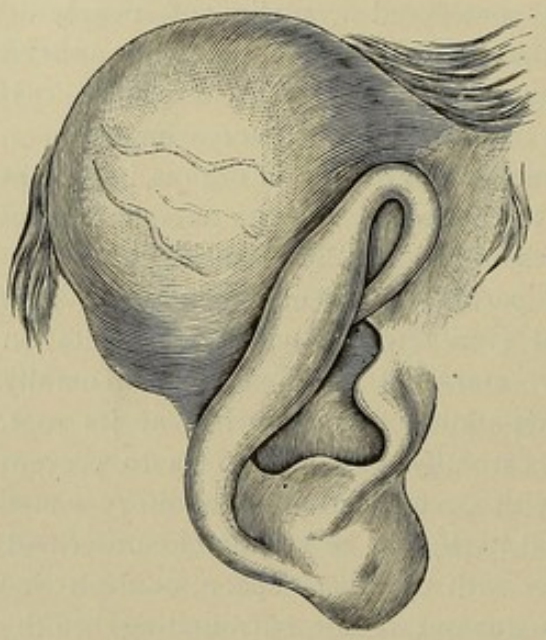
9. *Cysts.*—The so-called retention-cysts, and also the new cyst-

formations, are both found on the auricle and in the external auditory canal. To the first kind belong the comedones, which are frequently seen on the concha, and are due to retention of sebaceous matter in the hair follicles; also the small miliary epidermic retention-cysts most often seen at the edge of the eyelid; and, likewise, the sebaceous cysts. The wart-like formation called sebaceous molluscum, constituted by a prominent dilated follicle filled with retained sebum, is also found in this region.

The wens, due to retention of epidermic accumulations and sebaceous material, present themselves as round or somewhat flattened tumours of variable size. The largest one seen on the ear by the author was situated on the posterior surface of the auricle, and is represented in its actual size in the adjoining figure. They grow very slowly, often for many years, and may become very large. The tumour depicted in Fig. 112 began, according to the patient, five years previously; reached its present size in three years' time, and then remained stationary.[1]

Fig. 112.

Wen on the posterior surface of the auricle.



Toynbee states that he met with sebaceous cysts in the auditory canal ten times in 1013 cases in which he made sections of the ear. According to him, the larger ones may cause a dilatation of the canal, and are even said to partially wear down the bone by pressure. In one case described by him, both the outer and inner walls of the mastoid process were penetrated by the tumour, which had also eroded the petrous portion of the bone at its posterior and upper part, and finally encroached upon the cavity of the tympanum. The author thinks this may possibly have been a case of cholesteatoma.

Cysts of independent formation are rarely found on the auricle. Certain tumours sometimes occur there which develope quickly after a slight injury, or without any ascertainable cause, and their interior usually contains a serous fluid resembling that in othæmatomata of long standing (*Böke*[2]). Perhaps these may be looked upon as cysts, though

[1] Compare *Pappenheim*, "Specielle Gewebelehre des Gehörorgans," 1840, S. 146; and *Buck*, "Diagnosis and Treatment of Ear Diseases." New York, 1880, p. 123.

[2] "Cystis auriculæ." Wiener medicinische Presse, viii. Jahrg., 12, 1867.

the author, on account of their rapid development, is inclined to consider them rather as of inflammatory origin.

Sometimes, on the other hand, growths are observed of very slow development, and with serous or mixed contents, which must certainly be regarded as cystic new formations. They usually occur on the anterior surface of the auricle, and sometimes enlarge to such a degree as almost to cover the entire ear, without causing, however, any particular symptoms.

Cysts in the external auditory canal may readily be confounded with abscesses or exostoses. The history of the case, however, and more particularly a careful examination with the probe, will generally furnish evidence as to their true character.

Here, as on other parts of the body, cysts may become inflamed, and sometimes a spontaneous cure is brought about in this way. Such a process in the auditory canal may occasion a tedious otorrhœa, with ulceration, and their various results. It is therefore better to extirpate these formations as soon as possible. This may be done as easily on the auricle as on other parts of the body; but in the external auditory canal the procedure is very difficult. It is advisable rather to evacuate them first by a crucial incision; then to excise as much of the cyst-wall as possible, and to thoroughly cauterise the base. With larger cysts on the auricle an endeavour may be made, after evacuation of the contents, to bring about inflammatory adhesion by injecting some dilute tincture of iodine.

Schwartze[1] observed in a child aged ten a cyst on the auricle, which was in connection with another one as large as a small apple, in front of and below the ear. The swelling was smooth on the anterior surface, rough and elastic on the posterior aspect, and had produced œdema of the face. On exploratory puncture, a clear, slimy fluid escaped in which abundant pus cells were found. Repeated aspiration with a Pravaz syringe, and injection of iodine and glycerine solution, brought about obliteration of the cyst cavity and a permanent cure. The isolated auricular appendages which are occasionally seen in this region, especially in front of the auricle, represent, according to *Schwartze*, dermoid cysts: they contain epidermis and hair.

Schapringer[2] reports on two patients with cysts with serous contents, situated on the auricle. In one of the cases the cyst had become developed a long time after some trivial injury; in the other case no cause could be assigned. They grew slowly, were translucent, and situated between the cartilage and the perichondrium. Incisions were made on the posterior surface of the auricle, and their contents evacuated. A cure followed in one case; in the other the result was unknown.

10. *Cholesteatomata.*—The temporal bone is a favourite seat of these tumours. They occur as primary neoplasms in the external ear far more

[1] "Die chirurgischen Krankheiten des Ohres," S. 78.

[2] "Seröse Cyste der linken Ohrmuschel. Incision. Heilung." Monatsschrift für Ohrenheilkunde, xviii. Jahrg.

rarely than in the deeper structures. Some authors have regarded many atheromata of the auditory canal as cholesteatomata. They are, however, of rare occurrence, although cholesterine flakes are very often found mixed with discharges in the canal in chronic inflammatory processes. These formations are found both in the auditory canal and on the tympanic membrane—most frequently after or during an inflammation of those structures. They are composed of thin laminated masses of cells, very like those of plants, between which are collected cholesterine and free fat. Their appearance is pearl-like and shining, of a whitish-grey or yellowish colour, and sometimes enveloped by a delicate connective-tissue covering. They project free into the auditory canal, where they may be mixed with matters of all kinds, even with fungi.

The cholesteatomata may arise primarily in the tympanic membrane. In a patient who had succumbed to typhoid fever, *Wendt*[1] found, besides considerable swelling of the lining membrane of the tympanum, an endothelial cholesteatoma, which was surrounded by a very delicate capsule of connective tissue, and was in connection with the membrana propria. It projected into the cavity of the tympanum as a hemispherical tumour 1½ *mm.* in diameter. *Küpper*[2] found in a patient who died of consumption a tumour 1½ *mm.* in diameter on the drum-membrane in the region of the umbo, and projecting towards the external auditory canal. Microscopically it had the characters of a cholesteatoma. A similar case came under the author's observation in a patient with increasing deafness and with noises in the ear, who had suffered from a chronic inflammation with otorrhœa several years previously. On the posterior segment of the tympanic membrane was a silver-grey shining swelling about the size of a pea. On examination with Siegle's speculum it remained in the same situation, while the rest of the membrane was put into motion. No trace of inflammation was perceptible in either the external or the middle ear. Upon inflation with the air-ball a slight improvement resulted in respect of the subjective auditory sensations, while the hearing distance was not sensibly increased. The probable diagnosis of cholesteatoma was made, and a crucial incision carried superficially through the tegumentary layer with the myringotome, upon which the growth sprang somewhat forwards. It was carefully enucleated by means of a sharp spoon. Microscopic examination confirmed the diagnosis. No perforation-sound on inflating the middle ear could be heard either before or after the removal of the growth. The space which it had occupied between the layers of the membrane could, however, be

[1] "Ueber ein endotheliales Cholesteatom des Trommelfelles nebst Bemerkungen zur Histologie der Eigenschicht." Archiv für Heilkunde, xv. Bd.

[2] "Sectionsbefunde. 4. Cholesteatom des Trommelfelles." Archiv für Ohrenheilkunde xi. S. 16, u. ff.

distinctly recognised. The noises in the ear, which must have been due to pressure of the tumour upon the incus-stapes articulation, disappeared after the operation, but the hearing improved only very slightly. The deafness was undoubtedly due to objective changes in the various aural structures remaining after the chronic inflammation.

Prognosis and Treatment.—When the growth is situated on the outer parts of the ear it causes no serious symptoms. If, however, it is associated with a purulent inflammation of the deeper structures, and interferes by its size with the free discharge of pus, it may lead to dangerous results. Its removal is, however, indicated in all cases.

11. *Granulomata.*—The granulation-tissue neoplasms found in the structures of the external ear comprise *tubercle*, *lupus*, and *syphilitic new formations*.

(*a*) *Tubercle.*—In patients affected with suppurative median otitis and perforation of the tympanic membrane, occurring in association with pulmonary tuberculosis, the author has been able to demonstrate tubercle in the membrana tympani. The latter structure was always very much infiltrated, in certain places ulcerated, and covered with firmly adherent exudation containing tubercle-bacilli. Occasionally he has also found the bacilli in large numbers in the substance of the tympanic membrane of such patients who have succumbed to the malady. Quite recently an opportunity occurred of accurately observing the development of granulations in the membrane, and their caseous degeneration. The patient was suffering from middle-ear inflammation on both sides, and was sent to the author's clinic by *Prof. Schrötter*. The right membrane was much infiltrated, and exhibited a perforation of moderate size on the anterior segment. On the left membrane was a distinctly circumscribed smooth nodule of reddish appearance, about as large as a hemp-seed. The vessels along the malleus were strongly injected, and the posterior superior segment was also red and swollen. Two days afterwards a second nodule was observed on the anterior segment just below the first, but no pain was present. On the succeeding days the upper nodule assumed a yellowish appearance, and the epidermis became somewhat loosened : it had, however, not increased in size. The same change took place in the lower granulation in the next few days, followed three weeks afterwards by disintegration ; and gradually the membrane became perforated in the situation of the nodule. Examination of the first scanty purulent discharge showed isolated tubercle-bacilli, which increased in quantity later with a more abundant otorrhœa. The perforation had already existed more than a week without any pain being present, the only symptom being deafness. It was only with the development of inflammation in the auditory canal, in the further course of the affection, that moderate pain was experienced. This, however, disappeared with

recession of the inflammatory process. Symptoms of middle-ear inflammation are still present. In this case, then, the development of tubercles in the tympanic membrane could be followed in a phthisical patient suffering also from inflammation of the middle ear. The author has, indeed, seen no case of tubercle of the drum-membrane without a simultaneous middle-ear affection.

(*b*) *Lupus.*—This arises, both primarily, and by extension from the neighbouring parts, on the auricle, and also in the external auditory canal. The tympanic membrane is likewise frequently affected secondarily by the growth; but whether it ever arises primarily in this has not been ascertained.

All forms of lupus occur on the external ear. When it developes primarily on the auricle, it has generally the characters of *lupus exfoliaticus*; but *lupus hypertrophicus* and *lupus exulcerans* are also found there, and sometimes occasion very extensive destruction. Individuals suffering from lupus exedens have been seen by the author who have lost the entire auricle, together with the cartilaginous auditory canal; while ulceration was still in progress in the skin of the osseous portion of the canal and on the tympanic membrane. In other cases there was occlusion of the canal, or adhesion of the auricle to the scalp. Generally there is little pain connected with the ulcerating process, but sometimes it may be very severe when the auricle, or especially when the auditory canal or drum-membrane is affected. Even on the membrane, however, lupus is sometimes painless. On the other hand, deafness is always, and subjective auditory sensations are sometimes present when the disease attacks the deeper parts of the external ear extensively.

Lupus may be cured on the ear, as on other parts; but relapses are likewise of frequent occurrence. The aim of treatment is to destroy the granulations and pathogenic germs by the galvano-cautery or solid nitrate of silver. Electrolysis has of late also been successfully employed. Special attention should be given to preventing occlusion of the auditory canal. With the view of preventing recurrences, the diet and regimen of the patient should be carefully regulated—nourishing food and residence in healthy air being indispensable. With regard to internal remedies, Fowler's solution and cod-liver oil have been particularly recommended.

(*c*) *Syphiloma.*—Amongst the earlier manifestations of secondary syphilis, both roseola and papular syphilides occur on the external ear, and, as on other parts of the body, disappear under ordinary anti-syphilitic treatment. Local treatment is rarely necessary with the papular affection, unless ulceration take place. The parts may then be painted over with a 5 per cent. solution of corrosive sublimate, and pledgets of lint soaked in it may be applied. If much pain be present, anodyne remedies may be used.

Gummata occur both on the auricle and in the external auditory canal, but more often on the mastoid process, where they may attain a considerable size. They are sometimes distinctly circumscribed; more frequently, however, their margins are not well defined. To the touch they are generally very elastic, and may readily be mistaken for simple periostitis. The history and other objective characters, however, suffice to differentiate them. If ulceration take place, the edges appear callous and infiltrated, and the base fatty-looking, with little tendency to heal.

The treatment must be on ordinary anti-syphilitic lines.

12. *Inorganic new-formations.*—Calcareous deposits are sometimes found on the auricle, and gouty concretions are reputed to have their favourite seat here.[1] In the external auditory canal concretions of carbonate and phosphate of lime are said to occur; but the author has not met with them.

[1] *Garrod*, "The Nature and Treatment of Gout": London, 1859.

CHAPTER X.

FOREIGN BODIES IN THE EXTERNAL AUDITORY CANAL.

As foreign bodies in the auditory canal are to be regarded not only substances introduced from without, but also such as, although originating in the ear, interfere with the normal function by reason of their excessive amount, or their altered character, or by their unusual situation.

Matters introduced into the ear sometimes undergo changes in the canal; thus in many cases parasites finding their way here undergo further stages of development. The substances most frequently found are:—Plugs of cotton-wool, small stones, pieces of paper, beans, peas, lentils and other similar seeds; the stones and seeds of various fruits, especially of cherries, locusts, and melons; glass beads, small buttons, grains of shot; various vegetable substances, as pieces of hay or straw, garlic, etc. Particular mention may be made of insects which find their way into the auditory canal—*e.g.* fleas, bugs, flies, wasps, butterflies. Flies sometimes deposit their larvæ here, which then undergo further development.

Living larvæ have been often observed in the ear. *Stoehr*[1] removed in one day fifty-eight larvæ (of sarcophaga carnaria) from the auditory canal of a man of seventy-two, into whose ear something flew two days before, while he was engaged in loading hay. On the following days, and in spite of the introduction of a two per cent. solution of carbolic oil, six more living larvæ, which had reached 15 *mm.* in size, were removed. The author has seen several similar cases. *Scheibenzuber* removed about forty larvæ from one ear. In another case a boy six years of age, who had an otorrhœa, and into whose ear a fly made its way while he was playing on a dunghill, was attacked on the evening of the following day with violent ear-ache. Twenty-five large maggots were taken out of his ear with a hair-pin. As the pain did not cease, he was next day brought to the author, who removed seven living maggots with the ear-forceps, whereupon the pain left him. The two last-mentioned cases were reported at the time by the author.[2]

Von Tröltsch[3] found in a boy's ear a large number of bird-mites (dermanyssus avium): these acari were from 1 to 5 *mm.* in length and 1 *mm.* broad, of a yellowish-white, brownish, or black colour, with eight legs somewhat darker than the rest of

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[1] "Lebende Larven im Ohre." Bayr. Intell. Blatt, 1878.

[2] "Zwei Fälle von lebenden Larven in der Trommelhöhle und im äusseren Gehörgange." Monatsschrift für Ohrenheilkunde, iii. Jahrg., 3 und 4.

[3] "Zur Lehre von den thierischen Parasiten am Menschen. Archiv für Ohrenheilkunde, ix. Bd., S. 193.

the body. This creature cannot easily bore into the healthy skin, but may produce considerable irritation, and even penetrate the skin when its texture is loosened, as by inflammation. *Von Tröltsch* alludes to the possible presence of other such parasites in the ear, derived from domestic animals. *Trautmann*[1] also directs the attention of aurists to the parasites met with in rabbits, dogs, and sheep (dermatodectes), which cause considerable destruction, especially in the ears of rabbits. He notes that these mites might easily find their way into the ears of children by their playing with animals infested with them.

Foreign bodies are generally introduced into the ear in the case of children at play. Sometimes, however, they are inserted in the way of remedies, and forgotten; or the patient may be unable to remove them. They may occasionally remain in the ear for many years without producing any symptoms, so that it may be difficult for patients to remember when they were introduced.

Among the substances which, though originating in the ear itself, are to be regarded practically as foreign bodies, may be mentioned:—Blood and blood clots, epidermic scales, hairs, large accumulations of cerumen, liquid or inspissated exudations, and pieces of necrosed bone. Their presence presupposes the existence of morbid changes, of which mention is made elsewhere.

Special reference must be made to *excessive collections of cerumen in the canal*, which are without doubt due to abnormal processes in the ceruminous glands. Occupation has been by some thought to play a large part in its accumulation; but the author can only agree with this conjecture in the sense that the auditory canal may become sooner impacted in persons who work amongst much dust. That the condition, however, is not dependent on the occupation is sufficiently shown by the circumstance that in the same patient one ear is often found impacted with cerumen, while the other one is quite clear.

Excessive accumulation of cerumen is met with in persons of all ages, —more often, however, in males. The longer it remains in the auditory canal, the harder and darker it becomes; while when recently secreted it is semi-liquid and of a light-yellow colour. The constituents of the ceruminous plug vary, some being of normal occurrence in the auditory canal, others derived from without, and mixed with the former.

Foreign substances induce various symptoms in accordance with their own physical and chemical characters, and with their mode of introduction. Injuries of various kinds may be brought about through them, and they may also from their constitution lead to different consequences, chiefly inflammation, which may continue long after their removal from the auditory canal. They interfere in particular with the hearing by hindering

[1] "Bericht über die otiatrische Section der 49. Versammlung deutscher Naturforscher und Aerzte, 1786.

sound-conduction. If only a small space be still left between the foreign substance and the walls of the canal, the patient may still hear very well. The hearing may become also, now better, and now worse, as the result of movements of the lower jaw, or by pulling the outer ear, on account of the alterations in the size and shape of the canal thus brought about. If the canal be quite occluded by the substance, the degree of deafness thereby caused will depend upon the conducting capacity of the obstructing material.

Subjective sensations of diverse kinds may be also caused by the presence of a foreign substance ; generally by excessive pressure upon the tympanic membrane, by which the intra-auricular pressure is increased by transmission through the chain of auditory ossicles. The symptoms in question may naturally be brought about by other results, due to the presence of the foreign body, and may be of periodic recurrence.

In regard to other phenomena which may be induced by a foreign body in the ear, experience shows them to depend upon its mode of introduction, and upon its physical and chemical constitution. Individual peculiarities, however, have also an important influence in the matter. It may thus happen that a perfectly innocuous substance which has found its way into the auditory canal without producing any injury, may sometimes evoke and maintain the most serious symptoms.

Boyer relates that in a girl who suffered from epilepsy, atrophy of one arm, and anæsthesia of the corresponding half of the body, all the symptoms disappeared on removal of a glass bead which had remained fixed in the auditory canal for eight years. *Wilde* likewise mentions a case of epilepsy accompanied by deafness, which was cured by the removal of a foreign body.

In the Vienna Medical Weekly Journal[1] a case is reported in which an insect (myriapod) which had got into the auditory canal, had occasioned epileptic spasms and hemiplegia, together with frequent vomiting. The latter symptom ceased directly the insect was removed ; the convulsions became gradually less frequent, and the paralysis also diminished, and disappeared in six weeks. *Weinlechner*[2] reports two cases occurring in *Schuh's* hospital practice which terminated fatally. The bodies introduced, a pebble and a coffee-bean, had got into the tympanic cavity, from which they could not be removed. Unilateral facial paralysis appeared in both cases, followed by purulent meningitis, which ended fatally in a few days. In two other cases the foreign body (a locust seed) remained in the tympanic cavity without causing subsequent urgent symptoms. Numerous cases, again, are recorded in which the foreign body remained in the ear for years without producing any symptoms at all. *Michel*[3] relates a case where a piece of lead-pencil, 4½ *mm.* long and 3 *mm.* in thickness, was fixed for eleven years in the ear without causing any serious symptoms. The patient felt occasionally a slight itching, and a feeling of weight in the auditory canal. *Rein*[4] gives an account of a case in which a carious molar tooth remained for forty years in the auditory canal without

[1] X. Jahrg. 6, 1860.
[2] Wiener Spitalszeitung, 1862.
[3] Allg. Wiener Med. Zeit., vii. 31, 1862.
[4] Pr. Ver. Zeit. N. F. V., 25, 1862.

producing the least disturbance. *Dr. Bartscher*[1] had under his observation a child three years of age, with chronic otorrhœa, who pushed a small ring into its ear. The rough attempts to remove it which were made by the parents resulted in its being pushed farther on into the cavity of the tympanum, from which the efforts of three surgeons failed to extract it. The ring was so placed that its opening looked upwards and inwards, and was wedged in between the promontory and the posterior wall of the tympanic cavity. All kinds of instruments were introduced, but it could not be moved, and remained for weeks without causing any bad symptoms. Further attempts to remove it were therefore abandoned, and nine months afterwards the child was still quite well. Several similar cases are described by the author in the Wiener Med. Halle, 1864.

Israel[2] saw a man of thirty, who had pushed the top of a lead-pencil into his ear, and this found its way into the cavity of the tympanum. After fruitless efforts at extraction, the patient experienced pains in the arms, in the whole of the upper part of the body, and in the hip; the head and ear were, however, free from pain. With these symptoms were associated dilatation of the left pupil, spasms of the orbicularis palpebrarum on the left side, and of the left levator alæ nasi. There was also intense hyperalgesia of the skin, especially on the left side, and contraction of the left hand. After a hypodermic injection of atropine had been given, the contraction permanently disappeared, and also for a time the hyperalgesia, with which toothache had been associated. The foreign body was removed after preliminary detachment of the auricle and the cartilaginous portion of the auditory canal, whereupon all the nervous phenomena disappeared. The latter are attributed by *Israel* to pressure upon the nerves of the tympanic cavity, produced by the pus imprisoned behind the foreign body.

Küpper[3] had under his care a girl of eighteen, who, after having had for three weeks an inflammation in the right ear, introduced into it a piece of a root with the view of relieving the accompanying toothache. She, however, could not remove it, and from that time began to be attacked with epileptic convulsions, frequently several in one day. *Küpper* found polypi in the ear, and having removed them under anæsthesia, a violent paroxysm came on. Some days afterwards a piece of wood 1 *cm.* long and ½ *cm.* thick was taken out of the auditory canal. A few hours later another epileptic attack came on, and two days later yet another—which however was the last. The ear got well in four weeks under treatment with boric acid. In a female patient, aged seventy-six, in whom headache, vertigo, vomiting, and violent spasms of the muscles of the face and extremities were present, all the symptoms disappeared after removal of an accumulation of epidermis which pressed upon the tympanic membrane. *Robert*[4] records a case of extremely obstinate neuralgia of the face, which only disappeared after the auditory canals had been cleared of plugs of cerumen.

The objective appearances which may be caused by a foreign body vary with its nature. In many cases no morbid changes at all may be induced; while in others, the signs of injury or of severe inflammation are evident.

The injurious results of excessive accumulations of cerumen have been, in the author's opinion, much exaggerated; and he believes with *Kramer*

[1] Journal für Kinderkrankheiten xxi., 1863.

[2] "Ueber nervöse Erscheinungen, veranlasst durch einen fremden Körper in der Paukenhöhle." Berlin. Klin. Wochenschr., xiii. Jahrg., 15.

[3] "Mittheilungen aus der Praxis." Archiv für Ohrenheilkunde, xx. Bd.

[4] Annales des maladies de l'oreille, etc., 1886, Nr. 5.

that diagnostic errors have often been made from this circumstance. Not only the soft structures, but the bone even is said to have been destroyed in this way. A mistake may more especially arise with the products of an existing or a previous inflammation. Such products may be coloured by cerumen so as to resemble it closely and be mistaken for it. A cursory microscopical examination even may not suffice to decide the nature of the material, since the substances sometimes found in cholesteatomata may also be present in small quantities in cerumen. A preparation of the author's, which is represented in the adjoining figures, illustrates this statement. It was removed from a man who died suddenly, and was the subject of a judicial autopsy. A cholesteatomatous tumour was found in the left temporal bone, having developed originally in the tympanic cavity. It had destroyed the upper segment of the drum-membrane, and pushed the rest out towards the auditory canal into which it had grown. On opening the canal, the mass there presented the appearance of cerumen, and was seen to be continuous with the portion, also of a brown colour, which was on the other side of the membrane in the tympanum (Fig. 113).

The author had the opportunity of seeing a case similar to the above in *Prof. Duchek*'s hospital practice. The cholesteatoma had grown into the auditory canal through its posterior wall from the mastoid region. In this case also it had quite the appearance of cerumen.

Masses of cerumen may readily set up inflammation from the irritation which they produce, and this may lead to destruction of various structures, if suppuration take place. The author has had under his care many patients who sought treatment on account of pain in the ear, in whom the plugs of cerumen had brought about an inflammatory condition of the skin which disappeared completely after removal of the mass. In the author's experience these accumulations lead rather to hyperplasia than to ulceration—a conclusion likewise suggested by the fact of their being often found on removal surrounded by a stratified covering of epidermis.

With reference to the *diagnosis* of a foreign body in the ear, it must be pointed out that the statements of patients are not absolutely conclusive. In numerous instances foreign bodies, even insects, have been believed to be present for years in the ear, when there was nothing there: in others, on the contrary, where the possibility of such a thing has been denied, the presence of a foreign substance has been demonstrated. On the other hand, the patient's statement cannot be quite ignored, since a substance which has entered the ear may easily remain hidden from the eye of the examiner.

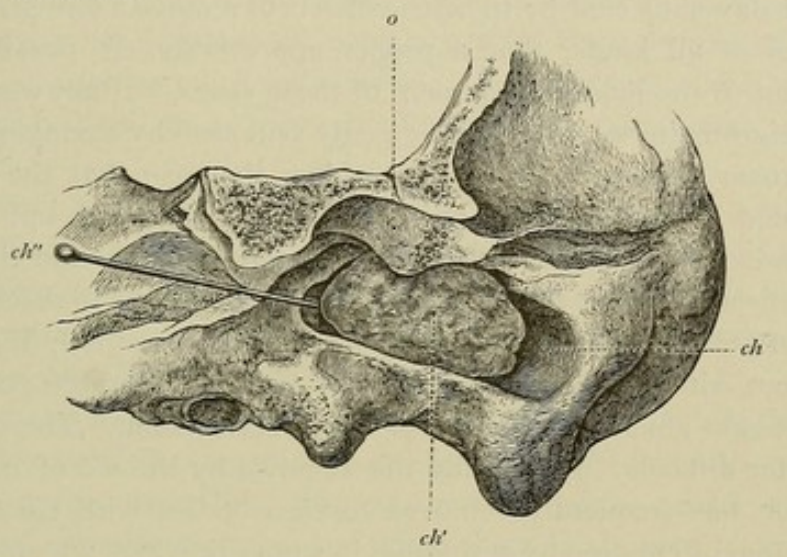
The author once had under his care a patient who stated that an insect had crept into his ear while he was lying in a meadow. He came after a very restless night, but the author could discover nothing in the auditory canal. On syringing out the ear, however, a living larva 3 *mm.* long was washed away; upon which all the symptoms disappeared. Larvæ may easily get into some depression in the auditory

canal, and deceive the observer by their resemblance to epidermic scales. *In all doubtful cases the ear should be syringed out.*

It is of course clear that the true nature of a case can only be properly made out after the removal of any foreign substance which may be in the

Fig. 113.

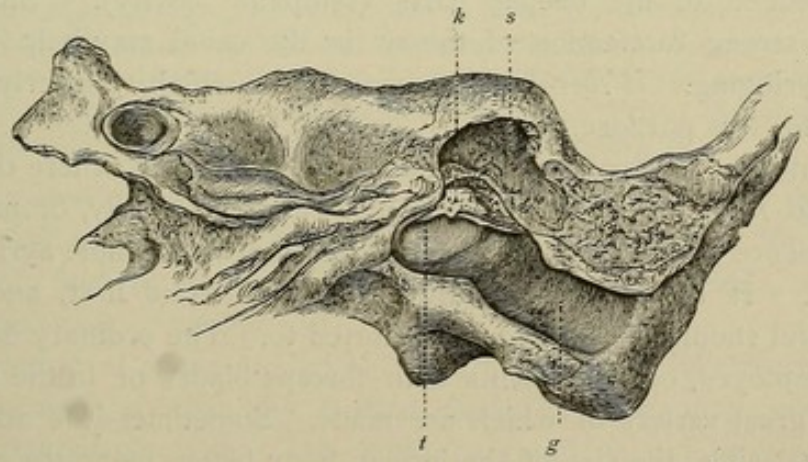
A cholesteatomatous tumour which grew from the tympanic cavity towards the external auditory canal, and also towards the cranium. The anterior wall of the auditory canal has been taken away.



The mass *ch*, *ch'*, *ch''*, is seen growing out from the tympanic cavity under the upper wall *o*; in colour it resembled cerumen; at *ch''*, a portion of the membrana tympani is seen.

Fig. 114.

The same preparation, after removal of the cholesteatomatous mass.



Here the auditory canal (*g*) is seen free; at *k*, is the carious head of the malleus, and the crown of the incus likewise affected with caries; *s*, shows the loss of substance in the petrous part of the bone, caused by the encroachment of the growth towards the cranial cavity; at *t*, is seen the drum-membrane, perforated and bulged outwards towards the auditory canal.

auditory canal. It is, for example, quite possible that a plug of cerumen may obscure a total loss of the drum-membrane and other morbid changes, so that the patient may hear much worse after removal of the mass than

before. It is equally possible that he may credit the aurist with such a result; no prognostic opinion should therefore be given until the foreign body is removed.

Treatment.—The most important matter is to remove the foreign substance as soon, and with as little discomfort as possible to the patient. It is only by acquaintance with the rough methods formerly employed, and with the unnecessary pain and danger to which patients are often even at the present day subjected by injurious efforts to remove a foreign body with instruments of all kinds, that a proper appreciation is possible of the improvement in the modern treatment of these cases. If not wedged in too firmly, foreign matters may be quite easily removed by syringing out the ear in a proper manner.[1] It is very seldom the case that the substance is so situated in the auditory canal as entirely to fill it up. There is usually space left somewhere between the foreign body and the walls of the canal, through which the injected fluid can pass so as to reach the space behind, and push the obstructing mass into another position, from which it is carried out with the return current. Or such a favourable position may even be brought about by the force of the direct current. There is usually much greater difficulty in effecting the removal by the aid of instruments. The author has frequently removed foreign bodies with ease from the auditory canal of children by syringing, in whom previous attempts made by various surgeons by means of instruments under full anæsthesia had failed. Such an experience must undoubtedly have occurred to many others. The author has also followed with advantage *Hedinger's* advice in using the force-pump as a *vis-a-tergo* previous to syringing, in the case of foreign bodies wedged in the deeper parts (tympanic cavity). Similarly, a preceding strong rarefaction of the air in the canal may help the effect of the syringing. *Weber-Liel* recommends a small, properly adapted air-pump for this purpose.

It cannot be denied, however, that cases do happen where the foreign body is so firmly wedged in the canal, either originally, or more often in consequence of unskilful efforts at extraction, that simple syringing-out is useless. It must, however, always be well tried first, and only if unsuccessful should instruments be resorted to. The ordinary ear-forceps may be employed, or instruments with forceps blades or in the form of a curette, a great variety of which are made. Sometimes it is advisable to lessen, if possible, the size of the foreign body before using the syringe or an instrument for its extraction.

The removal may occasionally be facilitated, according to *Voltolini*,[2]

[1] *Celsus* recommends syringing out the canal for the removal of foreign bodies (De medicina libri octo. Jena, 1713, Libri 6, Cap. vii., page 403).

[2] "Ein Beitrag zur Operation fremder Körper im äusseren Gehörgange." Archiv für Ohrenheilkunde, i. Bd., S. 151.

by placing the patient on his back with his head hanging somewhat downwards. The posterior-superior wall of the canal forms an obtuse, the anterior-inferior wall an acute angle, with the membrana tympani. In the above-described position of the head, the oblique inclined plane formed by the posterior-superior wall and the membrane is so placed as to facilitate the sliding outwards of the foreign body. In certain cases an attempt may be made before using the syringe to loosen the substance somewhat from its position by the aid of a suitable instrument. But under all circumstances the employment of instruments for the purpose of extraction should be avoided as much as possible. If it be found that they cannot be dispensed with, then they should only be used under very good illumination.

Numerous cases are recorded in which bad symptoms resulted from unskilful efforts at extraction. The necessity for much caution on the part of the surgeon arises also from the extreme sensitiveness of the auditory canal, and from the ease with which excoriations and hæmorrhages may be produced by even slight contact with instruments.

With small foreign bodies, if they are easily removable, the author is accustomed to employ the ordinary ear-forceps, in which case an examination of the deeper structures may at once be made. After syringing, a more marked vascular injection and other changes are seen in the tympanic membrane, and this interferes for a time with the formation of a correct opinion as to the true state of the parts. For the removal of substances which cannot be extracted with the ordinary forceps, the instrument shown in Fig. 115 will be often found useful.

The rod *i* runs through the tube *h*, and is fixed in the handle by the screw *s*. By pressure of the thumb of the hand grasping the handle upon the screw *d*, the tube *h* may be pushed forwards so that the extremities of the two parts approximate, and the foreign body may be grasped between them. When the pressure of the thumb is taken off *d*, the tube *h* is drawn back by the spring *f*.

Inspissated plugs of cerumen or other dried-up matters in the auditory canal should be softened before they are syringed out. This is most conveniently done by dropping in a solution of potash or soda, or by tepid water, almond oil, glycerine, etc.

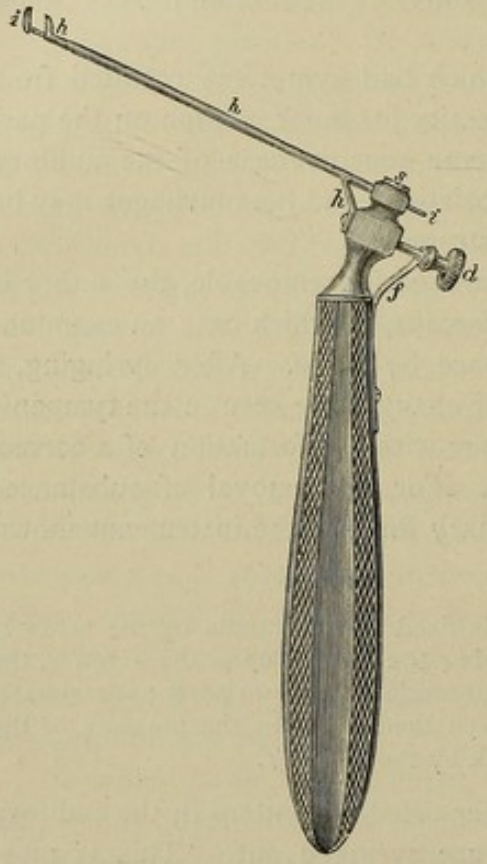
After removal of the foreign body an examination of the canal should always be made, so that any morbid condition which may possibly exist may be treated at once. The auditory canal should be plugged with cotton-wool for a few hours after the foreign body has been removed.

It has been pointed out that foreign substances should be removed from the auditory canal as soon as possible. It must, however, be borne in mind that cases do occur in which it is better, if extraction be not easy, to postpone interference until more favourable conditions present themselves. This is most often the case when an otherwise innocuous

substance is fixed in the canal, the soft structures of which have become so swollen up that operative measures would be required to extract it. With this state of things, no attempt should be made at removal until the inflammatory swelling has subsided and the canal thus become wider again. Numerous cases have been treated by the author in which, after futile efforts had been made to extract a foreign body, it some time afterwards came away of its own accord. The patient should of course always remain under observation, in order that operative measures may be at once undertaken should threatening symptoms supervene.

Fig. 115.

Crutch-shaped forceps (two-thirds the ordinary size).



In many cases the foreign body becomes pushed out of the auditory canal by granulations which develope behind. *Schell*[1] records the case of a man whose wife poured some molten lead into his ear while he was asleep. The resulting inflammation, which was accompanied by paralysis of the facial nerve, constant giddiness, and abolition of taste over the right half of the tongue, was followed by the growth of granulation-tissue, which so loosened the foreign substance that, though previously immovable, it could then be withdrawn with the greatest ease. It weighed 285½ grains, and exhibited a complete cast of the inner wall of the tympanum, having a projection inch long, which corresponded with the entrance of the Eustachian tube.

The author, like *Schwartze*, is inclined to question the accuracy of *Albert's* report of a case contained in *Linoke's* collection of selected cases (II., p. 182), to the effect that a sewing needle, which had got into the auditory canal, passed into the middle ear, and so into the pharynx, from which it was expelled in vomiting. It must, however, be admitted that smaller substances of a shape to permit it may pass from the middle ear through the Eustachian tube into the throat, and that this passage is particularly aided by syringing out the auditory canal.

Living maggots cannot always be removed by syringing, but must be taken out with the ear-forceps. This is due to the fact that they possess hard mandibles, by which they hold on to objects during suction, and are not dislodged by the stream of water. The spiny structure of the rest of the body likewise serves them in sticking on to substances.

[1] American Journal of Medical Science, 1875.

Köhler[1] recommends the introduction of oil of turpentine into the ear, which he allows to remain there for five minutes. On then syringing, the dead larvæ are washed away. A fly, or flea, or similar insects are at once killed by pouring in a little alcohol. The author has been unable to substantiate the statement that larvæ creep out of the canal when oil or glycerine, mixed with petroleum, turpentine, and other substances, are introduced. *Lichtenberg*[2] recommends the insufflation of chloroform vapour through the Eustachian tube for the treatment of maggots in the tympanic cavity.

The author agrees with *Schwartze* in looking on the so-called "agglutination-method" as sheer waste of time. It consists in sticking a ribbon on to the foreign body by means of a shell-lac solution, collodion, or glue, and then making traction. Even when successful, syringing will remove the substance more quickly.

Voltolini[3] recommends the use of the galvano-cautery for destruction of the foreign substance in appropriate cases. The method has been frequently employed with success by the author and others.

If the foreign body be wedged in the deeper parts of the auditory canal, and threatening symptoms should make their appearance, then operative means must be used for its removal, if this cannot be accomplished in any other way. *Von Tröltsch* proposes to divide the soft structures close behind the auricle, and to loosen them with the cartilaginous portion of the auditory canal from the bone. The foreign body is then to be extracted by an instrument inserted along the upper wall of the canal in children, the anterior-inferior wall in adults. *Moldenhauer*[4] recommends a similar method of procedure. Several cases are recorded in which this mode of operation has been attended with successful results.

When the foreign substance is fixed in the cavity of the tympanum, and cannot be extracted by the operation just described, it will be necessary, according to the author's experience, to enlarge the space in the osseous portion of the canal by removal of part of the bony wall on the posterior aspect.

An accurate report of 77 cases of foreign bodies in the ear, collected from various sources, has been furnished by *L. Mayer* in the Monatsschrift für Ohrenheilkunde, iv. Jahrg. 1—5.

[1] "Ol. Terebinth. gegen Fliegenlarven im Ohre." Monatsschrift für Ohrenheilkunde, xix. Jahrg.

[2] Pester med.-chir. Presse, 1875.

[3] "Das Zerbrennen fremden Körper im äusseren Gehörgange." Monatsschrift für Ohrenheilkunde, iii. Jahrg., 7.

[4] "Fall von Entfernung eines Fremdkörpers aus dem Gehörgange mit theilweiser Ablösung der Ohrmuschel." Archiv für Ohrenheilkunde, xviii. Bd.

II.

DISEASES OF THE MIDDLE EAR.

CHAPTER XI.

INFLAMMATION OF THE MIDDLE EAR (OTITIS MEDIA).

Inflammation of the middle ear is of more frequent occurrence than any other aural affection. Out of 33,627 ear cases treated as out-patients in the hospital practice of the author, up to the end of December 1886, there were 21,283 who had symptoms of median otitis.

The short description of the changes occurring in the mucous membrane of the middle ear as the principal seat of this affection, which will now be given, will furnish a basis explanatory of the classification of the forms of the disease which has been adopted by the author.

When, in consequence of some morbid influence, the mucous membrane becomes more or less hyperæmic and swollen, a more copious and watery secretion, poor in cells and fibrin, takes place from it, which is not only poured into the spaces of the middle ear, but diffused through the tissue itself (*serous exudation*). The epithelium also is loosened up, and some of the cells are thrown off and become mixed with the secretion, the character of which is largely determined by their quantity and by the further changes which they undergo. In many cases numerous epithelial cells are cast off, and mingle, little or not at all changed, with the secretion (*desquamative catarrh*). In other cases multitudes of cells undergo mucous degeneration, from which the secretion derives its peculiar ropy and viscid character. Sometimes a portion only of the cell-protoplasm undergoes the mucous metamorphosis, while other cells are thrown off unchanged, and others again suffer molecular disintegration. If this exudation-process passes away quickly, there is no development of new connective-tissue elements, or at the most an extremely slight one. The intumescence of the mucous membrane is due only to the serous infiltration and the swelling up of the epithelium. It therefore follows that no permanent structural changes remain behind after the catarrhal process has ceased. When, however, the affection takes a very slow (chronic) course, it may even in these cases happen that a quantity of new tissue-elements become gradually developed which lead to some permanent thickening of the structures.

There is another form of exudation-process whereby, from the

influence of certain factors, amongst which micro-organisms very probably play a chief part, an emigration of white blood-corpuscles takes place from the vessels, and confers upon the exudation a *purulent* character. The secretion from the surface of the mucous membrane does not coagulate, but presents a yellowish or yellowish-green appearance. It is soluble in water, and contains as its main histological constituent a large quantity of pus cells (white blood-corpuscles), together with more or less red blood-corpuscles, cast-off epithelial cells, and various other elements (micrococci, bacteria, etc.). The exudation is present, not only on the surface of the mucous membrane, but also in the tissue itself, either generally diffused through it or in limited patches (abscesses), and causes in this way considerable swelling and sponginess of texture. In association with this change there is increased liability to laceration, by which is explained the reddish colour of the exudation so frequently observed in purulent inflammation of the middle ear. The colour is much more often due to the presence of blood derived from lacerated vessels than to migration of red blood-corpuscles (*hæmorrhagic exudation*).

In certain cases—which, however, are of rare occurrence—a firmly adherent *croupous membrane* is found either on the whole of the mucous lining of the middle ear, or, as more often happens, on certain parts only —chiefly on the tympanic cavity. This is due to a fibrinous exudation on the surface of the mucous membrane, which leads to rapid death of the epithelium and of the superficial layer of the mucous structure (coagulation-necrosis). If such an exudation is also diffused through the deeper tissue of the mucous membrane, it brings about the death of the part (*diphtheritic inflammation*).

Sometimes the exudation, from the presence of putrefactive bacteria, undergoes decomposition; becoming discoloured, dirty greyish-yellow, greyish-green, or brownish, and giving out a particularly offensive odour.

It remains only to be mentioned that the various forms of exudation already described may be present in one and the same inflammatory process in different parts of the middle ear, and even in the same part at different periods in the course of the affection.

The gravity of the whole process varies with the nature of the exudation, and in the order in which its varieties have been described,—a fact manifested, not only in the objective appearances, but in the clinical characters of the disease.

If the influence of the above-described morbid changes upon the physiological function, and the importance of the integrity of the mucous membrane of the different sections of the ear be borne in mind, it will be obvious that the normal condition of the middle ear, and therefore of the hearing faculty, may be in a high degree impaired by their occurrence.

The tympanic membrane may become thickened, the Eustachian tubes narrowed or even quite occluded from swelling of the lining membrane; the mobility of the auditory ossicles hampered or destroyed by reason of their articulations being also enveloped by the mucous membrane; the membranes closing the fenestra ovalis and fenestra rotunda may become greatly thickened, so much so that their natural depressions may be obliterated; and the openings into the mastoid cells and the cells themselves may be closed up by the swollen tissue. When exudation takes place, the different spaces may be partially or completely filled by the secretion: in some cases perhaps merely a plug of mucus being contained in the commencement of the Eustachian tube, while in others the exudation may occupy the whole of the middle ear.

Structural lesions are frequently associated with these exudation-processes. If the secretion be very copious, it collects in the tympanic cavity more rapidly than it can flow away through the Eustachian tube. In such cases, even a serous or mucous exudation may gradually erode the tissues from the pressure it produces, or with a very rapid and abundant secretion, a sudden laceration may be brought about. In other cases (purulent exudation) an abundant migration of white blood-corpuscles may occasion, not only dislodgement, but also laceration, accompanied with more or less destruction of the tissues, which, especially in the croupous and diphtheritic forms of inflammation, may become of considerable extent in a very short time.

Lesions of this description have an importance depending upon the structures affected. They may involve perforation of the drum-membrane, as well as loosening or even complete dislocation of the articulations and other connections of the auditory ossicles, to such a degree that some or all of the ossicles may be quite exfoliated. The membranes closing the fenestra ovalis and fenestra rotunda may in this way become destroyed, with subsequent diffusion of pus into the labyrinth, etc. Finally, since the mucous membrane plays also here the part of the periosteum, the auditory ossicles and portions of the temporal bone may, after its destruction, become subject to carious and necrotic processes. Further reference to these and other consequences will be made when the different varieties of the disease are discussed.

The inflammatory processes which have been just described are enacted chiefly by the blood-vessels, and have for their result a more or less copious exudation. The mucous membrane of the middle ear is, however, the seat of other inflammatory changes, in which either no exudation occurs at all, or it is so slight that no particular infiltration of the tissue, or effusion on to its surface, is perceptible. The vascular phenomena are restricted to increased redness and swelling of the mucous membrane, while the characteristic event is an *inflammatory new formation*

of connective-tissue elements resulting in a general hyperplasia. There can be no doubt that the endothelial cells of the blood-vessels, as well as the cells of the mucous membrane, take an active part in this new fibro-plastic formation. Such processes always go on very slowly, and the newly formed cell-elements undergo further development, in contra-distinction to the new tissue formation associated with the exudative forms of inflammatory disturbance, in which the granulations, as a rule, undergo constant disintegration.

The newly formed tissue elements bring about mainly a permanent thickening of the mucous membrane (hypertrophy, sclerosis). Their lines of development are for the most part those of the normal structures, and they ultimately become intimately interwoven with these. In many instances, however, this is not altogether the case, but the inflammatory new formation extends beyond the normal planes of development, and appears in the shape of filaments, membranes, and even larger or smaller outgrowths. In this way the so-called false-bands, pseudo-membranes, and certain polypi, which may be of much pathological importance, come to be formed.

As results of the new tissue formation, there may occur thickening of the membrana tympani, excessive rigidity of the articulations of the auditory ossicles, stenosis and occlusion of the Eustachian tube, more or less thickening of the membranes filling up the fenestra ovalis and fenestra rotunda, narrowing and obliteration of the antrum mastoideum and mastoid cells, irregular adhesion of the drum-membrane with the inner wall of the tympanic cavity (synechia) and with the auditory ossicles, as well as irregular union of the latter with each other, etc.

It should here be mentioned that in this form of middle-ear inflammation the new development of tissue is not always limited to the mucous membrane of the middle ear, but that, especially in very chronic cases, the neighbouring structures become likewise involved. We thus frequently see hyperplasia and sclerosis of the auditory ossicles, and even of certain parts of the adjacent region of the temporal bone, more particularly where the mucous membrane acts as its periosteum. The author desires also to draw attention to the fact that, with all forms of inflammation of the middle ear, the surrounding structures, especially those of the labyrinth, may become more or less implicated.

Further details of these changes, and of the sequelæ of the inflammatory process, will be given with the special description of these affections.

In the middle ear, as in other regions, the course and termination of an inflammation is influenced in the largest degree by the character of the inflammatory products. It is therefore convenient to classify inflammatory affections of the middle ear upon this basis.

We thus distinguish:—

1. *Exudative Inflammations of the Middle Ear.*

2. *Plastic Inflammations of the Middle Ear.*

In the former, the *exudation element* is predominant; in the latter, the *inflammatory new formation.*

The exudative inflammations may be divided in accordance with the character of the secretion into:—

A. Catarrhal (exudation serous, or sero-mucous).

B. Purulent (exudation purulent, or sanguineo-purulent).

C. Croupous (croupous exudation on the surface of the mucous membrane).

D. Diphtheritic (croupous exudation with interstitial infiltration of the structure).

In cases where the exudation is of a mixed nature, the character of the case will correspond with that constituent of the exudation which involves the most important clinical symptoms.

As will be seen later, this classification is completely justified from a clinical standpoint, and it seems to the author best fitted to meet practical requirements.

I. Exudative Inflammations of the Middle Ear.

A. Catarrhal Inflammation (Otitis media catarrhalis).

Etiology.—Catarrh of the middle ear arises either primarily, or, as is more frequent, spreads by contiguity from a similar or some other affection of the neighbouring region. It occurs almost always on both sides, either simultaneously or at a short interval. In the latter case the left ear is usually the first affected, and suffers more severely. When the malady is unilateral, it is again usually on the left side—a fact possibly connected with the arrangement of the blood-vessels.

Primary catarrh here, as in other parts, is dependent apparently on meteorologic and telluric conditions which are not fully understood. It makes its appearance at all seasons of the year, in all conditions of the weather, and in persons of every age and constitution; but occurs with much greater frequency in children than in adults. According to *Von Tröltsch*, this is due to the much slighter development of the lips of the pharyngeal orifice of the Eustachian tube in children, and also to the relatively greater structural predominance of their pharyngeal mucous membrane. *Knapp* refers the cause to the feeble resisting power of the organism, and to the frequency of the acute exanthemata in children. The author is unable to corroborate *Von Tröltsch's* belief as to the inordinate frequency of the affection likewise in old people.

Some statistical data published by *Kutscharianz*[1] on results of post-mortem examination in three hundred cases in infants are interesting. The morbid changes in the middle ear were of two kinds. In one class there was abnormality in respect of the contents of the tympanic cavity (increased quantity of secretion containing epithelium and detritus); while the lining membrane was healthy, or nearly so. This condition was found in thirty cases, of ages ranging from three days to seven months.

In the other set of cases, numbering more than two hundred, the mucous membrane also exhibited changes in addition to those noted in the contents of the cavity. About twenty cases, of ages from eleven days to four months, showed signs of slight catarrh of the mucous membrane. In one hundred and fifty, varying from six days to four months, there was purulent inflammation with ulceration of the mucous membrane, and even of the osseous structures. The morbid changes were found most often associated with affections of the respiratory and digestive organs; next in order, with diseases of the brain and its membranes.

Catarrh of the middle ear is most frequently developed by contiguity from the naso-pharyngeal space affected either in the same way or with some other disorder.

Certain diatheses which predispose to affections of the mucous membrane generally—as struma, tubercle, syphilis—are favourable also to the establishment of middle-ear catarrh. It may likewise become developed in the course of certain acute maladies, with which inflammatory affections of the naso-pharyngeal mucous membrane are often associated. Such are the acute exanthemata (measles, scarlet fever, small-pox); typhus fever, many forms of pneumonia, puerperal fever, and acute inflammations of the buccal mucous membrane. When, however, the middle ear is attacked in the course of these diseases, the inflammation is more often of a purulent than a catarrhal character. Certain growths again in the naso-pharyngeal cavity, particularly the so-called *adenoid vegetations*, and even hypertrophied tonsils, may lead to middle-ear catarrh from continued irritation, and perhaps also on account of obstruction to the circulation of the blood by pressure upon the Eustachian tubes, or by in the same way impeding the outflow of the normal secretion through them.

The injurious influence of these growths may possibly also in some measure be due to their interference with the proper ventilation of the tympanic cavity, by obstructing the action of the tubal muscles of the soft palate. In a similar manner no doubt are to be explained such catarrhs as are associated with long-standing atresia or extreme stenosis of the nasal channels, or with great hypertrophy of the posterior extremities of the turbinated bodies, or again with osseous occlusion of the choanæ, as in a case of *Von Schrötter's* once seen by the author.

In the majority of cases, nevertheless, a catarrh of the middle ear may be recognised to originate by extension from a similar affection of

[1] "Ueber die Entzündung des Mittelohres bei Neugeborenen und Säuglingen." Archiv für Ohrenheilkunde, x. Bd., S. 119.

the naso-pharynx. Disorders of the muscles of the Eustachian tubes (paralysis, disorganisation, defective development as in cleft palate) may undoubtedly tend to induce middle-ear catarrh on this ground. The affection is also sometimes a consequence of vaso-motor derangements as they occur in association with diseases of the central nervous system. This statement is in accordance with the experimental results obtained by *Berthold*, *Baratoux*, and *Kirchner*, who, after intra-cranial division of the fifth nerve, observed an inflammatory condition, and under certain circumstances, suppuration, in the cavity of the tympanum. Eczema affecting the lining-membrane of the nostrils may likewise lead sometimes to catarrh of the naso-pharynx, and so of the middle ear.

With regard to what are now known as *adenoid vegetations* or *post-nasal growths*, there is no doubt that *Czermak*, *Türck*, and *Semeleder* saw and described these formations in the upper region of the pharynx shortly after the introduction of rhinoscopy. *Löwenberg*[1] also, and *Voltolini*[2] likewise, recognised their importance in reference to ear affections. For a more accurate knowledge of their nature we are, however, first indebted to the very concise accounts of *Wilhelm Meier*.[3]

They are found as isolated or multiple villous, cone-shaped, or leaf-shaped excrescences in the upper part of the pharynx, having a broad or pedunculated attachment, and covered usually with ciliated epithelium. They are of a soft consistence, and sometimes so large and abundant as to completely fill the upper part of the pharynx, partially or entirely block up the choanæ, close the Eustachian tubes, and push forwards the soft palate. In their structure they resemble the "adenoid tissue" described by *His*, for which reason *Meyer* named them *adenoid vegetations*. According to *Löwenberg*,[4] they consist of a network of fine fibrillæ, in the meshes of which are found numerous lymph-corpuscles. They are rich in blood-vessels; those situated on the lateral walls of the pharynx containing less adenoid tissue.

Neither climate nor occupation appears to influence their development. They are, however, more frequent in children than in adults. *Killian*[5] reports that amongst 712 patients in *Hartmann's* hospital practice, adenoid vegetations were present in 135; and of this number 101—*i.e.* more than 74 per cent.—suffered from ear disorders. The growths came under observation chiefly between the ages of six and ten years (sixty cases).

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[1] "Verwerthung der Rhinoscopie und der Nasendouche für Erkennung und Behandlung der Krankheiten des Ohres und des Nasenrachenraumes." Archiv für Ohrenheilkunde, ii. Bd.

[2] "Die Anwendung der Galvanocaustik im Innern des Kehlkopfes und Schlundkopfes nebst einer Anleitung zur Laryngoscopie und Rhinoscopie." Wien, 1867.

[3] Archiv für Ohrenheilkunde, vii. und viii. Bd.

[4] "Les tumeurs adenoïdes du pharynx nasal." Gaz. des Hôp., 1878.

[5] "Einiges über adenoide Vegetationen und die Operationen mit der *Hartmann'schen* Curette." Separatabdruck aus der Deutschen medicinischen Wochenschrift, 1887.

They are said to occur frequently in connection with cleft palate, and by many authors their production is said to be favoured by scrofula and hereditary predisposition.

If they be large and numerous, they often produce a peculiar effect on the look of the patient. By the more or less complete closure of the posterior nares, respiration through the nose is interfered with; in consequence of which the patient cannot long keep his mouth shut, and so is nearly always seen with it open. The breathing also is somewhat forced and louder, and the nose usually becomes compressed in the cartilaginous part, from the approximation of the alæ nasi in forced inspiration. The speech also becomes altered on account of the obstruction of the posterior nares, when this is present. In the same way, too, as hypertrophied tonsils and other neoplasms may by their excessive size so stretch the soft palate as to impede the function of its muscles, and thus lead to their more or less marked paresis and fatty degeneration, so likewise the presence of abundant adenoid growths may bring about similar consequences (*Störk*[1]). Nevertheless the contrary has been often observed by the author: the palate had become remarkably increased in thickness from hypertrophy of the muscles, brought on by their immoderate action, which was necessitated by the presence of the post-nasal growths.

The mucous membrane of the soft palate is often observed to be œdematous, and the aural disturbances probably depend in many cases upon a like condition of the mucous membrane of the middle ear.

The diagnosis of adenoid growths is usually very easy. On simply looking into the throat, they can sometimes be seen behind the soft palate, which may be pushed forwards by them. They may be recognised with most certainty by rhinoscopy, and occasionally even by anterior inspection. If rhinoscopy be impracticable, then simple digital examination will furnish evidence of their presence. *Killian* employs a 5 per cent. solution of cocain, or a 20 per cent. solution of menthol in olive oil for reducing the intumescence of the turbinated bodies which so frequently prevents inspection by anterior rhinoscopy.

Wiesener[2] directs attention to the occurrence of inflammation of adenoid growths, and expresses the opinion that in such cases strumous enlargement of the neighbouring lymphatic glands may result. As inflammatory conditions adequate to produce this, he names acute and chronic catarrh, and parenchymatous inflammation, the latter accompanied sometimes with copious mucous secretion, high fever, swelling of the cervical glands, increase in size of the vegetations, and occasionally with abscess formation (retro-pharyngeal abscess).

The author had under his observation for more than two years a patient aged twenty, affected with chronic middle-ear catarrh on both sides, and numerous

[1] Sitzungsbericht der Versammlung deutscher Naturforscher und Aerzte in Graz, 1875.

[2] "De adenoide Vegetationer i cavum nasopharyngeale og Betändelses processer af dem." Nordisht. med. Arkiv, xiii. Bd.—Referat in der Monatsschrift für Ohrenheilkunde, xviii. Bd.

post-nasal growths. He also suffered from pulmonary tuberculosis, which later terminated fatally. Some weeks before death, tuberculosis of the pharynx developed itself. Innumerable tubercles appeared in the pharyngeal mucous membrane, as well as on the tonsils and on the recurring growths. The tubercles degenerated rapidly, resulting in very painful ulcerations, which could be only relieved temporarily by brushing them over with tincture of opium. Later, the larynx also became ulcerated, and the patient finally sank with symptoms of pyo-pneumothorax.

With regard to hypertrophy of the tonsils, it ought to be remembered, as *Billroth* has remarked, that the condition may be caused by acute or chronic inflammation of neighbouring structures. In severe inflammatory affections of the middle ear, the tonsils not uncommonly become temporarily swollen, and smaller again with abatement of the otitis—a fact which should be borne in mind in reference to the question of tonsillotomy.

Taking cold is reputed the most common exciting cause of middle-ear catarrh, particularly by getting the feet cold and wet. It may also probably be brought on by other external irritating influences. Drinkers, snuff-takers, and persons who live much in smoky, dusty places, or in an atmosphere impregnated with pungent or highly aromatic vapours, become frequently affected. The presence of a foreign body in the naso-pharynx may occasion catarrhal inflammation in that space, and so by extension in the middle ear. The author once treated a patient aged twenty-nine, in whom the middle-ear catarrh was produced and maintained by a cherry stone in the nose, which had been there since childhood, and of the presence of which she had no knowledge.

The affection may be caused by direct conveyance of a catarrhal secretion to the part, and it is improbable that infection can occur in any other way. A particular predisposition to the disorder exists in many families. In such cases the individuals generally possess delicate, easily perspiring skins, and they are often accustomed to regard the deafness which overtakes them one by one as an hereditary disease, when it is really due to nothing more than persistently neglected colds.

Subjective symptoms.—Catarrh of the middle ear is generally unaccompanied by fever, whether it arises independently or in association with some other affection, unless this be itself febrile. Usually also it is painless. For these reasons it comes about that patients often suffer for months, or even years, without seeking advice for it. If the attack be a very severe one, some slight febrile disturbance may appear in easily excitable individuals; but even this is as a rule present only for some hours, or at most for one or two days. If there should be pain in the ear—a rare occurrence—it is darting, piercing, and not always limited to the ear alone, but radiates often over the same side of the head. The pain, which is either constant or evanescent, is due to tension of the structures, chiefly of the tympanic membrane, produced by the great swelling or by the large quantity of secretion in the tympanic cavity. That this is so, is shown by cases in which it completely disappears when the

contents of the tympanum are evacuated, to reappear only with a fresh accumulation. Children are often in these cases periodically attacked with violent ear-ache, particularly at night-time: after a longer or shorter interval the pain disappears. It depends upon the pressure of an abundant exudation upon the drum-membrane, and ceases with its evacuation or with change of position.

It must not be forgotten that in catarrh of the middle ear severe neuralgia is sometimes present, constantly or at intervals, during the entire course of the affection. Frequently with a quite unimportant middle-ear disorder violent pains are complained of over the area of distribution of the fifth nerve. In most cases the cause is found in carious teeth, or some other ailment. The teeth should always be examined in such cases: scarcely a case occurs in which the cause of the neuralgia is not due to this or some other coincident affection.

Roosa[1] observed a case of acute non-purulent inflammation of the Eustachian tube and tympanic cavity in an anæmic, hysterical subject, in whom violent trigeminal neuralgia and facial paralysis came on. Neither paracentesis nor *Wilde's* incision gave relief. Recovery took place, however, under ordinary tonic treatment.

Patients complain of a feeling of fulness and pressure in the ear more frequently than of pain; it is a very troublesome symptom, and sometimes lasts throughout the course of the catarrh. The sensation is caused by an unusual degree of swelling of the mucous membrane, or by impaired ventilation of the tympanic cavity, or by increased intra-labyrinthine pressure due to changes in the structures closing the fenestra ovalis and fenestra rotunda.

The defective ventilation of the tympanum is brought about by narrowing or obstruction of the Eustachian tube. If the obstruction be complete, or if from some other cause the air in the tympanic cavity cannot be renewed, then the air present in it becomes absorbed by the blood-vessels, and the tympanic membrane and the chain of auditory ossicles become then forced inwards by the preponderating external atmospheric pressure. The greater this preponderance of the outer over the inner pressure, the more is the plate of the stapes pushed inwards towards the cavity of the vestibule; and although the labyrinthine fluid can under the conditions prevailing in the labyrinth give way to a certain extent without inducing any nervous manifestations, yet if the pressure be considerable certain morbid symptoms may be evoked. To the same cause is likewise due the giddiness of which not a few patients complain at the commencement of a middle-ear catarrh, and still more frequently at a later stage. A temporary or permanent

[1] "Ein Fall von acuten Entzündung des mittleren Ohres combinirt mit Entzündung der Nackenmusculatur und Lähmung der Gesichtsnerven der leidenden Seite. Wiedergenesung." Zeitschrift für Ohrenheilkunde, ix. Bd.

hyperæmia of the brain and the meninges exercises, however, a large influence in the development of this symptom, which is easily referable to the numerous anastomoses between the blood-vessels of the ear and of those structures. The significance of giddiness in inflammatory affections of the ear is in such cases similar to that of the same symptom in inflammatory conditions affecting other cranial cavities: for example, the frontal sinuses, in which it is of common occurrence.

The hearing capacity may be impaired to a variable extent. Many cases go on for months and even years without either the patient or his friends noticing any deafness. In other and certainly not rare instances, extreme deafness sets in very soon. Striking variations in the hearing power moreover occur, which are explicable only by slight changes in the cause of the ear affection.

The diminished hearing capacity in middle-ear catarrh is due more especially either to derangements of the sound-conducting apparatus, or to consecutive conditions such as those just mentioned, which are thereby brought about in the labyrinth. In the former category, swelling of the mucous membrane first demands notice, since to this are accountable the thickening of the drum-membrane, the impaired mobility of the auditory ossicles, the narrowing or occlusion of the Eustachian tube, and the results of these changes, to which the imperfection in the sound-conduction is to be ascribed. The consequences of such conditions may of course be still further accentuated by the accumulation of inflammatory products in situations of importance in regard to the sound-conducting function.

The deafness is most often caused by collection of the secretion in the Eustachian tube or in the tympanic cavity itself. In the tube it is perhaps not so much the presence of the inflammatory product, as the above-mentioned secondary changes, to which the impairment of hearing is to be attributed; while as regards the tympanum, the deafness is to be ascribed partly to the pressure of the exudation upon the fenestra ovalis and fenestra rotunda, and partly to the impediment which it offers to the movements of the auditory ossicles and to the oscillations of the tympanic membrane.

It must likewise be remembered that it is not only the quantity, but also the position of the accumulation which influences the disturbance it produces. A small amount of exudation on the fenestra ovalis or rotunda, for example, may cause much greater deafness than a large quantity in places physiologically less important. Atmospheric conditions also may temporarily increase the deafness to a considerable degree—*e.g.* rainy, stormy weather.

Occasionally the sound of the patient's own voice seems much louder to him in the affected ear (increased autophonia). If only one ear is implicated, the symptom is all the more striking from the sound appearing at the same time weaker in the healthy ear. The increased resonance is

often described by patients "as if I were talking into a pot." The symptom is associated not only with the voice, but also with other sounds, even those of respiration; and is sometimes so annoying that the patient becomes very taciturn and out of humour. It is usually connected with considerable swelling of the mucous membrane of the Eustachian tube and of that of the adjacent structures. It appears that waves of sound are in such cases the better conducted towards the tympanic cavity and labyrinth, and that the structures of the tympanum also vibrate more strongly (increased tympanophonia).

In many cases also the hearing is not only impaired, but the sounds are positively changed, both in speech and with other auditory perceptions. The patient will often say that his friends' voices seem to have become "so thin," "so high," or "so shrill"; also that certain sounds which he had previously recognised correctly now appear different to him; or perhaps that he has a false appreciation of the pitch of musical tones. Sometimes again the sound is doubled (diplacusis). With catarrhal patients, tones are certainly often heard too high or too low; and as only a small number of persons have sufficient musical cultivation to recognise the fact, although amongst such the symptom is very frequently noted, it is probably a common one in this condition of the ear.

Sometimes extremely disagreeable sensations are produced by the sounds or tones (hyperæsthesia acustica). Persons who were previously very fond of music may become greatly irritated or excitable on hearing higher or lower tones, or by music generally, even when a favourite instrument is played.[1]

Subjective auditory sensations in middle-ear catarrh are caused by the same morbid changes as bring about the impairment of hearing. It is therefore easy to understand how much they may vary during the course of the same affection. Their rare occurrence in the case of children is very notable. Even with severe exudative inflammations of the middle ear, noises in the ear are almost invariably absent with them from first to last. This may possibly be due to the greater resisting-power in children of the structure closing the fenestra ovalis, whereby the base of the stapes is not pushed so far inwards, and the intra-labyrinthine pressure consequently less easily increased.

Soughi[2] in a case of dry catarrh of the middle ear in which the drum-membrane was only movable in its central portion on Valsalvan inflation or the use of Siegle's

[1] *Josef Böhm*, the teacher of *Joachim*, who was under the author's care for chronic middle-ear catarrh, repeatedly complained, not about the deafness, but that the tone of the violin was intolerable to him. Another patient, with considerable deafness and tinnitus, sought advice chiefly on account of the disagreeable sensation in the affected ear experienced when he pronounced the consonants *m* and *n*. In talking he obviously avoided the use of words in which they occur.

[2] "Otite moyenne catarrhale séche bilatérale, scotome auditif à gauche." Ann. des mal. de l'oreille, 1886.

speculum, observed the curious symptom that the tuning-fork which was heard at a distance of 25 *cm.* was not audible at 15 *cm.*, though it was again perceptible at 10 *cm.* Repeated examination was always attended with the same result. *Baratoux*[1] noted a similar case. There was bilateral subacute middle-ear catarrh, with cicatricial retraction of the right membrana tympani in front of the bright spot. On the left the greatest hearing distance for the watch was 19 *cm.*; on the right, 20 *cm.*; between 16 and 13 *cm.* it could not be heard, while from 13 *cm.* up to contact it was again audible. *Keller* likewise saw a similar case in a left-sided catarrh without exudation into the tympanum, in which a portion of the tympanic membrane in front of the bright spot was atrophic, and very mobile during respiration and phonation. The greatest hearing distance was 9 *cm.*; at 5 *cm.* the watch ceased to be heard, and continued so up to 1 *cm.* from the ear.

All the above-described subjective symptoms may vary in intensity during the course of the affection: they may completely disappear and again return. Occasionally symptoms referable to the *chorda tympani* may be observed. Such are increased secretion of saliva and perversions of taste; the latter sometimes of such a kind as not to be explicable by changes affecting the chorda tympani alone, but implying the co-operation of other nerves. *Blau*[2] also observed altered sensory perception in the tongue. According to *Urbantschitsch* and others, modifications of sensibility also occur in the region supplied by the trigeminus.

Guerder[3] saw a case of middle-ear catarrh, in the course of which occurred pains radiating towards the submaxillary glands, followed soon by an herpetic eruption over them, and accompanied by copious salivation. Both the eruption and the deafness quickly disappeared upon inflation with the air-ball. *Guerder* explains the symptom from irritation of the chorda tympani.

The *objective changes* in catarrh of the middle ear are to be ascertained by inspection, by auscultation, and by tactile examination.

(*a*) *Symptoms recognisable by the eye.*

It has been previously stated that catarrh of the middle ear is associated very often indeed with a catarrh or other affection of the naso-pharyngeal mucous membrane. In accordance with this, corresponding changes are found in a great many patients. In all cases therefore it is necessary to make an accurate examination of the region of the naso-pharynx, employing rhinoscopy when necessary, inasmuch as the origin of the middle-ear inflammation is frequently found in the upper part of the pharynx (post-nasal space), and would not be discoverable on simple inspection of the throat.

Changes are often observed likewise in the neighbourhood of the ear,

[1] Revue mens. de laryng. etc., 1884.

[2] "Mittheilungen aus dem Gebiete der Erkrankungen des äusseren und mittleren Ohres." Archiv für Ohrenheilkunde, xix. Bd.

[3] Annales des mal. de l'oreille, etc.

such as infiltrated glands, particularly if the affection be not localised in the aural mucous membrane.

The appearances which present themselves in the external auditory canal and drum-membrane are very various. Even with a high degree of catarrhal inflammation the canal may be quite normal; the skin of the osseous portion, however, is often hyperæmic, especially in plethoric individuals, and the cerumen is also apt to be excessive in amount.

The appearances presented by the tympanic membrane vary in accordance with the extent to which it is implicated in the middle-ear affection, and also in accordance with the manner in which they may be altered by objective changes in the other structures of the tympanum. It exhibits usually alterations in its colour and position. If the swelling and hyperæmia of the mucous membrane lining the tympanum and Eustachian tube be considerable, the appearance resembles that represented in Figs. 1 and 2, Plate II. It has a reddish, violet, or copper-coloured tint borrowed from the inner wall of the tympanum, towards which it is depressed; and the folds which pass from the short process forwards and backwards are the more distinct the nearer the central portion of the membrane is to the tympanic wall. On the folds, an irregular light-reflex is often seen, and frequently also in the neighbourhood of the short process, where it looks not uncommonly like the reflection from a small vesicle, and is believed by the author really to depend upon a collection of the intercellular fluid between the cartilaginous tissue and the upper end of the handle of the malleus (Fig. 12, Plate II.). Sometimes the posterior fold becomes so prominent as to curve down from the short process to below the lower end of the handle of the malleus; while in many cases, instead of the two normal folds, three or even four are observed radiating upwards from the short process. Sometimes, as described by *Bing*, they pass backwards from a point on the handle of the malleus in a more or less parallel direction with the normal posterior fold. Similar folds have likewise been seen by the author on the anterior portion of the drum-membrane, and others on the anterior and posterior segments, which joined so as to form a curved band in the central part of the membrane under the handle of the malleus.

The colour of the membrane is different on different places: these do not all lie in the same plane, and cannot all be uniformly illuminated; their tint therefore varies for this reason, as well as on account of the colour of the neighbouring structures.

The handle of the malleus of course accompanies the membrane in its movements up to a certain extent. It is, however, not pushed directly inwards, its lower end moving farther forwards, or, as much more often happens, farther backwards. In the former case it points either directly downwards, or even forwards and inwards (Fig. 5, Plate II.); while in the

latter case its direction may be almost horizontally backwards (Fig. 16, Plate II.). If the malleus be pushed inwards, it appears foreshortened; and this may be so considerable that it may be difficult to see anything of it except the short process.

The direction taken by the handle of the malleus in its movement with the drum-membrane appears to be the resultant of different forces acting upon it. Among these may be enumerated individual anatomical peculiarities of the external auditory canal and of the tympanic cavity, the condition of the tympanic membrane, its greater or less degree of flaccidity, the connections of the hammer, and the state of the tensor tympani muscle. Thus, with the drum-membrane represented in Fig. 5, Plate II., large bony elevations were present on the posterior and superior wall of the auditory canal. In the case represented in Fig. 3, Plate II., the promontory was so much developed that the lower extremity of the handle of the malleus was very soon brought into contact with it.

If the colour of the membrane contrasts conspicuously with that of the malleus, the latter appears more distinct, and its handle broader and *apparently thickened*, especially so if in its movement inwards it has turned round somewhat on its long axis (Fig. 1, Plate II.).

When the membrane is depressed, its posterior superior segment soon comes into proximity, or even into contact, with the descending process of the incus, which then becomes visible; sometimes even with a part of the stapes also, *as a yellowish-white streak running almost parallel with the handle of the malleus, but not reaching so far down* (Fig. 2, Plate II.).

With the alteration in the state and position of the membrane, the light-spot likewise changes its place and shape. It may not reach so far as the end of the handle of the malleus (Fig. 1, Plate II.); it may be broader than usual (Fig. 6, Plate II.), or punctiform (Fig. 13, Plate II.), or linear and broken (Figs. 12, 20, 34, Plate II.), or streaked (Fig. 6, Plate II.). Sometimes the light-spot is quite absent (Figs. 2, 3, 4, Plate II.), while in others again numerous reflexes of various shapes may be observed.

The extent of movement of the membrane inwards may be very considerable, and it may thus come into contact with various structures on the inner wall of the tympanum. It usually first meets the most posterior part of the promontory and the descending process of the incus; while, if still further depressed, it reaches round the process of the incus, as well as the region of the fenestra rotunda, and also above, in front of, and below the promontory.

From what has been stated it will at once be seen that very different appearances may be presented under similar conditions; that the planes of the different sections of the membrane, and therewith the light-reflex may change considerably; and that a complete description of all the possible appearances would be almost endless.

The movements of the malleus will naturally also have an influence

upon the form and the relations of the different sections of the drum-membrane to each other. Certain areas may thus appear to be increased or diminished in size. If, for example, the malleus should move considerably backwards and inwards, then the posterior region of the membrane usually becomes folded and apparently smaller; while the anterior segment is strongly stretched, and so apparently larger.

The appearance of the membrane also varies greatly according as the exudation takes place merely into the Eustachian tube, or into the spaces of the middle ear; and in the latter case according to its quantity, nature, and situation. If found only in the tube, and if this be blocked up by it, the membrane may present the appearance depicted in Figs. 1 and 2, Plate II.: in such cases the mucous membrane of the tympanum is usually very hyperæmic, and any serous exudation present is collected nearly wholly on the floor of the cavity, and is invisible from the auditory canal. In other such cases the mucous membrane of the middle ear is not materially affected, and the membrana tympani, even if considerably depressed, still retains its grey colour, and at the most becomes lustreless, with a bright spot altered in shape and position. Fig. 6, Plate II., represents such a condition in a case of severe catarrh of the tubes, with accumulation of the inflammatory products in them.

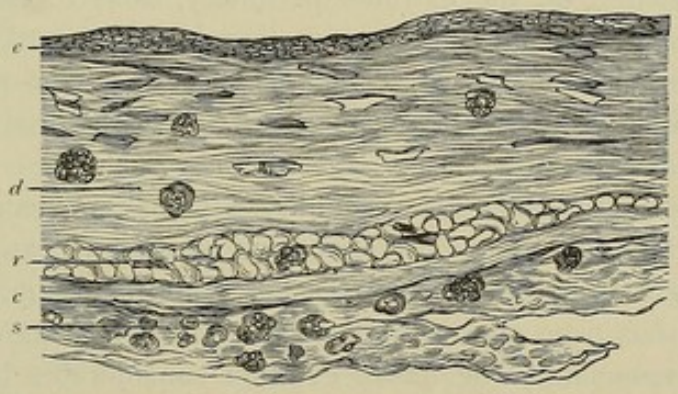
With copious exudation into the cavity of the tympanum, the membrane is bulged out, either in part or as a whole, towards the auditory canal. The more yielding portions are naturally pushed farther out than the others: thus the membrane appears sometimes more convex around the malleus, while this itself lies in a furrow corresponding to its direction. Sometimes the anterior and posterior segments project over the malleus to such an extent that it is more or less concealed, being indicated merely by a furrow. The colour of the drum-membrane varies according to its own particular condition, and according to the colour of the exudation. Thus it looks occasionally dirty grey, or yellowish, with radiating and ramifying red lines due to injection of the small blood-vessels (Fig. 7, Plate II.). In some cases it is of a citron-yellow, or a greenish-yellow tint; in others its surface appears rough, with dirty grey or yellow spots corresponding to viscid masses of exudation as seen through it. In one patient of the author's with middle-ear catarrh, in whom the inflammatory product occupied the lower half of the tympanum, the level of the exudation was distinctly visible on the tympanic membrane. The appearance resembled very much the so-called "lunula," seen with purulent collection in the anterior chamber of the eye. When the patient inflated the middle ear by the Valsalvan process, the thin exudation was whirled up over the tympanic membrane, which then looked clouded; as the liquid again subsided, the upper part of the membrane could be seen to gradually clear, until the original appearance was again presented.

If the exudation into the tympanum be of a more viscid character, air-bubbles sometimes occur in it, and may be visible through the membrane. They are usually formed after blowing the nose, or after inflation by the Valsalvan process or the air-ball. The author has often watched them both arise and disappear. If the bubbles burst, the patient hears a short sound.

When the accumulation in the tympanic cavity can change its position, it may do this with movements of the head in accordance with the force of gravity, or through the influence of some other force. The change in the position of the exudation may be recognised by the changed situation of its level, and this is indicated as seen through the membrane by a more or less dark line resembling a hair; and also by a corresponding change in colour of the membrane. Such movements of the exudation occur very

Fig. 116.

Section of a drum-membrane, exhibiting fatty degeneration, in a case of chronic catarrh of the tympanum.



e, Epidermis; *d*, dermis layer; *r*, radial layer: *c*, circular layer; *s*, mucous-membrane. In the membrana propria, and in the dermis and mucous-membrane layers are seen fat accumulations, partly crystalline, partly flaky.

frequently, and through them is explained the fact that many patients hear momentarily better or worse when the head is in a certain position, or when they take a deep breath, or draw on the ear, and so forth.

In the majority of cases catarrh of the middle ear terminates without causing perforation of the drum-membrane. If, however, this should occur, it depends upon one of the following circumstances:—

1. The membrane may be ruptured by the rapid accumulation of a very abundant exudation.

2. An acute myringitis may be accidentally associated with the catarrhal affection, and may lead to perforation.

3. The membrana propria may undergo fatty degeneration (Fig. 116), especially in catarrhal conditions of long standing. As a result of this change, the tympanic membrane may easily become lacerated on very slight provocation, such as sneezing, or blowing the nose, straining, etc.

Such perforations are almost always single; instances in which more than one occur in the same membrane in a middle-ear catarrh are very rare. Cases have, however, been observed by the author in which two, and even three perforations, separated by narrow bridges of tissue, were present for a long time.

Schwartze has described a serous exudation as appearing upon the external surface of the tympanic membrane in cases of middle-ear catarrh without a perforation, and this the author has also frequently observed. The exudation may collect in the depths of the auditory canal, and produce maceration of the epidermis. The occurrence is only observed in very acute catarrhs, and is usually of very short duration.

Perforation resulting from a catarrh is generally found on the inferior part of the tympanic membrane, much more frequently on the anterior than the posterior segment, and mostly at the inner third of the distance from the malleus to the periphery. Those perforations which are situated on the extreme periphery, close to the inner margin of the annulus cartilagineus, deserve special mention. In this part the circular fibres are more sparsely arranged, and the pressure of an exudation may more easily break through the tissue, producing generally a somewhat curvilinear rupture.

As soon as a breach of continuity occurs, the membrane becomes drawn more inwards, if no obstacle to this be present; and the exudation oozing through the opening may occasion a myringitis, generally running a chronic course, from the continued irritation of the dermis layer. The epidermis desquamates, the tissue exhibits considerable hyperæmia, and its texture becomes looser (Figs. 8 and 9, Plate II.). The condition does not, however, last long, and the appearance comes to be presented which has been previously described in the chapter on acute and chronic myringitis. A secondary myringitis of this kind usually takes from the commencement a very slow and almost painless course. In isolated cases where no pain has been experienced during the earlier stages of a catarrh, more or less severe pain may be complained of after a perforation of the membrane has occurred. On careful examination, however, this is often shown to be due to a circumscribed or diffuse inflammation of the structures of the auditory canal, caused by the irritating action of the escaping exudation.

An accurate diagnosis will of course depend upon an exhaustive examination, and with a perforation at the extreme edge of the membrane an error may most readily arise. In such a case, especially if it be of quite recent development, the membrane appears reddened and swollen; the malleus is either invisible, or perhaps a trace of it only is seen, with all the usual signs of a true myringitis. In its further course

polypoid proliferations may appear on the outer surface of the drum-membrane, and the condition might readily simulate one of total absence of this structure, with polypi springing from the mucous lining of the tympanum. Other than ocular examination would probably be needed, and even then the most experienced examiner might only be able to come to a conclusion as to the nature of the case after prolonged observation.

(*b*) *Symptoms recognisable by Auscultation.*

If it be considered how imperfect the diagnosis of catarrh of the middle ear may remain when dependent upon ocular examination alone, the advantage of supplementing and corroborating this by other methods will be the better appreciated. One such method, which is indeed indispensable in diagnosis, is auscultation of the ear.

Amongst the chief auscultatory phenomena may be enumerated the following :—

(α) The current of air passing through the tympanum on emptying the air-ball produces a tolerably loud and resonant vesicular sound, occasionally associated with a feeble crepitation. This symptom indicates complete permeability of the Eustachian tube and tympanic cavity. Even if other symptoms should indicate the presence of an inflammatory process in the middle ear, it may nevertheless be assumed that the swelling of the mucous membrane is not very great, and that any exudation which may be present is very scanty. When the catheter is used, the auscultation sound may still be clear and resonant, even with a small instrument, in the majority of cases ; it is, however, best to use catheters of various sizes.

(β) Sometimes the air, in passing into the middle ear when the air-ball is compressed, produces at first a short, interrupted sound, as though a moist membrane were suddenly loosened from its attachments ; but with each further evacuation of the air-ball the air enters the tympanum more and more easily, producing a clear, normal, or almost normal, murmur. If the short interrupted sound which was first heard seems at a distance from the ear of the auscultator, then the walls of the Eustachian tube are probably stuck together. If, however, the first sound appear to originate close to the examining ear, the condition present probably is that the tympanic membrane has been detached from loose contact with the inner wall of the tympanic cavity.

(γ) If with the first, or the first few evacuations of the air-ball, a loudly resonant, short interrupted sound be perceived at some distance from the examining ear, but with succeeding inflations a clearer or less resonant sound be heard, this points to the tube being blocked up at the

entrance by masses of mucus or exudation, which have been expelled either into the pharynx or into the middle ear. In the latter case the cavum tympani has not been completely filled up by the exudative product. On withdrawing the catheter, some thick, yellowish exudation, sometimes mixed with blood, is generally found on the beak of the instrument. Sometimes so much secretion is blown out of the tube into the tympanum as to completely fill the latter cavity. If it be so viscid that the air cannot penetrate it, a sound is produced with the succeeding inflations which originates, not in the middle ear, but nearer to the pharynx, or else the air-ball cannot be completely emptied a second time. In such a case the cavity of the tympanum is filled up by the viscid secretion which has been blown into it—a condition to be further recognised by other symptoms.

(δ) A strongly resonant, protracted, almost rattling sound, originating apparently quite close to the auscultating ear, and audible during several successive inflations, indicates a very viscid accumulation in the tympanic cavity. The entering air causes air-bubbles to form, which then gradually burst again.

(ε) A very thin, almost whistling sound is heard when there is much narrowing of the Eustachian tube. An experienced ear may recognise from the apparent nearness or distance of the sound, whether the air really penetrates into the tympanic cavity or not. Sometimes the sound has a larger character, if the air-ball should be emptied at the same moment as the patient swallows—a circumstance due to the fact that the mouth of the Eustachian tube is dilated in the act of deglutition.

(ζ) Premising that no doubt exist as to the beak of the catheter being in correct position in the mouth of the Eustachian tube, then if on emptying the air-ball a very distant sound (pharyngeal sound) be heard by the examining ear, and the patient feel the air-current in his throat; or if the air-ball cannot be emptied, even though considerable pressure be employed, the condition is probably impermeability of the Eustachian tube. When such occlusion is due merely to extreme swelling of the mucous membrane, it may happen that the air may be forced into the tympanum when the air-ball is emptied simultaneously with an act of swallowing.

If it be considered that swelling of the mucous lining of the tube may in such various ways distort its calibre, even at its orifice, it will be seen how in many cases the entrance of air may be more readily effected by changing the catheter, or modifying its curve.

If with none of the above-described manœuvres can air be made to enter the tympanum, it may reasonably be concluded that the Eustachian tube is really closed up; and a practised examiner may

even be able to determine with much probability the situation of the occlusion.

From what has been said, it will appear that various auscultatory sounds may be audible one after another during the same examination. This in no way detracts from the value of the method in ear affections, any more than in those of other organs—*e.g.* the lungs. The evidence yielded is merely as to the physical state of the structures in question at a given moment, and offers of course no fixed basis for diagnosis of a definite morbid condition which underlies the symptoms with which it is consistent. Moreover, the preceding account of the auscultatory phenomena in middle-ear catarrh is by no means an exhaustive one; many others may be noted, some easy of interpretation, others of which an explanation may be difficult or impossible.

Reference to the *secondary auscultation sounds* must not be omitted. They may be turned to useful account in diagnosis, when taken together with the results of ocular examination. Thus, interrupted, more or less prolonged crepitation *râles*, in particular suggest the presence of viscid accumulations in the tympanic cavity. The inrushing current of air causes bubbles to form, and these successively bursting produce the continued secondary sound referred to. If irregular adhesions be brought about by false membranes, it may readily come to pass that, on inflation of the middle ear, particular sections of the drum-membrane yield more in the direction of the external auditory canal than others. This can generally be recognised by the differences produced in the appearance of the tympanic membrane reflexes (light-spots) when observed before and after inflation by the air-ball. If the more bulged-out parts of the membrane return to their previous position, the movement is accompanied by a prolonged secondary sound, perceptible both to the patient and examiner; and if a simultaneous inspection of the drum-membrane be made, its backward movement may be distinctly seen.

With regard to the exaggerated intensity with which the patient in some cases hears the sounds of his own voice (tympanophonia), it is to be observed that the increased resonance is perceptible also to the auscultator, and appears in most cases to depend upon considerable swelling at the commencement of the Eustachian tube, in association with a tympanic cavity still containing air.

According to *Hagen*, patients with exudation into the tympanum are said to perceive a peculiar rattling sound when the skull is percussed lightly; and the author has often heard such patients say that every sound produced on the head caused a peculiar clinking or clattering. The phenomenon is, however, by no means constant: indeed, in the majority of cases such sounds appear to the patient deadened. The symptom cannot be referred to the presence of the exudation; the cause appears rather to be connected with some simultaneous change in the labyrinth.

(*c*) *Symptoms recognisable by Tactile Examination.*

The recognition of certain changes by the touch may also furnish a useful aid to diagnosis in inflammation of the middle ear. The method is really practised in the ordinary introduction of the catheter; information being thereby obtained in regard to various changes in the cavities of the nose and pharynx and the beginning of the Eustachian tube. Thus, swelling of the mucous membrane; ulceration; tumours in the naso-pharynx; necrosis of bone; and other changes, may be recognised in this way by the touch.

The degree of narrowing of the tubes may be estimated by the amount of force needed to empty the air-ball through the catheter. Lastly, the actual condition of the Eustachian tube may be learnt by the use of the Eustachian bougie.

It may be here repeated that the diagnosis of an inflammatory process in the middle ear must rest upon the *collective results of the various methods of examination.* In many cases a method must be practised at different times. This is particularly necessary with inspection, which must be made *both before and after inflation* of the middle ear, so as to yield the most useful information.

Course.—Catarrh of the middle ear may be either *acute* or *chronic.* The chronic form of the affection is dependent for the most part either upon constitutional troubles, or upon various extraneous circumstances, amongst which are chiefly influential such as are connected with the occupation of the patient. A chronic course is not at all rarely attributable simply to negligence on his part. The affection is usually painless, and the second ear is often not implicated for a long time; besides which the disorder is often so slight that the accompanying impairment of hearing is not important enough to interfere with ordinary social intercourse. For these reasons, the patient commonly neglects to seek advice, and ultimately often has to suffer the troubles of a chronic disorder, with its results. Such consequences are, in the main, those which may modify to a certain extent the clinical appearances usual in chronic catarrh; and will therefore be here spoken of in greater detail.

In the first place, it should be mentioned that perforation of the membrane may not necessarily be present even with a chronic middle-ear catarrh which has lasted for many years. On the contrary, the tympanic membrane usually becomes thickened, in consequence of the prolonged, if slight, new-tissue formation in the mucous layer. A more common change, however, consists in inspissation and calcification of mucous exudation, which is accumulated either in the depressions of the mucous-membrane layer, or over its whole surface. So long as the exudation

still remains fluid, the tympanic membrane in the corresponding part looks of a decided yellow tint (Fig. 24, Plate II.); but when the secretion has undergone calcification, the colour is like that of macerated bone (Figs. 21 and 22, Plate II.). Such appearances may obviously vary in correspondence with changes in the nature of the exudation, and with other circumstances. For example, after inflation, such an exudation might be perhaps carried away from its previous situation.

If a perforation have resulted from the catarrh, the appearances may vary extremely. To say nothing of the shape and size of the aperture as influencing the result, a variety of changes may be brought about by secondary processes arising both in the membrane itself and in the external auditory canal, as well as in the middle ear in consequence of the breach in the drum-membrane. It is only necessary to suppose a case of secondary inflammation with granulation formation, and perhaps also calcareous deposit, in a membrane which has become perforated as a result of catarrh, together with polypoid formation from the mucous membrane of the middle ear, to realise how complicated and confusing may be the picture presented in certain cases.

There is nothing characteristic in the subjective symptoms associated with *chronic* middle-ear catarrh. Its diagnosis rests entirely on the duration of the disorder. *Experience leads the author to fix six weeks as the limit of duration of an acute idiopathic catarrh of the middle ear arising in an otherwise healthy individual. With a duration of six months he denominates it as subacute; and if longer still, as chronic.*

Acute catarrh, uncomplicated with perforation, often ends in recovery in a few days; the swelling and exudation disappear, and the structures regain their normal appearance. If perforation has occurred, the healing process takes longer; and cicatrisation occurs, as in cases of myringitis with perforation, unless the process be hindered by the presence of otorrhœa.

Complete recovery may also result in cases of chronic catarrh, provided the structures have not suffered so much change as to seriously interfere with their function, as is particularly likely to occur if the membrane has been perforated and become secondarily inflamed. Any of the consequences may then ensue which have been described with acute and chronic myringitis.

Prognosis.—The most important point in reference to the prognosis is whether the affection has arisen in an individual otherwise healthy, or whether it is associated with some constitutional disorder. In a tubercular subject, for example, a catarrhal inflammation will run a much more unfavourable course than in a healthy one. If a considerable loss of substance has occurred in the tympanic membrane, recovery takes place with greater difficulty, and the result in regard to the hearing power will be probably much more unfavourable than in other cases.

The prognosis in respect of audition and subjective auditory sensations may be generally conjectured from the result of the first inflation with the air-ball. The presence of subjective phenomena must usually be regarded as an unfavourable prognostic sign. Those cases augur best in which the hearing capacity is quite restored and the subjective phenomena disappear after the first inflation. If, however, this be not the case—if the hearing should be little if at all improved, and any subjective sensations present should still remain after employment of the air-douche—one would not be justified in predicting complete recovery. The greatest caution is necessary in hazarding an opinion if the symptoms should point to implication of the labyrinthine structures, especially if they have existed for a long time.

Weber's procedure may be of some use as an aid to prognosis. Experience shows that if with unequal hearing-power on the two sides, a tuning-fork placed on the vertex be heard better by that ear which is the deafer to ordinary sound-conduction through the air: that is to say, when it gives a positive result, then it may generally be concluded that a defect exists in the sound-conducting apparatus on that side. And since such defects are as a rule more amenable to treatment than those affecting the sound-perceiving apparatus, the result will to that extent have a favourable signification. It must, however, be remembered that not all imperfections of the sound-conducting apparatus are capable of being relieved; besides which, the above-mentioned inference from a positive result with Weber's process cannot be always unreservedly made. In certain cases the cranial bones on one side may be so constituted as to conduct the sound-waves better than on the other, with the result that the tuning-fork may be better heard; while, at the same time, incurable disease may exist in the ear. The result of the process, therefore, though it may, if positive, be regarded as a favourable sign, is by no means a perfectly trustworthy guide in regard to prognosis.

Treatment.—This has a twofold aim—viz. to improve the local condition, and to obviate recurrences of the disorder. In connection with the latter object, especial attention is to be directed to the general bodily condition of the patient, and suitable treatment should be diligently employed for the cure or amendment of any existing disease. This is particularly indicated in regard to those constitutional affections which have been previously mentioned as exercising so prejudicial an influence upon the course of a catarrh of the middle ear. In such cases the local treatment should from the commencement be associated with general measures, the continuance of which is in many cases still indicated when the local condition may no longer need special attention.

Affections of the neighbouring regions which may be associated with a middle-ear catarrh will likewise call for proper treatment. The naso-

pharynx especially will demand careful examination, and the application of needful measures for the relief of any disorder there present. New formations, particularly *adenoid growths*, which are of such common occurrence in children in connection with catarrh of the middle ear, and serve to maintain this disorder, are to be removed as soon as possible.

Various means may be adopted for this purpose, the choice of which must usually be regulated by the nature of the particular case. The use of the rhinoscope as an aid to operation is generally unnecessary. Occasionally the vegetations may be detached by means of the nail of the examining finger, which should always be previously made surgically clean by means of an antiseptic solution. *Doyer*[1] prefers this method to the employment of instruments. *Justi*[2] substitutes for the finger-nail a sharp spoon about 7 *mm.* broad by 15 *mm.* long, which is fixed on a metal ring, or on a strong but flexible stem connected with a handle. The instrument is fastened to the index finger between the first and second phalanx, so that the tip of the finger projects beyond the spoon as a guide to it. *Trautmann* also recommends the sharp spoons on account of the rapidity and completeness with which they can be used for operation.[3]

The instruments of *Hartmann* and *Gottstein* (Fig. 117), adapted from the ring-shaped knife originally designed by *W. Meier*, are much more convenient, and have latterly been often used by the author. Instruments of various sizes should be kept on hand. The author has had some made with the short shank of the triangular portion somewhat curved, and with these one can more easily operate on the lateral wall of the pharynx. The instrument of *Gottstein* is introduced into the post-nasal space through the mouth, while the ring-shaped knife of *Meier* has to be used through the nose. *Lange*,[4] who also employs a ring-shaped knife, which is, however, introduced through the mouth, disapproves of *Meier's* instrument. *Zaufal* and *Ganghofner*[5] recommend the employment of Zaufal's nasal speculum during operation.

Catti[6] and *Löwenberg* recommend the use of forceps-shaped instruments resembling that represented in Fig. 118, which was introduced in the first edition of this work for the purpose of making applications to the

[1] Report of the Section of Otology, Internat. Med. Congress, Amsterdam, 1879.

[2] "Ueber adenoide Neubildungen im Nasenrachenraume." *Volkmann's* Sammlung klinischer Vorträge, Nr. 125.

[3] Vergl. *Pohl*, "Die Rachentonsille, ihre Hyperplasien und deren Behandlung." Inaug. Diss., Berlin, 1879.

[4] "Einige kritische Bemerkungen über den Krankheitsbegriff: Die adenoiden Vegetationen im Nasenrachenraume nebst einer neuen Operationsmethode." Monatsschrift für Ohrenheilkunde, etc., xvii. Jahrg.

[5] "Ueber adenoide Geschwülste im Nasenrachenraume und deren Behandlung." Prager medicinische Wochenschrift, 1877.

[6] "Ueber Behandlung der adenoiden Vegetationen im Nasenrachenraume." Monatsschrift für Ohrenheilkunde, 1879.

pharyngeal mucous membrance. In the operating instrument, however, there is a second downward curve at the outer extremity, in order that the hand of the operator may not get in his own light. *Delstanche's*[1] instrument is too complicated ("Adénotome à coulisse"). *Catti's* forceps are hollowed out in front, and ribbed on the opposing surfaces; while *Löwenberg's* instrument has cutting edges at the anterior extremity.

Voltolini, *Schaeffer*,[2] *Michel*,[3] and many others recommend the employ-

Fig. 117.

Gottstein's instrument for removing adenoid growths (half the usual size).

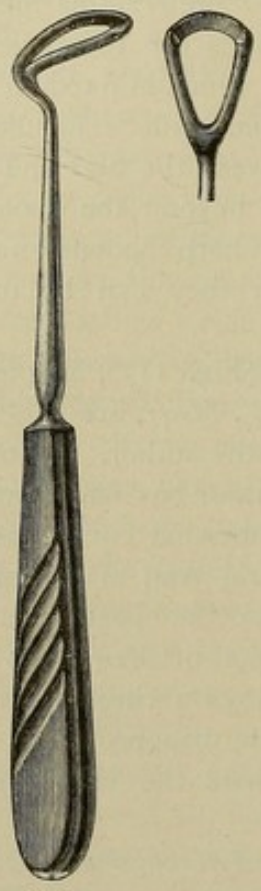
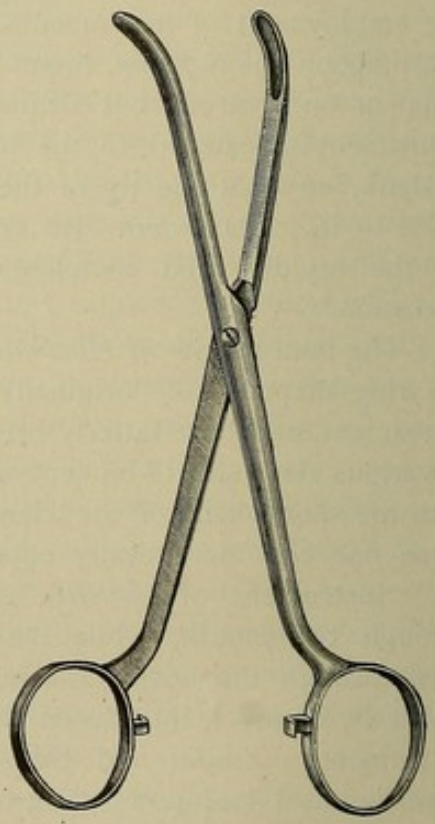


Fig. 118.

Vulcanite forceps for cauterisation (half ordinary size).



ment of the galvano-cautery. The author agrees with *Hedinger*,[4] that this method is particularly suitable for growths attached by a broad base; and in such cases he uses a flat cautery, or the galvano-caustic chisel recommended by *Voltolini*.

If hæmorrhage should occur, it may usually be arrested by syringing through the nose; or if this should fail, by a plug soaked in perchloride of

[1] Archiv für Ohrenheilkunde, xv. Bd.
[2] "Zur Operation der adenoiden Vegetationen." Monatsschrift für Ohrenheilkunde, xvi. Jahrg.
[3] Archiv für Ohrenheilkunde, xii. Bd.
[4] "Die adenoiden Vegetationen." Württ. med. Correspondenzblatt, 1885.

iron. To prevent recurrence of the growths, it is well to touch the parts with nitrate of silver, solid or in solution, or with the galvano-cautery. Treatment of the vegetations without operation, as by simple cauterisations with nitrate of silver, may perhaps accomplish something, but is rarely effective.

Knapp considers it unadvisable to operate too freely, lest a dry catarrh should be produced. It is certainly unwise to induce too extensive cicatrices. *Hopman*[1] considers anæsthesia applicable in the operation. There is no doubt this is so; but it is unnecessary, perhaps without exception.

Hypertrophied tonsils, which are often the original cause of catarrhal inflammation of the pharynx and middle ear, should be excised, either entirely or in part. The application of astringents, or cauterisation, is very tedious; less likely to prevent their reappearance; and with each fresh enlargement a renewed attack of catarrh usually occurs, inducing a repetition of the middle-ear affection. Their removal is very easy, and the after treatment rarely lasts longer than five or six days, so that as their physiological importance is so very small, no hesitation should be felt in the operation.

If, however, tonsillotomy be objected to, cauterisations may be practised. For this purpose the author generally uses a solution of nitrate of silver (10 to 15 parts in 100), applied on a small piece of cotton-wool by means of the forceps drawn in Fig. 118. With these not only the tonsils, but the different parts of the post-nasal space may be conveniently reached. The hooks on the rings of the instrument catch each other and lock it, so that the cotton-wool or sponge cannot fall off. These cauterisations should be made every day, or less often, as the condition may demand.[2]

Gargles may be of some assistance in naso-pharyngeal catarrh, but it is certain that only in the rarest instances are they successful by themselves. Generally the liquid only acts upon the mucous membrane of the mouth, as the patient, to avoid swallowing it, instinctively makes the soft palate tense, and draws the tongue back to the posterior wall of the pharynx. The gargle therefore does not usually reach the naso-pharynx at all. The author usually instructs his patients simply to allow the liquid to come into contact with or bathe the parts by inclining the head backwards.

To make applications in catarrhal inflammations of the nasal fossæ, syringing through the nose may be practised. The author usually employs

[1] "Zur Operation und Statistik der adenoiden Tumoren des Nasenrachenraumes." Deutsche medicin. Wochenschrift, 1885.

[2] The galvano-cautery is particularly suitable for the treatment of hypertrophy of the tonsils, and may often be employed with advantage where excision is impracticable or undesirable; especially in those cases in which an operation is undertaken for the removal of post-nasal growths under anæsthesia, *when this is indicated*, and the employment of the tonsillotome is inapplicable.—EDS.

for such injections solutions of boric acid (4 per cent.), alum (2 to 3 per cent.), borax (4 to 6 per cent.), or tannin (2 to 4 per cent.—with the addition of a little glycerine). If it be desired to bring the liquid into contact only with the mucous membrane of the post-nasal space, all that is necessary is to syringe through one side of the nose; the liquid then flows back again through the other side after having passed over the upper region of the pharynx. But if it be required to pass the solution through the Eustachian tubes into the middle ear, the second nostril should be closed more or less completely by pressure against the septum. By regulating this pressure one may also regulate the quantity and force with which the liquid enters the tubes. In making applications merely to the post-nasal space, instead of syringing, a little of the solution may be poured through the nose while the head is inclined backwards. Sprays also may be used instead of injections. *Prof. Schnitzler's* spray-apparatus is very convenient for this purpose. *Von Tröltsch* employs a syringe, to which is affixed a tube furnished with lateral orifices.

The sniffing-up of astringent solutions is usually not nearly so efficacious as syringing, as they generally only penetrate in this way some third of the way back. The same may be said of the snuffing-up of powders. Alum, or some other astringent in fine powder, is employed in this manner (alum, 1 to 6 parts; powdered sugar, 6 parts).

Any of the above methods of treatment may disorder the sense of smell for a time, but the disturbance soon disappears again.

The local treatment for the ear is to be directed with regard to the changes present in it.

If merely the commencement of the Eustachian tube be affected by a catarrh of the naso-pharynx, the treatment just mentioned will be sufficient; but even here it is well to inflate the middle ear, since the troublesome feeling of pressure is thereby relieved, and the hearing also improved. It often happens that when a patient is first seen, the inflammatory swelling has already disappeared, and nothing but a plug of mucus remains in the first part of the tube, causing the disagreeable subjective symptoms. If in such a case the ear be inflated with the air-ball, the mucus is very often driven either into the pharynx or into the mastoid cells, upon which recovery at once ensues.

Inflation of the middle ear with the air-ball should be practised with caution. A greater force than is necessary should never be employed, as in many patients very disagreeable symptoms may be brought about in this way (giddiness, faintness, vomiting), and the tympanic membrane may even be ruptured, especially if it be fattily degenerated or cicatricial. In the case of children the author simply empties the air-ball without anything being done on the part of the child (*Schwartze*). With adults this is very seldom effectual, and the author follows *Lucæ's* plan in directing the patient to

phonate "*a*" (ah) during the evacuation. If the inflation be still unsuccessful, he employs his own method, in which the patient pronounces one of the syllables *hak, hek, hik, hok, huk, hk,* while the air-ball is being emptied. Finally, should this procedure be still without result, he has recourse to Politzer's process. With this method, the pressure and the effect produced are generally greater than with the others, but it is at the same time more likely to be followed by injurious consequences. In isolated cases all the above methods are without effect, and one must resort to the catheter. Even with this it may happen that an act of swallowing on the patient's part may be necessary in order that air may be forced into the middle ear (*Kramer*).

The author does not consider it proper, especially with a unilateral affection, to subject the ear needlessly to so severe a pressure as is produced by the Politzer process, and expressed this opinion soon after the introduction of the method. *Schwartze*[1] says, "By injudicious employment of Politzer's method with unilateral disease, injury may result from the effect of the concussion of the air upon the healthy ear. Transitory tingling and rushing noises are of frequent occurrence from the process, and in rare cases they may persist for some time, Occasionally vertigo and fainting, and even epileptiform seizures, may result." Such incidents are rare in adults; but the author can recall a case in which such severe and persistent giddiness with headache occurred after the employment of this method, that the patient was confined to his bed for fourteen days, and even then he had a whistling noise in the ear which did not disappear again. That similar results may now and then occur is probable, and indeed *Urbantschitsch*[2] has reported such cases. *Schwartze* remarks that "the great value of the method of treatment by Politzer's process is not lessened because injurious effects may attend its injudicious employment in unsuitable cases." The author agrees with this, but still thinks that their occurrence indicates the necessity for much caution in the use of the process, and that it should only be employed when less energetic means are unsuccessful.[3]

Simple inflation without the catheter is especially indicated where the nasal mucous membrane is inflamed, as in such cases the introduction of the instrument is often unpleasant or even painful, and the mucous membrane becomes still further irritated. If, however, the affection be limited to the mucous membrane of the middle ear, the author prefers to employ the catheter, should repeated inflation be necessary. With other methods, the air forced through the nose passes in all directions into the accessory spaces, and may in particular injuriously affect the eye. This is not merely a theoretical objection, for the author has frequently heard complaints about eye troubles, especially of dryness and a feeling of weight, in

[1] Die chirurgischen krankheiten des Ohres, p. 135.
[2] Lehrbuch, p. 377.
[3] The translator considers that the possibility of an injurious result following upon 'Politzer's process' has been greatly exaggerated. Ill effects are so rare that they may be quite left out of consideration.—Eds.

patients in whom inflation had been methodically practised for a considerable period; and he has also often seen a conjunctival catarrh follow.

The necessity for repeating the process of inflation depends upon the subjective and objective symptoms actually present. In certain cases all troublesome symptoms may disappear after a single application, while in others it may be advisable to repeat the treatment several times daily.

If after the first inflation the subjective phenomena entirely disappear, then one may wait, at all events for some time, without repeating the process, provided this be not indicated by the objective changes which may be present. Many such cases occur in which it is unnecessary to practise more than one inflation. If, however, the subjective symptoms should return, or the objective conditions are such as are likely to be improved by using the air douche, the process should be repeated at proper intervals. Amongst such cases those may be particularly referred to where inflammatory products have to be removed from the middle ear, especially from the tympanum, as well as those in which the effect of pressure is desirable. The pressure of the inflated air is to be regarded as one mode of methodical compression, and acts by promoting absorption. Its efficacy should not be disregarded or undervalued in this connection.

With great hyperæmia local bleeding may be beneficial, especially if the subjective noises should be very troublesome, and persist after inflation has been carried out. The number of leeches applied must be in proportion to the extent of the morbid changes, and to the condition of the patient; the same may be said in regard to repeating their application.

Although the author must in general agree as to the abuse of treatment by bleeding, both local and general, which is even yet not extinct; yet, on the other hand, it must be admitted that the limitation of bleeding simply with the object of abating pain is too narrow. Under the conditions just indicated local bleeding may be beneficial; but if, after a second or third repetition, no good effect follows, nothing more is to be expected from the treatment. Secondary changes in the labyrinth have then generally occurred, and upon these the bleeding exercises no good influence, and may possibly be even injurious.

The use of vesicants and irritating ointments to the skin in the region of the ear, so much prized by the public, is without any effect in middle-ear catarrh. The administration of saline aperients is often very useful in these cases, and the author has found considerable advantage from regular courses of mineral waters, such as Friedrichshall, Marienbad, Karlsbad, Rukóczy, especially in obviating the tendency to relapses.

When a catarrh is treated from the first according to the above indications, if no other affection or extraneous disturbance should supervene, recovery often takes place in the course of a few days, or at most in a few weeks. If, however, this is not the case, and especially if there should be great swelling of the mucous membrane, treatment by injection

through the catheter may be employed. For this purpose astringent solutions may be used of the same strength as for naso-pharyngeal catarrh. At the commencement of the disorder, as well as with intense hyperæmia of the mucous membrane, this treatment is positively injurious, since it tends to increase the hyperæmia ; while simple inflation with the air-ball has on the other hand the most beneficial effect.

Politzer[1] has recommended plugging the external auditory canal with cotton-wool saturated with grease, with the view of checking the absorption of air in the middle ear, and so preventing the depression of the tympanic membrane. The result has proved unsatisfactory, as the desired effect is not attained, and the noises in the ear are increased.

If the catarrh should show signs of becoming chronic, every effort should be made to endeavour to prevent this. The mode of life of the patient and other circumstances, such as occupation, which may prejudicially influence the course of the affection, must be if possible regulated.

The author has often observed that catarrhs which have existed for weeks have quickly disappeared on change of residence from town to country. The effect of change of climate—in winter to the south, in summer to a more bracing situation—has been even more markedly advantageous.

Chronic catarrh often lasts for years without the establishment of perforation or otorrhœa. Evacuation of an abundant exudation from the tympanum has not unfrequently to be effected by paracentesis of the drum-membrane, and yet the incision very soon heals without the occurrence of any otorrhœa worthy of notice. On the other hand, in cases associated with constitutional disorders, such as tubercle, syphilis, or anæmia, a tedious discharge may become developed.

It needs scarcely be said that the application of remedies to the structures of the external ear or its vicinity can have no direct effect upon the mucous membrane of the middle ear so long as the tympanic membrane is not perforated. The introduction of solutions into the auditory canal may even induce irritation, and still further increase the disorder. While therefore the drum-head remains intact, applications to the latter structure and the canal should be avoided. It must, however, be admitted that absorbents applied in the immediate neighbourhood of the ear are sometimes distinctly of service, especially iodine and mercurial applications in cases of long-standing middle-ear catarrh in scrofulous or syphilitic subjects. They may be used as ointments, or painted on in solution over the region of the mastoid process.

[1] "Ueber luftdichte Verstopfung des äusseren Gehörganges als Heilmittel bei chronischen Mittelohrkrankheiten." Wiener medicinische Wochenschrift, xvii. Jahrg., 1867.

Though local treatment by way of the auditory canal is either useless or may be even injurious when the membrane is unaffected, it may on the other hand sometimes be employed with advantage when the membrane is perforated and otherwise exhibits signs of morbid change, or the canal also is in an unhealthy state. Remedies may likewise be introduced in this way if their direct action on the mucous membrane of the tympanum be desired, though the more certain method is by way of the Eustachian tube.

Politzer proposes to cause a solution to be drawn into the tympanum when the membrane is perforated, by filling the auditory canal with the liquid, and then, while closing this with the finger, inflating the middle ear according to his method. The author, after following this treatment for some time, has relinquished it on finding that in most cases the solution escaped into the throat without exercising the desired effect upon the mucous membrane of the tympanum.

With regard to any morbid conditions present in the auditory canal or tympanic membrane as sequelæ of the inflammatory process, it not unfrequently happens that they disappear by themselves on abatement of the middle-ear inflammation and cessation of the irritating discharges. Even granulations developed in this way in the auditory canal occasionally disappear spontaneously.

The treatment of such conditions as may tend to produce an unfavourable result, on the other hand, must not be too long delayed. Thus with a high degree of narrowing of the canal from swelling of the soft structures, dilatation as previously described must be carried out at an early period. Polypoid proliferations also, due to consecutive inflammation in the external ear and impeding the escape of discharges, must be removed.

The employment of medicated vapours formerly held an important place in the treatment of middle-ear catarrh; and many authors still lay stress upon its value. The author also used vapours extensively at one time, but he is since persuaded that quite as much can be attained by solutions introduced through the Eustachian tube. He seldom employs them now, and usually only when treatment by injections is ineffectual, in which case indeed they also generally fail. He does not wish it to be understood that he considers the vapour treatment of no value, but that injections will effect just as much in most cases, and with less trouble in the application.

Of the vapours hitherto employed, that of a solution of common salt ($\frac{1}{2}$ to 1 per cent.) is probably most effective. Besides this, borax (1 part to water 200) may be used; or alum of similar strength; or sal ammoniac.[1]

[1] *Von Tröltsch* recommends the vapour of sal ammoniac to be introduced in the nascent state. An apparatus is used consisting of three vessels inter-connected by means of glass tubes. One vessel contains strong ammonia; another hydrochloric acid; and both communicate with a third containing water in which is a little hydrochloric acid. Tubing also connects

Bonnafont used tar-vapour. With the exception of such as have a sedative action, as sulphuric ether and chloroform, and sometimes have a beneficial effect upon the subjective auditory symptoms, there is no particular choice to be made between them. Perhaps the temperature at which they are mostly used is to be regarded as the useful factor, and so far therefore the employment simply of steam is quite as efficacious and less troublesome.

Carbonic acid gas has been freely used and praised for its action in chronic catarrh. For this purpose it is prepared from carbonate of lime and dilute hydrochloric acid. Experience, however, does not show that it has any special action.

For the introduction of any of the above vapours, the force-pump apparatus may be used. With substances which volatilise easily, a few drops may be poured into the air-ball, the air expressed from which will then be impregnated with the vapour.

The compressed-air treatment by means of various pneumatic apparatus, to which such good results have been ascribed by some writers in acute and chronic aural catarrhs, is in the author's opinion unnecessary, as the same effect may be attained by simpler methods, and will only be desirable when certain other affections are also present.

The use of various medicated baths, as of iodine, iron, or salt, may be beneficial in connection with ear-trouble associated with general disorders for which their employment is indicated. Brine baths are particularly useful in the case of persons with delicate, sensitive skins, who are prone to relapses. *Pagenstecher* recommends the methodical use of warm baths, and some patients are said to have derived benefit from the Wiesbaden warm baths.

The treatment of tedious otorrhœa occurring in chronic middle-ear catarrh with perforation of the membrane, will be discussed further on in connection with purulent inflammation.

B. Purulent Inflammation of the Middle Ear (Otitis media purulenta s. suppurativa).

Purulent median otitis occurs either in an ear up till then free from inflammation, or it becomes developed as an exacerbation of an existing catarrhal process. Unlike the latter, it is nearly always unilateral, and is as common on the right as on the left side.

The pus produced is found more or less abundantly on the free

the bottles with an air-ball which, when emptied, drives ammonia vapour and hydrochloric acid vapour into the third vessel, where they combine to form the vapour of sal ammoniac. From the last they pass through an elastic tube, fitted with a suitable nozzle to adapt it to the catheter.—Many simpler forms of apparatus for producing sal-ammoniac vapour are now made, and may be readily adapted for aural use.—EDS.

surface of the mucous membrane, or diffused in the tissue itself. It may also occur collected at certain points to form abscesses, occasionally even between the mucous membrane and the bone. If formed rapidly, lacerations of the inflamed structures, especially of the tympanic membrane, may be brought about; and purulent otitis is in general characterised by the conspicuous lesions by which it is attended.

Etiology.—The various injurious influences which have been enumerated as capable of causing a catarrhal inflammation, may likewise bring about a purulent process. In this, however, the presence of micro-organisms appears to play an important part. A purulent median otitis occurring in connection with a pneumonia may perhaps depend upon this cause (*Friedländer*, *Weichselbaum*, and others). Whether, however, micro-organisms are necessarily associated with the formation of pus, has not been conclusively settled.

Traumatic influences, such as the entrance of fluid through the Eustachian tube in employing Weber's nasal douche, etc., favour the development of purulent inflammation. It has often been induced by plugging the nose for epistaxis (*Créqui*, *Gellé*, *Guerder*), either as a result of the presence of blood which has found its way into the tympanum, or as consecutive to the production of a traumatic pharyngitis. So also a foreign body in the middle ear may in like manner cause a purulent median otitis.

Foreign bodies may gain admission into the tympanum, not only through the external auditory canal, but also through the Eustachian tube. Many such cases have been recorded.

Fleischmann found post mortem a grain of barley in the Eustachian tube of a man who had complained for several years of a noise in the ear and of a peculiar sensation in the throat. *Heckscher*[1] relates the following case: A patient who had middle-ear catarrh was accustomed to catheterise himself, and also to introduce through the catheter into the tube a raven's feather fastened to a thin piece of whalebone. On one occasion the feather became disconnected during the manipulation, and remained fixed in the tube. It caused pain, and he felt it every time he swallowed. On the third day he succeeded in dislodging it with the aid of a catheter, and removed it from his throat with his finger. *Schall* reports a case in which, during a nasal injection, a small piece of vulcanite from the nozzle of the syringe found its way into the tympanum, occasioning severe inflammation. Incision of the drum-membrane was performed, and the foreign body extracted, upon which recovery followed. *Urbantschitsch*[2] quotes a case where a piece of the panicle of an oat entered the throat, and from there passed through the Eustachian tube into the tympanum, setting up a purulent inflammation. With this was associated a circumscribed inflammation with polypoid proliferation in the auditory canal, which remained in spite of active treatment. The inflammation only disappeared after the foreign substance had found its way later through an aperture in the tympanic membrane, and thus escaped.

[1] Monatsschrift für Ohrenheilkunde, iv. Jahrg., N. 1.
[2] "Wanderung eines Rispenastes durch das Mittelohre," Berlin. klin. Wochenschr., 1878.

In rare instances purulent median otitis has been caused by a suppurative inflammation of the structures in the cavity of the cranium. The pus either finds its way through some canal or opening in the temporal bone into the spaces of the middle ear, and there causes inflammation with perforation of the tympanic membrane; or else it brings about a carious destruction of the bone, and then flows through the passage thus produced into the tympanum. *Morgagni* attributed every otorrhœa to probable disease of the intra-cranial structures.

The author has been able in certain cases to diagnose the condition accurately. The last case occurring in his hospital practice was also seen by *Prof. v. Schrötter*. In this instance the pus derived from a cerebral abscess discharged itself through an, until then, healthy ear, and its origin could be recognised at a considerable distance by its characteristic odour. *Berndgen*[1] relates a similar case which he observed.

S. Kohn[2] observed perforative inflammation of the middle ear during dentition in two cases. He believes that by continuous irritation of the peripheral ends of the fifth nerve, a sympathetic or reflex irritation is caused of the nerves with which it communicates (vagus and glosso-pharyngeal), and that in this way vaso-motor disturbances are induced which terminate in inflammation. The same view is held by *Sexton*.[3] *Seibert*,[4] however, opposes this theory, which was first of all promulgated by *Woakes*.

Amongst the general diseases which are frequently followed by purulent inflammation of the middle ear, the exanthemata are most prominent—*e.g. measles, scarlet fever*, and *small-pox*. It may likewise be associated with *tubercle, typhoid fever, recurrent fever* (*Luchhau*[5]), *syphilis, puerperal affections, Bright's disease, pneumonia, ulcerative endocarditis*, etc.

Even the purulent form of inflammation is not always diffused over the whole of the middle ear, but is sometimes limited to certain parts of it. Such a demarcation can, however, only very rarely be made out during life.

In typhoid fever may be observed both true nervous deafness and also such as is due to catarrhal and purulent median otitis. According to *Bezold*,[6] as well as *Eulenstein*,[7] with whom the author perfectly agrees, deafness of a purely nervous nature sometimes occurs even during the first week of the fever, while at a later period inflammatory middle-ear affections are more common. He cannot, however, confirm the statement of *Bezold*, that perforation of the drum-membrane in typhoid occurs regularly on the posterior superior segment, and but seldom below the umbo; the author has seen it more frequently in this affection in the anterior

[1] Monatsschrift für Ohrenheilkunde, xi. Bd.

[2] New York Med. Journ., 1885.

[3] "On affections of the ear arising from diseases of the teeth." Americ. Journ. of the Med. Sciences, 157.

[4] New York Med. Journ., 1886.

[5] "Ueber Ohren- und Augenerkrankungen bei Febris recurrens." Virch. Arch., 82 Bd., 1880. *Luchhau* observed purulent median otitis in 180 out of 300 cases of ear affection which occurred at the crisis of the disease, during the epidemic of 1879-80.

[6] "Ueber die Erkrankungen des Gehörorgans beim Ileo-typhus." Archiv für Ohrenheilkunde, xxi. Bd.

[7] "Die Affectionen des Gehörorganes im Verlaufe des Ileo-typhus." Inaugural-Dissert.

inferior segment. *Hartmann's* observation, that in his cases the typhoid patient first became hard of hearing during convalescence, is only accidental.

Course and Symptoms.—The symptoms, even at the commencement, form quite a different clinical picture to that of the other varieties of middle-ear inflammation. *Otitis media suppurativa is notably a febrile disease*, unlike the catarrhal affection. Further, while in the latter the subjective symptoms mostly have reference to the auditory nerve; in this form the prominent phenomena, even at the beginning, relate to disturbances of the ordinary nerves of sensation. The disease announces itself by very severe and continuous piercing or tearing pain in the ear; over the corresponding side of the head, more especially at the back part and neck; or over the entire head. The pain is often greatly increased on pressure, particularly on the mastoid process when the inflammation has implicated some part of the region. With the pain, high fever is present, sometimes commencing with a rigor, and only abating or ceasing when the inflammation has passed its most acute stage. In children, vomiting often occurs at the commencement, and on this account the disease may be mistaken for a meningitis. Owing also to the proximity of the brain and its membranes, and to the numerous vascular communications between these structures and the ear, other signs of cerebral irritation may appear, such as periodical stupor, which may increase to a state of coma, muscular spasms of the most varied kind, and even epileptiform seizures.

The author has frequently seen epileptiform attacks occurring during the course of purulent inflammation of the middle ear in children, and *Trautmann* and *Schwartze* have recently reported some cases of this kind. *Trautmann*[1] treated a girl aged three years who had epileptiform seizures in the course of an otitis. After copious evacuation of the contents of the tympanum, only one further attack occurred. *Schwartze* observed in one case, a fresh appearance of the eclampsia with each recurrence of a middle-ear catarrh. *Schwabach*[2] observed a case of chronic suppurative median otitis which had caused destruction of the tympanic membrane and separation of the auditory ossicles. There was also a retro-auricular abscess. By pressure upon the inflamed structures, an abundant discharge of pus from the auditory canal took place, and at the same time, especially if pressure was made upon the deeper part of the superior wall of the canal, vertigo and horizontal oscillatory movements of the eyes towards the left occurred, which at once ceased when the pressure was taken off. The symptom disappeared with improvement in the ear disorder. *Schwabach* attributes the phenomena to increased intra-auricular pressure.

The deafness, noises in the ear, and other subjective symptoms which may be present, such as hyperæsthesia acustica and double hearing, depend upon the same conditions as in the catarrhal form of

[1] Bericht über die otiatrische Section der 59. Versammlung der Naturforscher und Aerzte in Berlin, 1886.

[2] Monatsschrift für Ohrenheilkunde, 1878.

inflammation. These derangements may be of the sound-conducting apparatus, or secondary changes in the labyrinth, or in the brain. Perversions of the sense of taste are observed in purulent as in catarrhal otitis.

Blau[1] made the interesting observation in a case of suppurative middle-ear disease of the right side, that the tones of the tuning-fork were heard from a quarter to half a tone lower by the right than by the left ear, while with bone conduction they seemed of the same pitch on both sides. This condition continued for some time after the perforation healed; later the normal perception returned.

The *objective appearances* are to be recognised by the same methods as were described with middle-ear catarrh.

Enlargement of the glands in the neighbourhood of the ear, especially those between the jaw and the mastoid process, and in the mastoid region, is frequently observed at an early period. Sometimes intense inflammation of the lining membrane of the mastoid cells occurs, accompanied by slight œdema of the skin in the region of the mastoid process.

The mucous membrane of the tympanum is usually attacked first and most severely; and as the mucous layer of the tympanic membrane participates in the process, the manifestations of this become very soon apparent. At first, signs of hyperæmia of varying intensity are noticed; later, the appearances differ with the course of the affection. The redness and swelling of the tympanic lining of the membrane produce the appearance represented in Fig. 10, Plate II. The drum-membrane is moderately convex externally, and of a somewhat livid colour, with signs of more or less hyperæmia, especially in the more vascular parts. With the membrane thus inflamed in consequence of the middle-ear affection, all the changes may be present which have been described with an independent myringitis. The inflammatory products may be found only on the mucous surface of the membrane in connection with more or less destruction of tissue, or they may accumulate in larger or smaller areas throughout the structure (abscesses). Perforation occurs later, either from an ulcerative process, or through the pressure caused by the large quantity of inflammatory products which are formed. It is not difficult to understand the possibility of a very rapid disintegration of the greater part of the membrane under these circumstances in certain cases of suppurative median otitis, and this is especially observed with a diphtheritic inflammation occurring in the course of scarlet fever.

The development of a perforation may sometimes be seen to take place more slowly. Occasionally unmistakable signs may be noticed of the destruction of tissue which is going on. Fig. 11, Plate II., gives a

[1] "Mittheilungen aus dem Gebiete der Erkrankungen des äusseren und mittleren Ohres." Archiv für Ohrenheilkunde, xix. Bd.

representation of the appearance of the same drum-membrane as in Fig. 10, but drawn two days later: a pustule was now seen; and next day a perforation on the same place could be recognised. Sometimes a very abundant accumulation of inflammatory products in the tympanum breaks through the inflamed and easily ruptured drum-membrane, escaping thus into the external auditory canal, and leaving a laceration in the membrane, the form and extent of which may vary greatly.

All the appearances which were previously described as occurring in inflammation of the tympanic membrane, may be present in purulent median otitis when the membrane is implicated in the inflammatory process.

Mention must once more be made of perforation of the membrane in the *portio flaccida*, above the short process (Shrapnell's membrane). This usually arises from purulent middle-ear inflammation, and may be of variable extent. It may be looked upon as one of the most unfavourable complications. On account of the irregular spaces in the portion of the tympanic cavity corresponding to this part of the membrane, which generally do not communicate with each other below, it is very difficult to thoroughly cleanse this region. Carious disease of the upper extremity of the malleus and the incus is thus readily brought about. The discharge of pus too, formed in the lower part of the tympanum, is naturally scarcely possible through the perforation, by reason of its situation. Such perforations attain a considerable size, and when of long standing may induce even a carious erosion of the neighbouring bone. In this manner the aperture may become larger in the upward direction, and the head of the malleus, as well as the crown of the incus, which are normally covered by the external lamina of the horizontal part of the squamous portion of the bone, may come to be visible through the auditory canal.

Perforations of the pars flaccida are not unfrequently associated with other lesions: for example, with extensive perforations in other parts of the membrane; with luxation of the articulations of the auditory ossicles; with exfoliation, or with caries or necrosis of some of these bones; and with irregularity in position, or with adhesion of the ossicles or of the rest of the drum-membrane, etc., etc.

Thus, in a case of the author's, of which the condition is represented in Fig. 119, there was so large a loss of substance above the short process, that the upper ends of the hammer and incus were visible. Through the extensive perforation in the lower part of the membrane a view of the tympanum could be obtained; and in this, besides irregular bands of new connective tissue passing obliquely over the inner wall, there were to be seen the incus-stapes articulation above, and behind and below the depression of the fenestra rotunda. The portion of the membrane still remaining appeared to have undergone calcareous degeneration.

Fig. 120 represents a case in which still greater destruction had occurred. The membrane was quite destroyed up to the anterior-superior segment, which was still in connection with the handle of the malleus. The chorda tympani remained, and appeared like a cord passing obliquely from behind forwards. The incus was quite gone. The internal wall of the tympanum was covered with an adherent membrane, by which the depressions of the fenestra ovalis and fenestra rotunda were obliterated; the position, however, of the former being indicated merely by the head of the stapes. The adherent membrane just referred to may perhaps have been partly constituted by the remains of the mucous layer of the membrana tympani. The malleus was drawn completely forwards, and below the lower extremity of the handle is seen an aperture through which air escaped when the middle ear was inflated.

The character of the discharge in suppurative median otitis is at first mostly sero-sanguineo-purulent, and only becomes entirely purulent gradually. Its quantity is variable, and generally very abundant.

The secretion may become sanguinolent (*otitis suppurativa hæmorrhagica*) from rupture of blood-vessels, or from migration of red blood-

Fig. 119.



Fig. 120.



corpuscles. After a short time the blood generally disappears again, and the exudation regains its simply purulent character. *McBride*[1] explains the rupture of vessels in such cases from long-standing occlusion of the Eustachian tube, combined with an unyielding tympanic membrane, as a result of which the exhaustion of the air of the middle ear makes itself felt upon the walls of the intra-tympanal vessels.

The appearances in the external auditory canal differ in accordance with the extent of the secondary changes which ensue. If a perforation of the membrane has taken place, the pus escapes from the tympanum, and, flowing over the tissues, renders them hyperæmic, easily excoriated, sensitive, and more or less inflamed upon slight cause. The symptoms then manifested will be those of diffuse external otitis combined with those due to the median otitis.

The objective changes in the *nose, pharynx, and Eustachian tubes* are to be investigated and explained on the same principles as in the catarrhal form of inflammation. There is often considerable narrowing of the tubes,

[1] "Otitis hæmorrhagica." Zeitschrift für Ohrenheilkunde, xv. Bd.

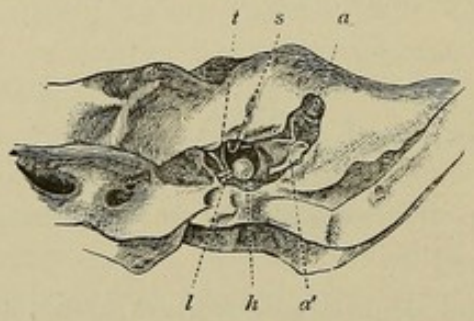
occasioned by inflammatory swelling of the mucous membrane; and much care must be exercised in the employment of bougies, on account of the ease with which the lining membrane may be injured—a result entailing possible consequences more serious here than with middle-ear catarrh.

In most cases the morbid process, when it has reached this stage, subsides; the fever gradually abates, the formation of pus lessens, and the perforation eventually heals. The time required for this varies from three weeks to three months, and even longer, chiefly on account of the more or less slow process of cicatrisation. Cases occur, however, in which other complications arise during the course of the inflammation.

Amongst such consequences may be first mentioned the partial or complete disconnection of the auditory ossicles from one another. With destruction of the inter-articular connections, the articular ends of the ossicles may still remain in contact, or they may be separated to a greater or less extent. In this way those displacements are brought about which are denoted *subluxations* and *luxations* of the bones. The ossicles may likewise undergo considerable displacement by certain forces (muscular contractions), or on account of the position of the patient's head at the time when they become separated from their connections. Such separations usually take place only after more or less extensive destruction of the drum-membrane; and, if complete, one or more of the ossicles may be carried away with the discharges. In this manner perfectly healthy bones are sometimes exfoliated, while in other cases they are only partly loosened from their connections, and if their nutrition is then defective some portion of their structure becomes necrosed.

Fig. 121.

Petrous portion of the temporal bone. The roof of the tympanic cavity and mastoid cells has been removed.



h, Head of the malleus; *l*, anterior ligament of the malleus; *t*, tendon of the tensor tympani muscle; *s*, head of the stapes with the tendon of the stapedius muscle; *a a'*, incus.

The most common articular disconnection is that between the descending process of the incus and the head of the stapes. In proportion to the large number of cases of purulent middle-ear inflammations coming under observation, the instances are very rare in which all the auditory ossicles have undergone disarticulation. The incus becomes most frequently separated from its connections; more rarely the malleus, and still more uncommonly the stapes. Instances in which all three bones are discharged together as a result of purulent middle-ear disease are excessively rare, and associated almost always with scarlet fever.

It may happen that one of the ossicles, especially the incus, becomes partially or completely separated from its attachments, without destruction or even perforation of the tympanic membrane, and it may undergo displacement in various ways. The state of things represented in Fig. 121 may thus be accounted for. The preparation is from the temporal bone of a girl aged twelve, who died from typhoid fever, and who was a congenital deaf-mute. In the left ear the Eustachian tube, membrana tympani, and malleus were quite normal; the stapes retained its natural position and connections; the mucous membrane of the tympanum was nowhere notably changed, and the tympanic cavity was of normal size and condition. The incus was, however, disarticulated from the malleus and the stapes, and was found lodged in one of the mastoid cells, close to the antrum mastoideum, with its crown directed downwards and the long process upwards. It was retained in this situation by newly formed connective tissue. After separation from its normal connections—probably in early infancy, or perhaps even during intra-uterine life—one must suppose it to have fallen into the position in which it was found through the mastoid fossa, which is large in the temporal bone of the child.

The formation of pus in the mucous membrane, and between this and the bone, has been before referred to, and from this may result destruction of the former and caries of the latter. Sometimes the development of an abscess in this way may be accurately followed. If it be situated on the inner wall of the tympanum, and the drum-membrane has been destroyed, it appears as an intensely red or perhaps yellowish swelling, which gives signs of fluctuation upon examination with the probe.

The tissue destruction which may result from purulent inflammation in the tympanic cavity and in the mastoid cells may also occur mutatis mutandis in the Eustachian tube. Here also the morbid process may go on to abscess formation with all its consequences. The pharyngeal abscesses which may be thus formed are particularly noteworthy. They are to be looked upon as gravitation-abscesses following upon a solution of continuity in some part of the tube. Such discontinuities of structure may occur on the anterior membranous wall, or at the isthmus tubæ; the cartilaginous portion being in the latter situation loosened from its connection with the osseous part of the tube. The pus then either becomes effused between the tissues of the soft palate, or if this remain unimplicated, the matter gravitates into the structures at the back part of the post-nasal space (retro-pharyngeal abscess). The tissues there swell up and narrow the pharynx, impeding deglutition, and likewise respiration, even perhaps to the point of asphyxia. In infants especially, in whom the anatomical peculiarities of the tube greatly favour this dangerous result it is incumbent upon the surgeon to attend most carefully to the structures of the pharynx, inasmuch as an oversight in such a condition may cost the

child its life. Not only in children, but also in adults, the author has frequently had to operate in such cases of gravitation-abscess, and sometimes he has been able to pass a suitably bent probe through the incision made in the soft palate into the tympanum, where, as the tympanic membrane had been destroyed, it could easily be seen through the auditory canal.

He has also repeatedly observed in cases of purulent median otitis, a complete separation of the cartilaginous from the osseous portion of the Eustachian tube, with diffusion of pus into the pharyngeal structures, the parotid gland, and the lateral cervical region. Sometimes the pus accumulates in the vicinity of the articulation of the lower jaw; the capsule of which, however, resists erosion for a long time. In the author's collection are six preparations from cases in which such purulent accumulation around the joint occurred after complete separation of the cartilaginous from the osseous section of the tube; in one instance only was the articulation actually opened.

Moreover, a solution of continuity of the structures of the Eustachian tube is by no means a necessary antecedent condition to these abscesses in the neighbourhood of the maxillary articulation. In the *Glaserian fissure*, which is especially wide in children, a communication exists by which pus may find its way into this region from the tympanum. It is obvious, therefore, that particular scrutiny of the parotid region is necessary during the course of this disease.

Moorhead[1] observed in a boy fifteen years of age an abscess of the tympanum, accompanied by fever and severe pains over the whole of the left side of the head. It discharged through the Eustachian tube. The breath was fœtid, but this symptom disappeared later, and recovery ensued.

Not infrequently the inflammation extends from the cells of the mastoid process to the periosteum covering the external surface of the bone. This extension is generally brought about through the vessels and other connective-tissue structures passing between the parts by way of the squamoso-mastoidal fissure, or the interstices and fissures representing this. Abnormal communications may also contribute to produce the same result.

In the same way as the middle-ear inflammation may extend outwards, so it may likewise pass inwards towards the cranial cavity. The natural paths by which such an extension may take place are very numerous, and sufficiently ascertained from a knowledge of the anatomy of the temporal bone. Such are the *apertura spuria canalis Fallopii, the internal auditory meatus, the aqueducts of the vestibule and cochlea, the*

[1] Brit. Med. Journ., 1878.

petro-mastoid canal (*Voltolini*), *and the canaliculi tympanici and carotico-tympanici.*

Individual peculiarities in the bone likewise play a large part in the matter, while the nature of the osseous substance itself has also an influence upon the course of the affection. A vascular, diploëtic bony tissue is usually much more easily attacked than one firmer, and poorer in blood-vessels. Most frequently it is seen that a middle-ear inflammation extends to the sigmoid sinus of the dura mater, and leads there to a thrombosis and phlebitis, from which further inflammatory phenomena ensue in the brain and its membranes. The dura mater covering the roof of the tympanum may also sometimes be observed to become affected, and consecutively to this a thrombosis of the petrosal sinus, of the bulbus venæ jugularis, etc. In other cases, wandering pus-cells and micro-organisms are undoubtedly transmitted, and also emboli which pass along the vessels and are deposited as excitants of inflammation amongst the structures of the cranial cavity. It is also clear that extension of the morbid process will occur more easily when caries of the bone is present.

Reference must be made to inflammation in the carotid canal around the carotid artery, which may occur in connection with purulent inflammation of the middle ear. Of this complication the author has been unable up till now to find any description or report, but it is nevertheless, according to his experience, not at all rare. In such cases the structures lining the wall of the canal are found to be loosened in texture and infiltrated with pus-corpuscles, and pus is likewise not unfrequently found collected between them and the wall of the canal.

A prolonged inflammatory process of this kind may also lead to hyperplasia of the walls of the vessel; and this, as will be shown later, may be of serious importance in respect of the life of the patient. If the jugular vein become involved in the inflammation, it is the intima which is mostly affected; phlebitis occurs with its various manifestations; and here also, as with the carotid artery, hyperplasia is brought about when the morbid process is of long duration.

Pus or other possible infective materials derived from the middle ear may be transmitted either along the natural histological lines of the tissues, or may be carried through the blood-vessels, and lodged in different organs. Metastatic abscesses may in this way become developed in distant parts, and accompanied by the establishment of the general symptoms of pyæmia. Thus there may arise, inflammation in the brain and its membranes, inflammation of the lungs, liver, spleen, glands, the articulations, the pleura, peritoneum, etc.

If the possible complications, as well as the influence of various external conditions and of morbid constitutional states upon the course of the affection, be considered, it will be apparent that this may be considerably

modified in different cases; that the otitis may readily take on a *chronic* character; and that both the subjective and objective symptoms may exhibit great variety.

In regard to the *prognosis*, we have to consider first of all the question as to danger to life, and secondly that in respect of the hearing power, and other derangements which may have been developed. In reference to the first consideration it is to be observed that the gravity of the disease ought not to be underrated. Various contingencies may arise which it may not be possible to recognise, and which may greatly influence the course and termination of the disease.

With the best knowledge and experience also it may be impossible always to prevent with certainty an inward extension of the affection. This unsatisfactory position is however modified to some extent by the fact that, notwithstanding the large number of cases of purulent middle-ear disease which occur, a fatal termination is extremely rare, and that such a result is generally brought about by caries and necrosis, the presence of which may usually be diagnosed. In such cases, moreover, the existence of some associated general affection, or the history of the entire course of the disease, furnishes as a rule trustworthy data in regard to the prognosis. The age of the patient is also, according to the author's experience, of importance. In earliest infancy the sigmoid sinus, through which the morbid process mostly extends to the brain and its membranes, is separated by a much greater thickness of bone from the mastoid cells than in adult life. This is likewise often the case in later years, when these cells not unfrequently become obliterated to some extent. A barrier is in this way opposed to the extension of the inflammatory process in childhood and in old age, which does not exist at other periods of life. We thus find as a matter of experience in purulent median otitis occurring in children or in aged persons, that the disease, if it extend itself, generally does so externally, and only exceptionally in the direction of the cranial cavity. In such individuals, therefore, we shall be justified in regarding the disease of the ear with somewhat less anxiety.

Particular attention must be drawn to the fact that even in cases in which the intensity of the subjective symptoms has in some measure abated, and even where the fever has likewise disappeared, all danger cannot be thought to have ceased; though it is as a rule true that the course of the disease is then towards recovery. Sometimes it happens, even at an early period, that the morbid process undergoes a slight temporary remission—only however to be soon renewed with greater violence. It is only when the fever has completely disappeared, the pain in the ear and head quite gone or almost so, the swelling of the mucous membrane of the middle ear diminished, and a reasonable certainty exists

that no serious complication has ensued, that all danger to life may be considered to have vanished.

The patient must generally have remained well for some considerable time before his recovery can be regarded as complete. The following case observed by the author exemplifies this statement. A strongly built railway labourer, aged forty, was attacked with a severe purulent inflammation of the middle ear on the right side, with perforation of the drum-membrane. Periostitis in the mastoid region, with the formation of an abscess, soon occurred. The abscess was opened behind the auricle, and the condition treated in the usual manner. At the end of six weeks the patient had so far recovered that he could be discharged. The perforation of the membrane had healed, and only a cicatrix remained behind the auricle from the abscess. Auscultation of the middle ear indicated that the condition there was normal; the noises in the ear had disappeared, and the watch could be heard on contact with the cranium, and at a distance of 6 *cm.* Three months after dismissal he came again, complaining of severe headaches. There was no fever, and no other apparently important symptom. The appearances in the ear were the same as on his discharge from the hospital. He was accordingly transferred to the care of *Prof. Duchek*, who was inclined to look upon the case as one of transient gastric disorder. He was rigidly dieted, and a weak solution of quinine prescribed; but the pains in the head became so severe in the course of the next two days that he returned. During the following two days, during which there was high fever, it became clear that the case was really one of grave cerebral mischief. On the third day after admission he became insensible, and on the fifth day he died. On post-mortem examination, an abscess as large as a hen's egg was found in the right temporal lobe, its walls giving evidence that it was of considerable duration. In the corresponding temporal bone no abnormality could be seen beyond moderate thickening of the drum-membrane and of the lining membrane of the mastoid cells. There can be little doubt, however, that the origin of the abscess is to be referred to the middle-ear disease from which recovery had taken place.

Rigors have an unfavourable signification. They are usually to be regarded either as a sign of an exacerbation of the local affection, or of secondary implication of the brain and meninges, or they may indicate the onset of pyæmia. The development of some affection of the thoracic organs in association with fever constitutes a group of equally bad symptoms.

Sometimes a severe purulent inflammation of the pleura appears in connection with a pyæmia, and rapidly proves fatal. It generally announces itself with violent, stabbing pains in the chest. Peritonitis may also result from a suppurative middle-ear affection. It is one of the most uncommon complications, but in all the cases observed by the author it has terminated fatally.

The hearing capacity is naturally much endangered by this disease. An unfavourable result of this kind will depend in the first place on the extent of destruction or change produced by the morbid process. The greatest reserve in respect to prognosis is necessary, from the fact that it is not always possible to recognise all the changes which may have taken place in the deeper structures, or to insure recovery in regard to such as

have been diagnosed to a degree consistent with the re-establishment of their functional integrity. In the great majority of cases the affection runs its course without producing a permanent impairment of audition, even though a perforation of the membrane may have been brought about. It is a good sign when tympano-cranial conduction is still present. If, with abatement of the inflammatory process, the hearing improves, though only to a slight extent, it may be fairly assumed that the improvement wil continue with continued recession of the inflammation. If, on the other hand, no capacity for hearing be perceptible after the cessation of the morbid process, little hope can be entertained of its return at some future period. With regard to other symptoms, what was said in respect to middle-ear catarrh holds good likewise for purulent median otitis.

Treatment.—With the conditions present in this disease, the least neglect may be followed by a fatal termination ; while proper intervention at the suitable moment may be attended with the most brilliant result.

The treatment should preferably be symptomatic, with the object of preventing as energetically as possible a further extension of the inflammatory process, as well as of destruction of the tissues. From the commencement the measures adopted should, as far as possible, be antiphlogistic. These, however, must be of such a kind as are not likely to increase the hyperæmia of the deeper structures by impeding the return of blood from the parts. So long as hyperæmia is present, or if, suppuration having recurred, there should be severe pain, then local bleeding is of much service. Possibly also, with symptoms of considerable cerebral oppression in robust individuals, venesection may prove beneficial. The local bleeding should be repeated as often as the symptoms appear to demand, and the state of the patient may permit of it.

The application of cold by means of cold-water fomentations or ice may be tried ; Leiter's cooling apparatus is also convenient. In many patients, however, the cerebral hyperæmia is increased by cold applications, as indicated by greater pain in the head and increased signs of cerebral mischief. In certain cases warm fomentations to the head alleviate the pain, possibly by their influence in aiding the return of blood from the inflamed parts. The author has treated cases in which it was necessary to apply ice-bags to the frontal and occipital regions, and warm fomentations at the same time to the ear, in order to relieve the extreme pain. In constipated subjects, and where a derivative effect is desirable, it is well to give purgatives at the commencement. Even if no special indication for such treatment exist, care must be directed to the regulation of the intestinal function ; and in selecting a drug for this purpose, those are to be avoided which are likely to cause vomiting, and so increase the cerebral pressure.

Narcotics may be administered for the relief of pain, and their employ-

ment is to be guided by the same rules as with inflammations of the external ear. For severe pain *Weber-Liel* recommends oil of turpentine in capsules containing 10 to 20 drops: three to be taken at noon, and five or six at night. In intermittent otitis he gives quinine. With feverish patients, *antipyrin* in doses of 8 to 16 grains is indicated, inasmuch as it generally also relieves the pains; and quinine in otitis intermittens.

Lucæ recommends the tincture of *gelsemium sempervirens* (7 to 15 drops every three or four hours); but the author has seen no result from it. *Theobald*[1] advocates atropine as a local application in acute painful inflammations of the middle ear. A little of an aqueous solution of the sulphate (liq. atrop. sulph. B.P.) is dropped into the ear every three or four hours, and allowed to remain there for ten minutes or a quarter of an hour. The author considers that this treatment ought certainly to be conducted with much caution, and by the surgeon himself. *Bacon Gorham*[2] praises sulphide of calcium for its anodyne effect in median otitis. He gives it in doses of $\frac{1}{20}$ gr. to $\frac{1}{10}$ gr. in children, and $\frac{1}{2}$ gr. in adults, as often as every two hours if necessary.

The inflammation of the deeper structures cannot be cut short or abated by blisters over the mastoid process or on the neck. The pain, however, may sometimes be diminished by this means.

It needs scarcely be said that acute suppurative median otitis being always a febrile disease, complete rest, both mental and physical, as well as strict regulation of the diet, ought to be insisted upon. For the rest, the local treatment must be governed by the actual conditions present. With severe pain, if the measures previously mentioned should be ineffective, gentle inflation with the air-ball often brings momentary relief. If still unsuccessful, incision of the drum-membrane, even though no suppuration be perceptible, is followed not infrequently by considerable diminution of the pain, especially if the flow of blood be encouraged for some little time. If suppuration has been already established, the pus must be evacuated as soon as possible, and if this cannot be brought about through the natural channel, then the *membrana tympani must be incised*, more especially if the Eustachian tube be contracted.

By paracentesis of the membrane, not only is the pus evacuated, but the hyperæmia reduced by division of the vessels, and in this way an abatement of the pains is effected. The operation is of the utmost value, and may under certain circumstances be truly the means of saving the life of the patient. The selection of the site of incision is under these conditions not a matter of indifference. Since the pus is mostly found in the lowest part of the tympanum, it follows that the lower segment of the membrane is the most suitable for the operation of paracentesis. Nevertheless the appearances in the membrane must determine this point. The incision

[1] Amer. Journ. of Otol., i., p. 201.
[2] "Calciumsulphid bei Ohrenerkrankungen." Zeitschr. für Ohrenheilk., Bd. xiii.

must not be made too small, in order that the matter may escape readily: this is particularly necessary when the exudation is very viscid. It may happen that, even with a large incision, the retraction of the tissues may not be sufficient to permit a free discharge, and it may then become necessary to make the incision crucial, or, as *Voltolini* recommends, to employ the galvano-cautery and burn out a piece of the membrane.

Paracentesis is most conveniently performed with the myringotome shown in Fig. 102; or a simple cataract needle may be used. Light should be thrown in by a reflector fixed on a frontal band, so that the operator may have both his hands disengaged, and as large a speculum as possible should be employed. The membrane is to be perforated with the myringotome, and upon its withdrawal the incision is to be extended to the necessary size in the direction desired. When the line of division is to be from above downwards, the membrane should be pierced above, and the extension made downwards so as to avoid injury to the chorda tympani. The hæmorrhage is as a rule very slight, amounting at most to a few drops. If it be thought desirable to keep it up for a time, the auditory canal should be carefully syringed with lukewarm water. In one case only has the author seen a hæmorrhage copious enough to cause fainting after this operation. This was in a patient whose membrane he had incised a few days previously without any unpleasant result, and a repetition of the operation was required on account of a serous accumulation. The incision was made in the posterior-inferior segment, and the blood poured out so abundantly that it looked as if a large vein had been divided. The canal was at once tightly plugged, but the bleeding continued for some minutes, forcing out the plug. It only ceased after the canal was packed with cotton-wool soaked in perchloride of iron, and this retained for a considerable time by the finger. The patient lost at least 10 ounces of blood, and was confined to bed for a week on account of weakness. The hæmorrhage did not recur, and no further unpleasant consequence ensued. Several months afterwards, however, a livid spot could be seen on the posterior-inferior part of the membrane. The patient then disappeared from observation. Whether the spot mentioned was due to a clot in the tympanum, or to some anomalous condition of the vessels of the tympanic membrane (*e.g.* telangiectasis), could not be determined. The author did not notice the appearance before the operation.

It is advisable to inflate the middle ear with the air-ball immediately after the operation, in order to encourage the escape of the tympanic accumulation. So long as pus continues to be formed in the tympanic cavity, the incision (artificial perforation) should be kept open. The employment of the air-ball aids in this; but if it should be insufficient, the probe should be passed frequently through the aperture. Should even this fail to keep the wound open, the operation must be repeated, though

before doing so it is always better to employ other methods with the same object, on account of the relaxation of the membrane apt to be induced by repeated incisions.

Frequent employment of the *Valsalvan process* for the removal of discharge from the tympanum is, on the whole, not to be recommended. The increase of blood-pressure in the veins brought about during the process produces a congestion, not only of the vessels of the labyrinth, but also of those of the brain and its membranes. This may be very often recognised by the increased prominence of the subjective symptoms at the time, and may be accompanied by injurious consequences.

If the pains persist in spite of the operation, *Schwartze* recommends the rapid establishment of mercurialism by means of inunctions and subcutaneous injections. "With the appearance of copious salivation," he states, "the violence of the inflammation is generally abated."

While the parts are still very congested and painful, the use of irritating or astringent substances, by way of the auditory canal or Eustachian tube, is to be avoided. When, however, an inflammatory swelling of the structures of the pharynx is present in addition to the median otitis, astringent gargles sometimes assist in reducing the swelling of the tubal mucous membrane, and in this way may exercise a very beneficial influence upon the whole course of the affection. Applications of solution of nitrate of silver to the pharynx may even be made with advantage.

During the course of a purulent median otitis attention should also be directed to the external auditory canal. It must be kept as widely open as possible. A contracted canal interferes with a proper examination, and by impeding the free escape of the discharges may lead to the most serious conditions. The measures by which the canal may be dilated have been already described.

In children and lethargic individuals with a unilateral affection, the healthy ear should be examined from time to time, as a similar condition becomes sometimes developed in this without being noticed, and may assume dangerous proportions. *Schwartze*[1] treated a patient aged seventeen, in whom, although a perforation was present, grave symptoms of cerebral irritation and high fever persisted. There was stupor, with strongly contracted pupils, continuous delirium, and plucking of the bed-clothes. It was discovered that the other ear was also affected, and the tympanic cavity full of pus, the membrane being considerably bulged outwards. Paracentesis was performed, and the patient recovered.

If rigors appear, large doses of quinine may be given with the view of reducing the fever (7 to 15 grains repeated two or three times at intervals of half an hour). Warmth to the body should also be applied to mitigate

[1] "Die chirurgischen Krankheiten des Ohres," S. 173.

the discomfort felt. In the intervals, acids may be administered. A careful examination of the other organs should never be omitted, in order that any necessary treatment may be employed as early as possible.

As in the case of a chronic middle-ear catarrh with perforation, an otorrhœa in purulent otitis may be most difficult to cure. It appears, therefore, advisable to describe the treatment of *chronic otorrhœa* somewhat more in detail.

The greatest care should in the first place be taken as to proper cleansing of the ear. The author is not a supporter of the method of so-called dry cleansing (*Becker*[1]). If it could always be carried out by the surgeon himself, it might be recommended in many cases. This is, however, very seldom practicable; while if the attendants are properly instructed how to use the syringe, more is certainly to be expected from this than from simply wiping out the ear. The objection that, in syringing, infectious substances may possibly be introduced, may be raised equally well against other methods, and it loses all force nowadays when the liquid used is always rendered antiseptic. The author, on the other hand, agrees with *Becker* in advocating the removal of liquid left behind in the deeper parts after other methods of cleansing, by means of aspiration with Siegle's speculum or some other instrument.

Merely syringing out the auditory canal is not always sufficient. Even when there is an extensive perforation of the membrane, the stream of water may not enter the middle ear at all, or not in sufficient quantity and force to wash out the retained matters. Inflation too by the air-ball before and after syringing remains sometimes ineffectual for this purpose. In such cases, therefore, injections must be made through the Eustachian tube, according to the methods before described (p. 196, *et seq.*).

For washing out thoroughly the middle ear and accessory cavities, *Hartmann* employs a tube of German silver or vulcanite, 2 *mm.* wide and 8 *cm.* long. It is straight in the middle part, but at about 1 *mm.* from one end (tympanic) is bent over at a right angle, while the other end is bent at an obtuse angle in the opposite direction, and has a bulbous extremity for the attachment of an indiarubber tube. When in use, the latter tube is connected with the syringe. Syringes with long, solid nozzles for direct injection into the middle ear have been employed for a long time, and are to be preferred; they being more easily cleansed and simpler to introduce.

The author finds the aspirating syringe represented in Fig. 122, contrived by him more than twelve years ago, to be very serviceable in the removal of fluid from the middle ear.[2]

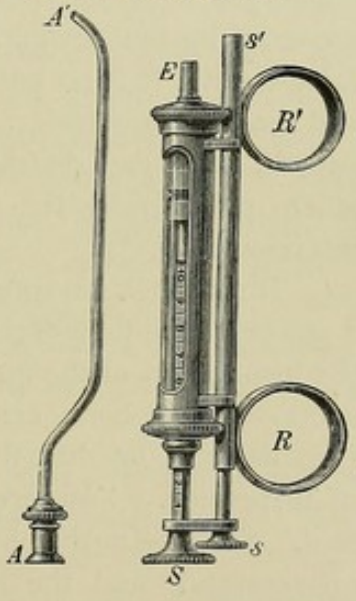
[1] Monatsschrift für Ohrenheilkunde, xiii. Jahrg., 5.

[2] "Ein neues Verfahren zur Herausbeförderung flüssiger Substanzen aus den Räumen des Mittelohres." Monatsschrift für Ohrenheilkunde, viii. Jahrg., 1874.

It consists of the syringe proper, and a nozzle-piece, *A A'*, of variable thickness, and curved somewhat like a bayonet at the outer end. The other (tympanic) end *A'* may be bent in any way required. The nozzle-piece being fitted on to the syringe, the latter is held by the index finger in the ring *R'*, and the thumb in *R*. The end *A'* is then inserted under good illumination into the tympanum, and the piston-rod *S*, which is connected with the rod *s s'*, is withdrawn by drawing back the index finger towards the thumb. *Schalle*[1] recommends for the same purpose a silver cannula, to which a piece of elastic tubing 30 *cm.* long is attached, and through which the middle ear is aspirated either by the mouth or by an air-ball.

Fig. 122.

Aspirating syringe for the removal of fluid accumulations from the middle ear (two-thirds the usual size).



With regard to the liquid employed in syringing, it is well, if possible, to avoid one with a disagreeable smell. Further, in chronic cases, in which syringing will be necessary for a long period, attention should be paid to a possible effect of the solution used upon the general system. The author has, for example, treated cases in which the frequent use of a carbolic acid solution so impaired the appetite that it had to be changed. If the discharge has no disagreeable odour, the author almost always employs a boric acid solution. A teaspoonful of a 20 per cent. solution of boric acid in alcohol is added to about half a pint of hot water. When the pus has a bad smell, the boric acid solution is insufficient for its removal, and a 2 to 4 per cent. solution of carbolic acid, or a weak violet-coloured solution of permanganate of potash, may be used. It is well to keep stronger solutions of these substances, and to dilute them as required. *Burckhardt-Merian* recommended a teaspoonful of a 10 per cent. alcoholic solution of salicylic acid added to three pints of water, or a 5 per cent. solution of Glauber's salts. *Politzer* adds four or five drops of oil of turpentine to three pints of water. The author has often seen irritation of the structures, and even external otitis, result from the use of both salicylic acid and oil of turpentine. They should therefore be changed as soon as any marked sensitiveness appears.

The author uses cotton-wool or carbolised wool for drying and afterwards plugging the canal. Other suitably medicated wools may also be employed, such as iodoform or perchloride of mercury wool, or boracic gauze.

[1] Zeitschrift für Ohrenheilkunde, viii. Jahrg.

Amongst substances useful in otorrhœa, *finely powdered boric acid* takes the first place, and was first introduced into aural practice by *Bezold*.[1] The auditory canal is washed out with a boric acid solution, and all foreign matters removed as far as possible from the middle ear by inflation with the air-ball. The canal is then properly dried, a little of the powdered boric acid is blown in, and the canal plugged with cotton-wool. A fresh insufflation is made when the powder has disappeared, or turned yellow by the discharge. Boric acid is in most cases of otorrhœa more valuable than any other remedy hitherto employed. It does not form into a ball in the canal—as is the case, for instance, with the alum powder which *Politzer* recommends—and it does not irritate the structures. Nevertheless, it should be used with care, and not, as often happens, given to the patient to use as he pleases. The author has frequently seen instances of its great abuse by patients, in whom a painful and dangerous condition has been brought about by complete obliteration of the canal by the powder, with the formation of pus still going on in the middle ear. It is no answer to this objection that syringing out the ear will remove the powder. It is not every practitioner, and still less every patient, who can do this properly. The treatment must be controlled, where possible, by the aural surgeon, or he can accept no responsibility for results.

The author has often found recovery hastened by the injection of a 4 per cent. solution of boric acid into the Eustachian tube, in addition to the insufflation of the powder into the canal. To enhance the deodorising action of the boric acid, *Politzer* recommends the admixture of a little carbolic acid, or that the powder should be rubbed up with a little oil of turpentine. Powdered borax is as a rule less efficacious than boric acid. Still the author has seen a few instances in which boric acid proved unsuccessful, and the borax yielded good results. Powdered iodoform has been particularly recommended by *Rankin* and *Mathewson*,[2] *H. N. Spencer*,[3] and others. The author, with *Blau*,[4] finds it of some service in tubercular cases. It should be deodorised as far as possible, and used in the same way as boric acid. *Chisholm*[5] praises a mixture of equal parts of salicylic acid and light magnesia.

Stetter[6] found the odourless iodol recommended by *Mazzoni* similar in action

[1] "Zur antiseptischen Behandlung der Mittelohreiterung." Archiv für Ohrenheilkunde, xv. Bd. *Bezold* thinks so highly of its action that, should its continuous use for some time be without result, he looks upon this as a diagnostic point between simple otitis on the one hand, and tuberculous and scrofulous otitis on the other.

[2] Boston Med. and Surg. Journ., xcii., 21.

[3] Amer. Journ. of Otology, i., 870.

[4] Archiv für Ohrenheilkunde, xxiii.

[5] Philadelphia Med. and Surg. Reporter, xxxiii.

[6] "Ueber die therapeutischen Wirkungen des Iodols bei Ohreiterungen." Archiv für Ohrenheilkunde, B. xiii.

to iodoform. *Wagenhäuser*, and after him *Bürkner*,[1] recommend where other remedies have failed, and the perforation in the drum-membrane is very large, the red precipitate powder. According to *Gottstein*,[2] calomel is of more service in many cases than boric acid. He advises syringing out first with a 1 per cent. solution of corrosive sublimate after previous inflation of the middle ear with the air-ball. The canal is then to be dried with cotton-wool, the calomel blown in, and a cotton-wool plug inserted.

In the employment of different solutions, the choice is to be regulated in the first place with reference to their antiseptic action in cases where injurious micro-organisms are present in the inflammatory products. Other considerations are: any deodorising influence which may be required, and the possible occurrence of hæmorrhage.

In simple catarrhal exudation, the instillation of 10 drops two or three times a day of a lukewarm sulphate of zinc solution, which is allowed to remain in the ear for some minutes, is often sufficient to cure the otorrhœa, provided everything else is done which the state of the middle ear may demand (zinci sulph., 1 to 5 parts; distilled water and glycerine, of each 200 parts). The same holds good of the other astringents mentioned in connection with external otitis. The author frequently employs the gelatine preparations previously described, and can strongly recommend them. The objection which has been raised to them that they may block up the auditory canal does not hold if they are properly made. Those used by the author yield, when they liquify, a very watery, clear liquid, which is absorbed by the cotton-wool, or flows away. He has never observed any "plastering up of the auditory canal" such as has been stated to have occurred.

In obstinate cases of otorrhœa, and when the employment of the medicament must be entrusted to the patient himself, the author most often uses a solution of boric acid in water and alcohol (finely powdered boric acid, 1; distilled water, 30; rectified spirit, 5 to 30); or a solution of boric acid in pure alcohol. This last solution should always be introduced by the surgeon himself on the first occasion, as the spirit sometimes causes severe pain, and will necessitate the immediate syringing out of the canal with tepid water. It does not follow, however, that it should not be tried again, since it is found that the structures may become habituated to it. It even sometimes happens that the pain on a first application ceases after a very short time, and does not recur on continuing the remedy.

It is not improbable—it is even probable—that simple alcohol, which was first recommended, in otorrhœa associated with median otitis, by

[1] "Zur Behandlung der Ohreneiterung," Berliner klinische Wochenschrift, 1884.
[2] "Die Anwendung des Kalomels in der Behandlung der Otorrhœa." Zeitschrift für Ohrenheilkunde, Bd. xiii.

Weber-Liel, may be just as serviceable as a solution of boric acid in it. The author, however, believes that this is not so in all cases, and so considers the combination preferable. Next in importance to the boric-alcohol treatment is that by a concentrated solution of nitrate of silver, which was recently recommended by *Schwartze*, and is frequently employed by the author. This treatment is indicated especially in very obstinate cases, with extensive destruction of the tympanic membrane and great swelling of the mucous lining of the middle ear. After the ear has been freed from all foreign matters, some of a 10 per cent. solution of the crystals of the nitrate is poured into the ear, and the head inclined in different directions so as to bring the liquid as much as possible into contact with the various parts of the middle ear. It is then allowed to run out again, and the ear syringed several times with a solution of common salt, in order to neutralise any of the silver salt remaining.[1] Any pain which may ensue usually disappears very soon. Sometimes, however, patients object to the application, and a weaker solution may then be tried. If, after the concentrated solution has been used three times, the otorrhœa shows no diminution, its further use will probably be ineffectual.

To prevent blackening of the tissues by the silver solution, a small glass syringe should be used to introduce it into the canal, and it may afterwards be sucked out again by the same means. The canal should be plugged with cotton-wool, to absorb any of the solution which may remain, and finally the parts may be washed out with a concentrated solution of iodide of potassium.

Salicylic acid is warmly recommended by many authors. *Bezold*[2] advises its use when bacteria are present in abundance in the pus (ac. salicyl., 2 parts; rectified spirit and water, of each 50 parts). Carbolic acid is much less employed, as even a 1 per cent. solution sometimes causes acute irritation. Only in cases of extreme necessity does the author use a stronger solution than this, since further disagreeable accessory symptoms may be readily induced. *Walb*[3] recommends the introduction through a small tube of a few drops of a 4 per cent. solution of carbolic acid into the tympanic cavity. It is to be retained for two days by plugging the canal.

A solution of corrosive sublimate is in more general use than carbolic acid. It was first recommended by *Wagenhäuser*, and is often employed by the author in syphilitic cases (1 to 2 parts in 1000). Permanganate

[1] *Schwartze* observed in one case that the liquid introduced into the auditory canal passed through the Eustachian tube into the pharynx and thence into the other healthy tube. He therefore advises the head not to be moved into the horizontal plane during the process.

[2] "Die Salicylsäure in der Ohrenheilkunde." Monatsschrift für Ohrenheilkunde, ix. Bd., 8.

[3] "Zur Behandlung der Mittelohreiterung." Deutsche med. Wochenschrift, 1881.

of potash has a well-marked deodorising effect, and may be used in all strengths (0·1 to 1 per cent.). The author cannot say, however, that he has seen much improvement in regard to the otorrhœa either from this or from resorcin, which has been recommended by *De Rossi* (resorcin 1 part, water 100 parts). The neutral acetate of lead has been advocated in many quarters. The author uses it in 1 to 5 per cent. solutions in otorrhœa due to external otitis without perforation of the membrane, or in cases of median otitis only, if the loss of substance in the membrane should be very extensive. With small perforations it should be avoided, as it readily forms insoluble combinations with constituents of the discharge, which is then retained in the tympanum, and exercises a constant irritation.

Lange[1] praises aceto-tartrate of aluminium in 10 to 15 per cent. solutions. It should not be used stronger, as it may cause capillary hæmorrhage and swelling of the structures of the auditory canal. *Brandeis*[2] recommends boro-glyceride in 10 to 15 per cent. solutions, to be instilled two or three times a week. *Weber-Liel*[3] speaks of good results from tinct. thujæ occident. It is to be dropped into the ear, or the parts painted with it, or applied by a saturated cotton-wool plug. The author had previously prescribed it for granulations associated with otorrhœa. He has found thymol to be useless in a $\frac{1}{5}$ to 1 per cent. solution; while in greater strength it is very irritating. Lime-water alone, or with the addition of a little tincture of opium, was formerly much used.

Speaking generally, it may be said that these different remedies are effective, either quickly or not at all. The practice of the author is therefore not to employ the same substance for a longer time than two or three weeks, and then to change it if no improvement has taken place. He has also observed that a remedy which was at first apparently ineffective has sometimes proved serviceable, when resumed at a later period and in a weaker solution.

Polypoid proliferations of long standing are often the cause of a chronic otorrhœa, and must be suitably removed before applying any of the above remedies, as the latter are only exceptionally of any service in this condition. Further reference will be made to this matter.

With regard to perforations of the membrane following on a median otitis, it is to be observed that healing takes place as a rule only after cessation of the inflammation in the middle ear. The process of cicatri-

[1] "Ueber Aluminium acetico-tartaricum siccum und Aluminium acetico-glycerinatum siccum bei Affectionen des Nasen-Rachenraumes und des Larynx." Monatsschrift für Ohrenheilkunde, xix. Bd.

[2] "Behandlung der eiterigen Mittelohrerkrankungen mit Boroglycerid." Zeitschrift für Ohrenheilkunde, xii. Bd.

[3] Monatsschrift für Ohrenheilkunde, xvi. Jahrg.

sation is to be watched, and if necessary aided, according to what has previously been laid down on this subject.

C and D. Croupous and Diphtheritic Inflammations of the Middle Ear (Otitis media cruposa et diphtheritica).

These forms of inflammation are characterised by rapid destruction of tissue, and the formation of inflammatory products of firm consistence, which adhere closely to the subjacent structure. These products appear on the surface of the part as greyish-white, reticular membranes croupous membranes), and originate, according to *E. Wagner*, from coagulated epithelium. Such a process is spoken of as *croupous*, as distinguished from one implicating the tissue of the mucous membrane itself; and which, besides exudation from the vessels, is characterised by coagulation-necrosis of the tissue cells and leucocytes. The latter is known as *diphtheritic* inflammation. Both these forms are seen in the middle ear, and may be also *primary* or *secondary*. The primary disease is extremely rare: the secondary occurs generally as an extension of a similar process from the pharynx, chiefly as a sequela of scarlet fever.

The *etiological factors* of diphtheritic inflammation of the middle ear must be looked for in infective conditions and the action of chemical substances. *Klebs* and *Löffler* have demonstrated the presence of special bacterial organisms in diphtheria. *Gottstein's* view that in diphtheritis affecting the naso-pharyngeal region, infection may extend to the ear, by inflation with the air-ball, seems to the author to be well founded, and demands careful consideration.[1]

The author had the opportunity of observing an interesting case of acute primary diphtheria of the middle ear in a man who had been sprinkled with sulphuric acid. Some of it entered the ear, causing severe burns. When he came under treatment on the third day, the greater part of the tympanic membrane was destroyed, the structures of the middle and external ear highly inflamed, and partially covered with croupous membranes, which were very firmly adherent. The patient had violent fever, and for many days very severe pains, which abated only as the inflammation assumed a purulent form. He disappeared from treatment after seven weeks with a loss of substance in the central part of the drum-membrane, and a somewhat contracted auditory canal.

The *subjective symptoms* of croupous and of diphtheritic inflammation of the middle ear are similar to those of severe suppurative median otitis, and exhibit nothing specially characteristic.

The *objective appearances* likewise furnish clear diagnostic evidence only when the special inflammatory products are evident; and these are often wanting at the commencement of the disease, and in cases where

[1] "Beiträge zu der im Verlaufe der acuten Exantheme auftretenden Gehörsaffectionen." Archiv für Ohrenheilkunde, xvii. Bd.

the affection is limited to the Eustachian tubes or the mastoid cells. In a primary diphtheria it may also happen that the characteristic membranous formation may be present on the inner wall of the tympanum and be invisible, from the tympanic membrane remaining unperforated. Diphtheritic inflammation may likewise arise in the tympanic cavity in connection with a similar condition of the pharynx, while the Eustachian tube remains unaffected. Or the pharyngeal process may have already terminated when that of the tympanum commences. Here also therefore the diagnosis must be made independently of direct evidence of the disease. In such cases the presence of very severe pain in the ear lasting for days, with high fever, and the absence of other conditions to which the pain might be due, will point with some probability to the diagnosis; while in most cases the further course of the disease gives evidence of its existence. According to *Katz*,[1] severe febrile symptoms, with delirium appearing from the eighth to the fourteenth day in the course of scarlet fever, are probably to be connected with inflammation of the middle ear; and the absence of any remission of these symptoms after several days have elapsed will give reason to suspect the existence of a croupous process.

Küpper[2] found the cavity of the tympanum and the Eustachian tube filled with false membranes, like those present on the tongue and in the pharynx of a girl who had died from diphtheria, and had not suffered from either deafness or noises in the ear.

From a therapeutic standpoint the author desires to insist on the fact that by energetic treatment of the pharyngeal diphtheria much may be effected as regards the ear; and that here especially an early paracentesis is indicated. A large incision should be made, in order to facilitate the removal of the inflammatory products. The author finds the galvano-cautery very suitable in such cases, but like *Gottstein* has not seen good results from destruction of the membrane by caustics. An attempt to remove the false membranes should be made by injections or the brush, and if necessary by suitable instruments—*e.g.* sharp spoons, polypus-snares. For the relief of the pains, the author has found painting the parts with tincture of opium most useful; or the introduction into the ear of a mixture of this and lime-water (tinct. opii 2 to 5 parts to aq. calcis 10 parts). Cocain may also be tried. As caustic applications, the substances before mentioned may be used. In a case in which there was a simultaneous severe labyrinthine affection with deafness, *Wolf*[3] observed recovery

[1] "Ueber croupöse Entzündung des Mittelohres bei Scharlach." Berliner klin. Wochenschrift, 1884.

[2] "Sectionsbefunde." Archiv für Ohrenheilkunde, xi. Bd.

[3] "Zwei Fälle von schwerer Labyrintherkrankung bei Scarlatina-Diphtheritis." Zeitschrift für Ohrenheilkunde, 1885.

from the latter after the subcutaneous injection of pilocarpin. Lastly, every case of diphtheritic inflammation of the middle ear, when death does not intervene, passes over into the purulent form of median otitis, which is to be treated on the principles previously laid down.

2. Plastic Inflammation of the Middle Ear.

(*Otitis media plastica s. hyperplastica s. hypertrophica s. sclerotica s. sclerosis membranæ mucosæ auris mediæ.*)

This form of inflammation is characterised, as before mentioned, by a proclivity to the development of new tissue which but seldom undergoes a retrograde metamorphosis. In the previously described varieties of middle-ear inflammation, a more disintegrative tendency is to be observed; and while in certain cases the mucous membrane does regain its normal condition, it is on the other hand frequently destroyed to a variable extent, and generally replaced by cicatricial tissue. In the inflammatory process now under consideration, however, *an increase in bulk* of the inflamed structure is first of all perceived (hypertrophy, sclerosis).

We find in the catarrhal and purulent inflammation, besides an increase in the amount of intercellular fluid, a more or less consistent, mucous or purulent inflammatory product, the amount of which is in proportion to the intensity of the inflammatory process. In the plastic form of inflammation the intercellular fluid is at the most only slightly increased, or a very little serous exudation is found in the tympanic cavity; where, however, the plastic and exudative processes are combined, a more consistent inflammatory product, mucous or purulent, may be found in the middle ear.

Etiology and Course.—The affection owes its existence to the same causes as catarrhal otitis, but its course is always a more chronic one. It occurs generally after puberty and in later years, while the exudative forms appear more frequently in childhood. The constitutional condition also seems to influence the character of the inflammation, since the exudative process is found more often in delicate, anæmic individuals, whilst plastic inflammation attacks more plethoric, robust persons. There are, however, exceptions to this statement. Plastic inflammation in the naso-pharynx usually occasions similar affections of the middle ear. As in catarrh, both ears are generally involved, either simultaneously or after a short interval; and the course of the disease is usually the same on both sides.

The tissue elements arising from the inflammatory process, either in a limited area or diffused through a larger extent of the mucous membrane, undergo further development and entail various results. By

the growth and division of the cell-processes, which enter into the most diverse connections with similar processes of neighbouring cells, originates a variously arranged, more or less closely reticulated tissue, which either extends uniformly throughout the whole of the inflamed structure, leading thus to general hyperplasia of the mucous membrane; or, when the new formation has taken place in circumscribed patches, results in the development of isolated or multiple granular growths, or even distinct polypi.

In the further development of the newly formed tissue elements, they often leave the plane of their matrix, and grow in other directions. This is to a certain extent the case with the above-mentioned polypoid growths, but is shown more conspicuously in the connective-tissue bands and membranes found especially in the tympanum and in the mastoid cells, from which the most abnormal connections of the various structures of the middle ear may result.

Fig. 123.

Section of hypertrophied mucous membrane from the tympanum: it is more than five times the normal thickness.



Calcified masses are seen disseminated throughout the tissue: on the addition of hydrochloric acid they exhibited the characteristic reaction.

The formations arising from the plastic inflammatory process have a strong tendency to persist; sometimes, however, they undergo a retrograde metamorphosis, as shown in their molecular disintegration, fatty degeneration, and reabsorption. When the process is very chronic, they may likewise become calcified (Fig. 123). Even the blood-vessels and nerves may undergo changes. The former shrink and are transformed into connective-tissue cords, or suffer fatty degeneration, or calcify. The nerves may atrophy, become molecularly disintegrated, and the resulting material reabsorbed. The calcification, which may occur in the retrogressive process, may be extremely detrimental to the hearing capacity. If, for instance, such a change takes place in the membranes closing the fenestra ovalis and fenestra rotunda, or affects the articulations of the auditory ossicles, the sound-conducting power must be considerably impaired.

Subjective symptoms.—If the inflammatory process does not affect structures, the integrity of which is important in regard to the conduction of sound, it may exist for years without perceptible symptoms, and may subside without its previous presence having been recognised, though if the structures be subsequently examined the corresponding changes will be manifest.

It is otherwise when the disease attacks from the beginning, and with some intensity, the whole or a large section of the mucous membrane of

the middle ear. In such cases there is *never* any pain; at the most only a sensation of fulness and pressure in the ear. Deafness and noises in the ear, on the other hand, make their appearance at an early period, and are to be explained on the same lines as in other forms of middle-ear inflammation. It is the same with the giddiness and weakness of memory, of which these patients not unfrequently complain. These various symptoms are the more distressing from the fact that they are apt to be present more continuously than in other varieties of inflammation in which the objective morbid changes are more variable.

With rare exceptions, both the impairment of hearing and the subjective auditory sensations become progressively worse. This is due partly to the continuous development of the new tissue, partly to the secondary changes which take place in this. Among such changes are the shrinking which goes on in the new-formation, occasioning retraction of the different structures; the rigidity produced in the articulations; and the abnormal position of the ossicles which may follow. Not only is the function of the conducting apparatus thereby impaired, but secondary labyrinthine changes may likewise ensue.

The deafness in such cases, if it be of long duration, may be increased by atrophy of the auditory nerve from functional inactivity—a condition which is, in most of these patients, actually brought about.

The *objective appearances* in plastic inflammation of the middle ear are very diverse, in accordance with the parts implicated, the intensity of the morbid process, the previous condition of the ear affected, and the actual character of the inflammation—viz. whether it be purely hyperplastic, or combined with some other form.

In far-advanced processes, appearances are sometimes met with in the external auditory canal, which must be connected with the middle-ear disorder. Apart from a certain dryness of the skin, due to diminished secretion of cerumen, and respecting which patients often complain, a hypertrophy of the soft structures to a variable degree, and even of the osseous walls of the canal, may be recognised in severe cases. In the greater number of instances, however, the canal appears perfectly normal.

The same feeling of dryness is also experienced in the nose by many individuals who have been affected with this disease for a long time. The nasal mucous membrane is thickened, and no secretion takes place; so that these patients may not feel the necessity of blowing their nose for years.

Plastic inflammation of the middle ear rarely occurs without the Eustachian tube being involved in the morbid process. The lumen of the tube is thus found to be more or less narrowed, or even obliterated, and from this follow the previously described secondary changes in the

tympanic membrane and auditory ossicles: the drum-membrane sinks in, and the ossicles in consequence become displaced. The appearances as seen through the auditory canal will vary according to the condition of the mucous membrane of the tympanum and that of the drum-membrane itself.

In many cases intense hyperæmia is present for years in the mucous membrane of the inner wall of the tympanum, especially over the promontory; and this is visible through the tympanic membrane as a red or orange-coloured spot with blurred margin. When the Eustachian tube is narrowed, or the drum-membrane sinks inwards from other causes, it may come into contact with the promontory, and may even exercise so much pressure upon it as to squeeze the blood out of the vessels. The mucous membrane then becomes paler; and if this state of things lasts a long time, it may become adherent to the membrana tympani, and the process of the incus and head of the stapes may then become visible.

When the tympanic membrane is itself involved in the inflammatory process, it exhibits various appearances. If a new formation of tissue take place in its substance, it becomes either simply thickened, or may enter into abnormal connection with other structures if the newly formed tissue project from its surface. The attachments of false membranes or bands may be recognised as so many lighter-coloured, greyish-white points and spots on the tympanic membrane; while such of the new tissue as does not extend beyond its structure usually runs through it circularly or in a curved form, and is most often observed in that part where the circular fibres of the membrana propria are normally present in greatest abundance. The new formation appears situated between the layers of the membrana tympani, presenting the appearance of an independent, accurately circumscribed structure (Fig. 124), of a milky-white, lead-grey, or opalescent colour (Plate II., Figs. 25 and 26).

On account of the new connective-tissue bands by which, as before mentioned, abnormal connections are frequently brought about between the auditory ossicles and the membrana tympani, the relations of the different structures as seen through the auditory canal may appear variously altered. Thus, the malleus is sometimes found displaced in various ways, and occasionally the tissue may be distinctly seen which connects the descending process of the incus with the malleus, drawing this backwards. In other cases newly formed tissue may be recognised connecting the descending process of the incus with the posterior wall of the tympanum, or with the posterior-superior segment of the drum-membrane, and so on.

The membrane is not, however, always depressed; in some cases indeed, it loses its normal concavity and becomes more plane, especially in cases in which the Eustachian tube is little or not at all involved in the

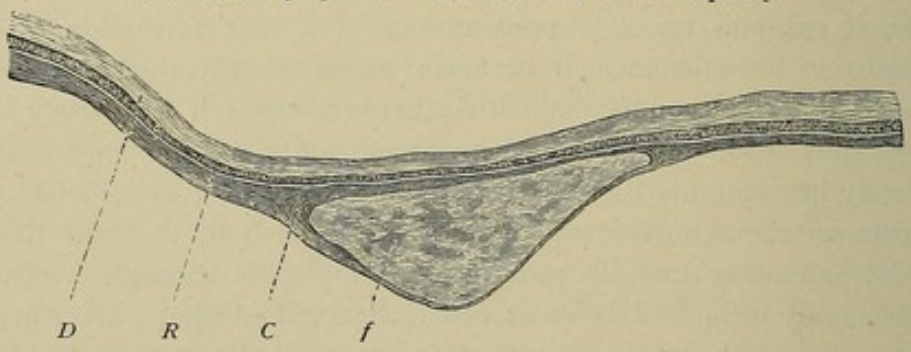
inflammation, but the tympanic membrane has become thickened. If the hyperplastic process has affected the entire membrane, it then becomes thickened and almost quite plane, the vessels being for the most part obliterated, and its appearance resembling that of parchment.

The new connective-tissue bands exhibit, as before mentioned, a tendency to contraction. The like is observed in regard to the tendinous structures, from which a shortening of these results, particularly of the tendon of the tensor tympani muscle (*Politzer*). The contraction of this tendon may have an important influence upon the entire course of the affection, on account of the displacement of the whole chain of auditory ossicles which ensues, and through which the intra-labyrinthine pressure-conditions become changed.

The author[1] has by his investigations shown that when the tensor

Fig. 124.

Section of a tympanic membrane with a circular opacity.



D, Dermis layer; *R*, radial layer; *C*, circular and mucous-membrane layers; *f*, connective-tissue new formation.

tympani muscle contracts, or its tendon is retracted, the malleus is not merely drawn inwards, but that, from the insertion of the tendon on the inner edge and anterior surface of the handle, the bone is swung somewhat round its long axis. The anterior surface being thus turned more inwards, and the posterior surface more outwards, the handle looks broader as seen through the auditory canal. This often occurs as a result of plastic median otitis, and is of some service as a diagnostic mark. Individual peculiarities in the insertion of the tendon, and in the structures in the vicinity of the malleus, modify its movements to some extent, and may therefore influence considerably the secondary consequences of such a retraction of the tendon, as well as alter in other ways the conditions visible on examination. Thus, for example, as a result of the tendon retraction, the handle of the malleus may be displaced in such a way that the tympanic membrane appears

[1] "Anatomisch-physiologische Studien über das Trommelfell und die Gehörknochelchen." Wien, 1867.

twisted ; the tensions of its various segments become altered, some being relaxed, many abnormally stretched, and others folded.

It has been previously mentioned that the newly formed tissue sometimes undergoes fatty degeneration, disintegration, and subsequent reabsorption. From such a reabsorption not only atrophy but even perforation of the drum-membrane may result. The changes occurring in the membrane during the course of time may be extreme ; a considerably thickened membrane exhibiting later, perhaps, signs of atrophy in places, and even perforation.

In the plastic, as in the catarrhal processes, the most diverse conditions may be associated, the explanation of which is not difficult on acquaintance with the pathology of the affection.

The *diagnosis* of this form of median otitis cannot at the commencement be determined with the degree of accuracy which is to be desired. It is usually only after some time that this is possible, as the characteristic objective appearances are not always to be made out with the requisite clearness.

The results of auscultation may throw light on the space-conditions of the Eustachian tube and tympanic cavity, but are only serviceable for diagnosis when connected with the results of other methods of examination. In those cases in which auscultation does not sufficiently elucidate the state of the Eustachian tube, tactile examination (by the bougie) should be adopted.

Since plastic median otitis may be circumscribed in extent, and may involve parts so situated that neither inspection nor other modes of examination may be able to furnish trustworthy data, the diagnosis will in such cases have to be made by way of exclusion.

From every other form of inflammation of the middle ear it is distinguished by the absence of exudation, so that its differentiation from these is not generally difficult. From a possible affection of the labyrinth, however, its distinction may be very difficult, and in certain, though rare cases, a probable diagnosis only is possible.

The history of the case should be carefully investigated. An association of ear disorder with other affections not unfrequently affords ground for the diagnosis. The presence of diseases which are commonly followed by ear troubles—as, for example, naso-pharyngeal affections, the acute exanthemata, tubercle, etc.—will favour the probability of a middle-ear inflammation ; while a co-existent cerebro-spinal disorder would point rather to a labyrinthine derangement. The sudden onset of an aural affection also, accompanied by great impairment of hearing, would tend to the diagnosis of labyrinthine disorder rather than plastic inflammation of the middle ear, since the latter disease could not make such progress in the course of a few hours or days as to bring about great deafness.

The absence or presence of sound-conduction by the cranial bones is of value only in ear affections of rapid development: a sudden disappearance of bone-conduction is not observed in cases of plastic middle-ear disease, but probably occurs in labyrinthine derangements. If the bone-conduction gradually disappears in the course of a chronic ear disorder, the symptom does not in itself supply trustworthy evidence for diagnosis. In general, however, it remains present longer in simple plastic median otitis than in primary labyrinthine disease.

Other symptoms, such as objective auditory sensations, vertigo, paracusis Willisii, may be either present or absent both in middle-ear inflammations and in affections of the labyrinth; they are therefore of little diagnostic value. It is only when all these symptoms come on suddenly, together with great loss of hearing, or when the subjective auditory sensations are such that they must be regarded as true hallucinations (hearing of voices), that we are compelled to look upon the condition as a deeper labyrinthine, or perhaps a cerebral disease.

A positive result with Weber's experiment tends to indicate the presence of middle-ear disorder; though it must be admitted that the same phenomenon may be exhibited in some cases of bilateral affection of the labyrinth.

Rinne's experiment is by itself less serviceable for differential diagnosis than Weber's. Thus, if a case be supposed in which there is some diminution of sound-conduction as a result of hyperplasia of the structures closing the fenestra ovalis and fenestra rotunda, while the condition of the labyrinth is still normal, Rinne's experiment yields a positive result, but the tuning-fork is heard to vibrate before the auditory canal for a shorter time than in a normal case. The same result may be imagined, however, in a case of early labyrinthine disease. If again Rinne's experiment should give a negative result, it is not difficult to conceive this with either one or other form of the aural diseases mentioned. It will therefore be seen that the experiment by itself does not give reliable evidence of the pathological condition.

According to *Bezold*,[1] with whom *Rohrer*[2] agrees, a negative result with Rinne's experiment in all bilateral aural affections in which the difference between the hearing distances on the two sides is not very considerable, is said to indicate the presence of an alteration in the sound-conducting apparatus. A normally long, or only slightly shortened positive result with the experiment, associated with greatly diminished hearing distance, together with negative results upon examination with the mirror and upon inflation, is said to exclude any material derangement

[1] Allgemeine Wiener medic. Zeitung, 1887, Nr. 13.
[2] *Ibidem.*

of the sound-conducting apparatus, whether the affection be bilateral or unilateral.

The author is aware from repeated experience that these statements are true in very many instances; nevertheless the exceptions to them are far too numerous to permit their acceptance as trustworthy diagnostic indications. He believes, however, that an affection of the sound-conducting apparatus may be inferred with perfect certainty when, with a positive result with Weber's experiment, Rinne's yields a negative, or a considerably shortened positive result. Rinne's experiment may to a certain extent be considered to corroborate or prove the diagnosis of an affection of the sound-conducting apparatus which has been arrived at as the result of Weber's experiment. That, however, the contrary statement does not hold—that is to say, that with a positive result with Rinne's, and a negative result with Weber's experiment, an affection of the sound-conducting apparatus cannot always be excluded—follows sufficiently from what has been previously stated.

The *prognosis* in plastic inflammation of the middle ear is upon the whole unfavourable, especially when the mucous membrane on the inner wall of the tympanum over the fenestra ovalis and fenestra rotunda is involved in the process. A cessation of the inflammation; a return to the normal state; or even the maintenance of a given condition without further progress in the morbid process, is but seldom observed. Even in cases in which the formation of new tissue-elements has ceased, it cannot be said that the morbid process stops, since the secondary changes brought about in the new formation, and consecutively also in the normal structures of the ear, aggravate the symptoms.

The constant presence of subjective auditory sensations which remain unrelieved by inflation of the middle ear, or Menière's symptoms, or paracusis Willisii, are circumstances which make the prognosis very unfavourable. In the great majority of cases we must be content to aim through our treatment at inducing a slower progress in the course of the affection, or at the removal or mitigation of the troublesome effects which originate from the products of the disease.

The *treatment* has for its objects the checking of the morbid process and the relief of the injurious results of the hyperplasia, so far as these may be possible. More especially is indicated the amelioration of any co-existent affections which are connected with the ear disease, as well as that of any possible external influences which may contribute to maintain the disorder. The regimen of the patient must be thoroughly regulated, and all things forbidden which might produce congestion of the head. In general, mountain air or high elevations agree with these patients.

In the stage of hyperæmia, local bleeding may give relief in plethoric persons and such as are prone to congestions, but the morbid process

cannot be cut short in this way. Methodical rarefaction of the air in the external auditory canal may render good service by reducing the hyperæmia of the deeper structures. It is most readily effected by the apparatus designed by the author: a small air-ball is connected with a tube about 50 *cm.* long, to the end of which a nozzle is fixed like that of an otoscopic tube. The air-ball having been compressed, the nozzle is inserted into the auditory canal, from which the air becomes exhausted when the air-ball is allowed to expand again. The nozzle is then removed from the canal, and the process repeated. With robust and corpulent individuals, the administration of saline waters is indicated—*e.g.* those of Marienbad, Carlsbad, Kissingen, or Vichy. Yearly courses of these waters assist in retarding the rapid progress of the disease.

If the mucous membrane of the Eustachian tube is implicated, endeavours should be made to maintain the passage open by inflation with the air-ball and the employment of bougies. The latter also, by the pressure they cause, tend to promote absorption. The inflation is useful likewise by putting the ossicles in motion, and preventing thus, to some extent, rigidity of their articulations or their complete ankylosis.

If the process is far advanced, extending over the entire mucous membrane of the tympanic cavity, the author is accustomed to make injections through the Eustachian tube of a solution of caustic potash (3 to 10 parts in 2000), daily or at longer intervals. Similarly, 2 to 5 per cent. solutions of iodide of potassium, or a 1 per cent. solution of carbonate of soda, may be employed. The author has occasionally found injections of very dilute acetic acid of some use. The vapours of acetic ether, iodic ether, or of sal-ammoniac, have also sometimes been found serviceable; as well as weak solutions of corrosive-sublimate in syphilitic cases (1 to 2 parts in 2000). In cases of extreme sclerosis associated with great impairment of hearing, one may, if all other remedies fail, try direct injection according to the author's method, without a catheter, of a 1 per cent. solution of iodide of potassium or carbonate of soda. This treatment has for its aim the promotion of absorption by stimulation of the mucous membrane. In isolated instances the author has seen severe purulent perforative inflammation follow, and in most cases there has been no good result worth mentioning. In many, however, the treatment has been brilliantly successful. The author employs it only after having fully acquainted the patient with it, and obtained his acquiescence. He formerly injected a concentrated solution of nitrate of silver, but has now given it up. More can be done as regards the sequelæ of the plastic process, and of this further mention will be made more in detail later.

CHAPTER XII.

INFLAMMATION OF THE PERIOSTEUM OF THE MASTOID REGION (PERIOSTITIS PARTIS MASTOIDEÆ OSSIS TEMPORIS).

Circumscribed and diffuse inflammations of the skin of the mastoid region, so long as they do not extend to the deeper structures, are of no importance in regard to the ear. It is however different, if the deeper tissues, especially the periosteum, become inflamed. In that case not only may the auditory function be damaged, but even the life of the patient may be seriously endangered. On these grounds, therefore, a more detailed description is necessary.

A *primary* periostitis in this region is of very rare occurrence (*Jacoby*,[1] *Voltolini*,[2] *Williams*,[3] *J. Neumann*,[4] and others). When it does occur it is usually from traumatic causes, rarely from cold; and the process is not confined generally to the periosteum, but affects all the soft tissues of the region.

Secondary periostitis, on the other hand, is of frequent occurrence in connection with inflammatory processes of the aural structures.

The extension of inflammation to the periosteum in the region of the mastoid process is greatly favoured by the anatomical relations of the part. The soft structures of the posterior-superior wall of the external auditory canal are in continuity with those of the mastoid portion of the bone, and in this way an inflammation in the canal is very readily propagated to the periosteum covering the mastoid process. An inflammation established in the lining membrane of the mastoid cells may extend itself without further implication of the bone, by way of the squamo-mastoid fissure which was first described by the author; or by the interstices left after its incomplete closure; or, again, by accidental fissures.

The anatomy of the region explains also the greater frequency of this affection in children compared with adults. In early life the osseous

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[1] "Zur Casuistik der primären und secundären Periostitis und Ostitis des Processus mastoideus." Archiv für Ohrenheilkunde, xvi. Bd., S. 286, u. ff.

[2] Monatsschrift für Ohrenheilkunde, etc., xi. Jahrg.

[3] "Ein Fall primärer Periostitis des Warzenfortsatzes." Zeitschrift für Ohrenheilkunde, xiii. Bd.

[4] Allgemeine Wiener medicinische Zeitung, 1885.

portion of the auditory canal is not only much shorter than in later years, but the union of the squamous with the petrous part of the temporal bone is in infancy brought about by soft tissues. Through these an inflammatory process in the auditory canal may at this period extend itself much more readily than at a more advanced stage in the development of the bone.

Etiology.—Under the conditions present in inflammations of the ear, a periostitis of the mastoid portion may become developed without the intervention of any special injurious influence. Its appearance is nevertheless greatly favoured by certain external causes, especially by taking cold, and by injudicious treatment of any inflammation already present, as by the employment of hot vapours, poultices, and fomentations to the ear, or the application of sinapisms or vesicants to the mastoid region.

Symptoms and Course.—The *subjective symptoms* of a periostitis of the mastoid region can rarely be observed by themselves, since the disease is usually secondary to some other inflammatory affection. They consist in a feeling of tension or intense pain. The pain is shooting or throbbing in character, is generally much increased on pressure, and continues till the pus finds its escape. From the commencement till its decline the inflammation is almost invariably accompanied by high fever, commencing not uncommonly with one or more rigors. Where the primary inflammation of the ear is attended with fever, this is increased upon the extension of the inflammatory process to the mastoid portion of the bone. Cases which run their course without any fever are of exceedingly rare occurrence.

The above-mentioned symptoms may naturally be accompanied by many others, which depend either upon co-existent affections of different regions of the ear, or upon a sympathetic disorder of the brain and its membranes.

The *objective appearances* are so readily recognised from the superficial position of the part, and are so characteristic, that a mistake in diagnosis is scarcely possible. When extension takes place from the external auditory canal, the periostitis is usually first recognised by swelling and redness of the soft tissues near the insertion of the auricle. The folds of the skin become smoothed out; and if the inflammatory process does not recede, the redness and intumescence extend rapidly over the mastoid region, often beyond this to the scalp, and forwards over the temporal and frontal regions. The skin becomes more and more reddened, shining, hot to the touch, and extremely sensitive; and the position of the auricle becomes altered in so characteristic a way as at once to arouse suspicion of the presence of the disease. The great swelling of the soft parts pushes the auricle forwards, and causes it to stand out from the side of the head more or less at a right angle. Its posterior surface becomes apparently smaller, and it becomes as a whole more concave from the swelling of the

soft tissues above and below. In severe cases, œdema of the skin in the vicinity usually appears, as well as swelling of the neighbouring glands. The œdema, which also spreads when the inflammation runs high, is sometimes so extreme that the patient is unable to open his eyes on account of the great tumefaction of the eyelids.

When the periostitis is associated with an otitis media, the skin remains unaffected for a longer time; the swelling over the mastoid process is more diffuse, and only later implicates the tissues at the place of attachment of the auricle; then consequently the before-mentioned characteristic position of the auricle is less conspicuous.

If the inflammatory process does not now recede, but suppuration becomes established, then both the symptoms and the objective appearances become more prominent. The swelling goes on increasing, and fluctuation becomes perceptible to a greater or less extent according to the more or less superficial situation of the pus and the size of the inflamed area. It should however be remarked, that in all cases in which the inflammatory exudation takes place between the periosteum and the bone, the objective signs may exhibit many variations from those usually seen, on account of the very intimate adhesion which exists between the mastoid process and the thickened fascia-like periosteum. This is especially so in regard to fluctuation, which in such cases may not be recognisable even when a large accumulation of pus is present: in many such instances merely an extreme elasticity may be felt. Inflammatory œdema, the result of circulatory derangement from tension of the tissues, will however raise a suspicion of the existence of suppuration in the deeper parts.

If the pus is not evacuated, the skin becomes livid, and may become gangrenous over a larger or smaller area. If again the superjacent structures are very tough and resistent, the pus may seek an outlet by way of the external auditory canal, which then becomes filled with it when pressure is made upon the inflammatory swelling. In certain cases, the author has observed the discharge of the pus through the Eustachian tube into the throat and nose when pressure was made upon the mastoid region, and in almost all these instances there was a simultaneous discharge through a perforation in the tympanic membrane.

As a consequence of the suppurative process, especially if the periosteum becomes separated from the bone, the latter readily undergoes necrosis, a result favoured by the spongy nature of this part of the temporal bone.

Periostitis of the mastoid region is, as already stated, usually a secondary affection. It may nevertheless, in its turn, set up otitis media and interna, and even an inflammation of the brain and meninges with all their consequences. It is not at all an uncommon occurrence for a purulent inflammation of the lining membrane of the mastoid cells to result

from a periostitis of the mastoid region which has proceeded from an external otitis.

In the extension of the periosteal inflammation to the intra-cranial structures, an important part is played by the vessels and connective-tissue tracts which pass through the mastoid foramina. The morbid process proceeds along these tissues first to the sinus sigmoideus, and thence may spread to the brain and its membranes, in which may become developed all the consequences previously described in connection with purulent median otitis.

Pyæmia also may arise from such a condition, and many cases have been recorded in which death resulted from this cause.

Prognosis.—As a rule recovery takes place in the great majority of these cases, even when of secondary origin. The dangerous conditions previously mentioned usually only occur in persons whose general condition is much lowered from some cause or another, or who have been very badly treated.

Even an actual implication of the bone may be satisfactorily held in check, provided the constitutional state of the patient does not favour its progress. In cases in which, after opening an abscess, the bone is found to be denuded for a considerable extent, the soft parts may nevertheless become again adherent, and regain their normal relations with the bone, if judicious treatment be employed. Should, however, the periostitis be associated with actual disease of the osseous substance, the prognosis will then relate to the pathological conditions of caries and necrosis. For the rest, the probable course and result will depend upon the existence of other possible affections, particularly of the ear.

Treatment.—This, from the commencement, should be stringently antiphlogistic. If energetically carried out in the stage of hyperæmia, and the conditions present are not exceptionally unfavourable, the inflammatory process will usually recede, especially in cases in which it has arisen by extension from the external auditory canal. When the periostitis spreads from the mastoid cells, however, so favourable a result is less likely to occur. The application of cold, as described in connection with external otitis (Leiter's cooling apparatus), combined with such other suitable measures, local and general, as may be called for by the symptoms, will generally yield favourable results.

When the hyperæmia is intense, local, or in proper cases, general bleeding is indicated. Local bleeding is most conveniently performed according to Wilde's method, which consists in making an incision 2 to 4 *cm.* long through the inflamed parts down to the bone. Care must be taken not to cut the auricular artery, the position of which should, if possible, be determined beforehand. The author usually makes the incision at a distance of from 5 to 10 *mm.* from the attachment of the

auricle. The bleeding should be kept up as long as required; some iodoform gauze being then placed in the wound, and a suitable dressing applied. The great advantage of this mode of treatment lies in the fact that not only does the incision bring considerable relief by the relaxation of the tissues, and that suppuration is usually prevented, but that if, nevertheless, pus should form, an easy outlet is thus provided for it. The ready escape of the pus is the more important, since it is often formed very deeply, and in the course of spontaneous evacuation would be met by considerable resistance from the superjacent structures, whereby the bone would be the more likely to suffer. Leeches may be applied in suitable number below the mastoid process with patients who are afraid of the knife.

If the antiphlogistic treatment fail to arrest the progress of the inflammation, endeavours should be made to limit the suppuration, and to provide an outlet for the escape of the pus as soon as possible. Tincture of iodine, either pure or mixed with tincture of opium, may be painted over the inflamed area, or in its immediate vicinity; and ice applications may still be continued to the part, which should be first covered with some waterproof material.

If pus has formed, it should be evacuated as soon as possible, and with proper precautions. As with all other abscesses, the opening should be made with reference to the free discharge of the pus, and to its escape under the influence of gravity. In applying now these considerations to the case of retro-auricular abscesses, it will be manifest that with some of them an opening will be indicated through the external auditory canal; while with others it should be behind the auricle in the mastoid region. The author has, as a guide for his practice, formulated the following rules, derived from his own experience :—

Abscesses in the neighbourhood of the upper third of the auricle are to be opened from the external auditory canal, unless any special circumstances should indicate another situation. Those in the region of the lower two-thirds of the auricle, on the other hand, should be opened externally over the mastoid process.

These principles the author adheres to when the abscess has already discharged spontaneously, or has been opened injudiciously in either situation. For example, if an abscess behind the lower two-thirds of the auricle has discharged through the auditory canal, and recovery appears retarded, his practice is to make another opening externally.

An acquaintance with the simplest rules of surgery, together with a consideration of the anatomical relations of the external auditory canal and the neighbouring region, will make it clear that a neglect of the above principles may entail the most serious dangers. The author is convinced that a large number of the bone affections ensuing upon a periostitis might

have been avoided if the abscess had been opened in a proper manner. The incision sometimes has to be made very deep, in order that it may reach the abscess. In general, the opening should be made as large as possible, in order to favour the rapid escape of the pus, as well as to facilitate the evacuation of possibly several suppurating cavities which are very apt to co-exist in this situation. A free incision is also advantageous should the bone itself be likewise affected.

After the pus has been evacuated, a careful examination must be made with the probe, more especially with the view of discovering the state of the bone—as to whether it be actually affected, or whether only denuded of periosteum. Further, it may be determined whether any bone sequestra be present; whether, too, the suppurating focus communicate with the mastoid cells or with the auditory canal; whether perhaps the soft structures of the auditory canal be loosened from the subjacent bone, and so forth.

If there be only simple periostitis without any disease of the bone, the cavity of the abscess should, after evacuation of the pus, be washed out with some antiseptic solution, a drainage tube then inserted, and a dressing applied. With large abscesses, especially if the bone is denuded, it is advisable to apply pressure from the upper parts and periphery towards the opening, by means of a suitable dressing. If the parts in the vicinity of the abscess-cavity should remain infiltrated they may be painted over with iodine with the view of inducing absorption.

The re-adhesion of the soft parts with the bone will be greatly favoured by the application of pressure by an appropriate dressing and bandage. Cotton-wool pads of suitable size and shape should be placed over the affected parts, and secured by circular turns of a bandage round the head. The pads are to be arranged in such a way that the pressure will be from the peripheral parts towards the abscess-opening; and if a drainage tube has been placed in this, the dressing may remain on for twenty-four hours, or even longer, without any injury. The good effect of pressure is also sometimes seen where the soft parts of the auditory canal are loosened from the bone: the canal is to be plugged in these cases. If the pressure cannot be borne on account of the pain it causes, the dressing must be removed and re-adjusted. With very profuse suppuration, suitable solutions may be employed in dressing the wound.

If on examination with the probe the bone itself appear to be attacked, the incision should be kept open, and the condition treated on ordinary surgical principles. Should the abscess over the bone be associated with pus formation in the mastoid cells, which is not discharged by way of the Eustachian tube, then an incision through the mastoid process will be indicated. Further mention will be made of this operation.

By many authors an independent primary inflammation of the mastoid process, without primary affection of the periosteum or inflammation of the middle ear, has been described: *Buck* ("Condensing Ostitis of the Mastoid Process," New York Med. Record, 1883); *Agnew*; *Orne Green* (Report of the First Congress of the Amer. Otol. Society); *Hartmann* (Zeitschrift für Ohrenheilkunde, vol. viii.); and others. The author has never observed such a circumscribed primary inflammation of the mastoid process; but he has seen many cases of middle-ear inflammation associated with a mastoid affection, in which the symptoms of the latter were the prominent ones; also cases in which the symptoms of mastoid inflammation occurring in the course of a median otitis remained present for some time after symptoms of inflammation of the other parts had disappeared.

CHAPTER XIII.

CARIES AND NECROSIS OF THE TEMPORAL BONE AND OF THE AUDITORY OSSICLES.

The most frequent proximate causes of caries and necrosis of the temporal bone are found in purulent inflammatory processes affecting either the bone itself or its periosteum. A purulent meningitis may likewise favour the occurrence of these affections, since the dura mater also plays the part of periosteum. Such cases, nevertheless, are very rare.

In the great majority of cases these diseases are due to a periostitis occurring in the course of an external or of a suppurative median otitis. They are seldom of primary origin in the bone itself.

The greater vascularity of the periosteum covering the temporal bone in early years, as well as the abundance and large size of the branches communicating with the interior of the bone, which is then less compact in its structure, furnish the explanation of the relatively greater frequency of these affections in children. The circumstance, too, that a strumous tendency, which generally favours caries and necrosis, is more frequently active in childhood, may be another reason for their more common occurrence at this period of life.

These processes are very rarely seen in perfectly healthy individuals, but when they are observed the causes are usually manifest. Among such may be mentioned imperfect cleansing of affected structures, with consequent decomposition of the inflammatory products; the invasion of noxious micro-organisms; and accidental obliteration of blood-vessels, or their separation from the bone with entailed arrest of nutrition.

Struma, tubercle, and syphilis are the chief constitutional conditions by which the development of caries and necrosis is promoted. Anæmia, likewise, and certain neuropathic affections, sometimes favour their occurrence. Inflammatory aural affections coming on after long-standing and exhausting diseases, and which at first may have exhibited only insignificant symptoms, may lead to grave disease of the temporal bone, even where no morbid constitutional state exists. In this way may be explained the bone affections which often follow upon a trifling middle-ear catarrh

occurring in scarlet or typhoid fever, with sometimes even a fatal result.

Primary inflammation of the bony matter of the auditory ossicles is extremely rare;[1] but they often become affected secondarily. Suppurative inflammations of the middle ear, especially in scarlatinal diphtheria, may lead to destructive processes in the auditory ossicles, since the affected mucous membrane acts the part of periosteum in relation to them, and assists in the construction of their articulations. Inflammations of the tympanic membrane, conveying as it does the principal blood-vessels to the handle of the malleus, may, under certain circumstances, lead to the destruction or obliteration of these vessels, and to consequent necrosis of the bone. With a perforation also of Shrapnell's membrane, carious inflammation of the upper parts of the malleus and incus may be brought about by the impediment to the escape of the pus, as well as by the influence of deleterious micro-organisms.

The behaviour of the auditory ossicles when affected by these processes resembles on the whole that of other "long bones": the articular ends, like the epiphyses, are attacked more often by caries; while their processes, like the diaphyses of the long bones, suffer rather from necrosis. In the latter case, portions crumble off; in the former, lacunar disintegration and partial or total destruction occurs. The parts which are most often destroyed by necrosis are the lowest portion or the whole of the handle of the malleus, and portions of the process of the incus: the articular extremities may meanwhile remain intact; or, on the other hand, they may be affected in a certain measure without entirely losing their vitality. Partial destruction of the upper extremities of these little bones results sometimes in very peculiar conditions. For example, the author possesses an incus from a patient suffering from caries, the crown of which exhibits a canal passing obliquely through it, due to the carious process, whilst the rest of the bone is unaffected. Cases, again, are tolerably common in which the head of the malleus, or the crown of the incus, appears hollowed out into a cup-like shape. Others even are met with in which the articular extremity of the malleus has been completely lost, while the handle still remains in its normal connection with the drum-membrane.

Since in the various inflammatory processes affecting the ear, the tympanic membrane is very frequently involved, and is often destroyed,

[1] *Oscar Wolf* reports a case in which he observed a primary osteitis of the malleus with its resulting necrosis and separation ("Mittheilungen über die necrotische exfoliation der Gehörknöchelchen." Zeitschrift für Ohrenheilkunde, Bd. x.). The patient had suffered with otorrhœa for five months, and some granulations in the region of Shrapnell's membrane were removed with a sharp spoon. The malleus came away on the ear being subsequently syringed out. Its head was carious, and the handle had partly disappeared from necrosis. *Moos* also reports a case of lacunar caries of the handle of the malleus in vol. xiv. of the Zeitschrift für Ohrenheilkunde.

it is natural that the hammer should most frequently suffer from caries or necrosis. On account, however, of the intimate connections of the malleus with the incus, the latter usually becomes likewise implicated; while the stapes, on the other hand, is much more likely to be spared. If the stapes be affected however, only the crura suffer as a rule; the base, so important in relation to the hearing faculty, being longest preserved.

With regard to the relative frequency with which the different parts of the temporal bone are attacked, the following scale represents the experience of the author in this matter:—The mastoid process is most frequently affected; next to this comes the roof of the tympanum; then the external auditory canal, most often on its posterior wall; then that part of the inner wall of the mastoid portion which displays the sulcus sigmoideus; less often the floor of the tympanum and the posterior wall of the carotid canal; and least frequently the proper petrous portion of the bone. Naturally several of these parts may suffer at the same time, and cases have even been observed in which the entire temporal bone was destroyed by caries and necrosis.

Bezold[1] gives a report of 111 cases of affection of the temporal bone. In 76 cases the mastoid portion was either the exclusive seat of disease or was involved in it. In 42 of these cases it was limited to the mastoid process; in 34 it had extended farther from it, or had encroached upon it from the adjacent parts. Of the 42 cases in which the disease was limited to the mastoid process, caries existed in 15, caries necrotica in 16, and necrosis in 11; while of the other 34 cases, caries was present 20 times, caries necrotica 10 times, and necrosis 4 times.

If the petrous portion of the bone be involved in the morbid process, it may happen that certain portions of the labyrinthine capsule become ulcerated away from the tympanum. Thus, the promontory may be completely or partially destroyed by caries, or the canalis Fallopii may be opened up. It is, however, rarer for larger portions of the pars petrosa to become necrosed and separated from their connections.

The origin and course of caries and necrosis of the temporal is just the same as in other bones. If the process proceeds from inflammation in the interior of the bone, disintegration of the osseous matter and bone-abscesses results (central caries): larger or smaller pieces of bone may become loosened from their connections, and then lie as sequestra in the suppurating area, or may be accidentally carried to other situations (caries necrotica). Such a course is usually taken in the more spongy parts of the bone—*e.g.* in the mastoid portion.

Inflammation arising in the periosteum and affecting the bone secondarily runs a similar course. The osteoclasts from the innermost

[1] "Erkrankungen des Warzentheiles." Archiv für Ohrenheilkunde, Bd. xiii., S. 43, u. ff.

layer of the periosteum bring about disintegration of the contiguous bony matter (lacunæ); or a larger or smaller portion of bone becomes necrosed by deprivation of its nutrient vessels due to pressure of an abundant accumulation of pus between the bone and periosteum. This is generally the case in the petrous portion, the periosteum of which is sometimes loosened from the bone to a considerable extent.

It is particularly noteworthy that inflammatory processes originating from the middle ear, and subsequently leading to caries and necrosis of the mastoid portion, sometimes before doing so, affect in the first place the external surface of this region of the bone, from which the deeper parts become involved later. The author has observed such a course more often in children, though it also occurs with adults. The possibility of such a mode of extension should not be overlooked in reference to treatment.

The *subjective symptoms* present nothing characteristic. They agree almost completely in nature, duration, and even in locality with those associated with purulent inflammatory processes of the various aural structures. As with these, the nature of the pain and the other symptoms may vary very much, in accordance with the acute or chronic course of the disease, and with the structure affected. A carious or necrotic process may go on in the temporal bone for months, or even for years, without occasioning much pain; while in other cases agonising pains may be present from the commencement to the termination of the disease. The same is true as regards the other symptoms occurring with the suppurative median otitis which may accompany the bone affection. In some cases complete deafness may exist, with or without subjective auditory sensations; while in others, the impairment of hearing and the noises in the ears may be quite absent. This will depend chiefly upon whether or not the auditory nerve is implicated in the bone disease.

From what has been said it will appear that the subjective symptoms afford no reliable basis for diagnosis; and since even the *objective signs* are also sometimes indeterminate int his respect, it follows that in certain cases we shall be unable to assert conclusively whether disease of the bone is present or not. The diagnosis will be most perfect when signs of a bone affection are discovered by the probe; but as this is not always possible even when such disease exists, we shall in doubtful cases have to fall back upon indications derived from a consideration of the symptoms taken as a whole.

Particular attention is to be paid to the following points:—(1) The actual condition of the bone itself; (2) the character of the pus and of any granulations present, especially such as appear in fistulous openings; (3) the condition of the lymphatic glands around the suppurating area; (4) the state of fistulous canals leading to abscess-cavities; (5) the condition of the

soft structures of the auditory canal, and of those covering the mastoid process: long-standing or frequently recurring swelling of these tissues, especially if accompanied with recurrent abscess-formation, is often associated with caries of the region; (6) the duration of the disease, and the general condition of the patient; (7) paralysis of parts supplied by nerves which run either through or in the vicinity of the temporal bone; and (8), as very important, the presence of particles of bone in the discharge.

The last sign constitutes an absolute indication of an affection of the bone. With every case of caries or necrosis—in the latter, it is true, only at an advanced stage of the disease, when the so-called limiting caries becomes established, but in *caries* throughout its entire course—more or less fine particles of bone (bone-sand) are carried away in the discharge. They may be recognised by the microscope, and when unequivocally derived from the affected structures, furnish certain evidence of the existence of caries. A negative result from a single examination of the discharge, however, by no means justifies the exclusion of bone disease, and the pus must be examined at different times in order that a trustworthy conclusion may be arrived at. A microscopical examination is however sometimes unnecessary, as the osseous particles may be perhaps recognised on simple inspection when a fistulous canal is syringed out, or they may possibly even be detected in the discharge by the finger.

With regard to any symptoms of paralysis of the facial nerve which may be present, the association of an otorrhœa with these has always been regarded by surgeons as of diagnostic significance in respect of an affection of the temporal bone. The paralytic affection was regarded as connected with changes in the nerve brought about through destruction of the walls of the Fallopian canal, and this is actually correct in a large number of such cases. It has, however, been settled, both from clinical and from post-mortem observations, that such a paralysis may arise without any osseous affection whatever, through a simple serous or other exudation in the Fallopian canal; or by a congenital or acquired defect of the bony wall of the horizontal part of the canal; or again from simple pressure of an exudation in the tympanic cavity; or from a neoplasm. The same symptoms may likewise be caused by a co-existent independent affection situated within the cranial cavity. It will thus be seen that the value of paralysis of the facial nerve as a diagnostic mark of caries is considerably lessened. Nevertheless, it should always be regarded as a suspicious symptom.

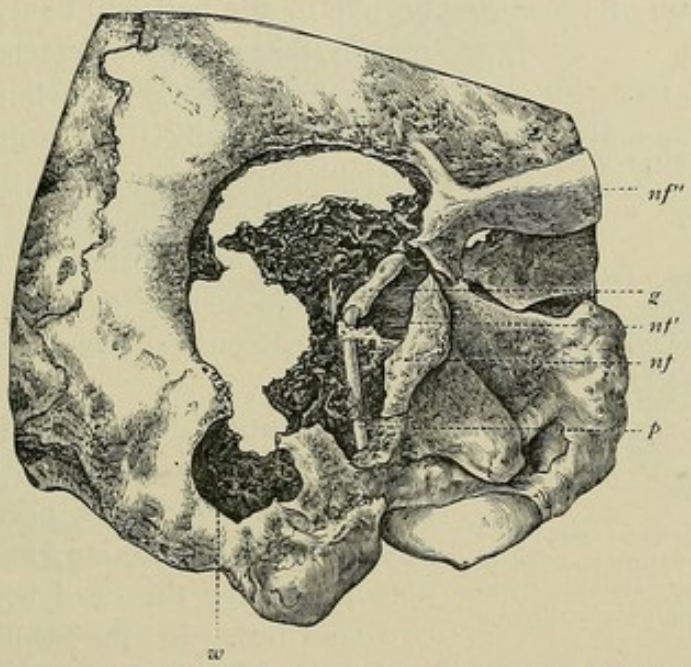
Particular emphasis must, however, in this connection be laid upon the fact that the absence of a facial paralysis does not in the least tend to show that caries of the temporal bone is not present, or that the Fallopian canal is not affected. The author had the opportunity of observing a case in the general hospital in Vienna under the care of *Standthartner*, a

preparation from which is represented in Fig. 125. In this both the horizontal and the descending portion of the *canalis Fallopii* were completely destroyed, and the nerve was for a long period bathed by the pus. On the descending part of the nerve even the sheath was absent, yet not a trace of paralysis was observed during the whole course of the disease. The patient remained under the author's observation from Aug. 6th, 1862, until Dec. 21st of the same year, when he died from hæmorrhage from the bowel.

Long-standing tumefaction in the neighbourhood of the apex of the

Fig. 125.

Carious temporal bone (external view).



p, Zygomatic process; *nf*, *nf'*, *nf''*, facial nerve (at *nf* its sheath is still preserved, but elsewhere destroyed); *g*, anterior wall of the osseous external auditory canal. On account of the great destruction of bone, the tympanum, external auditory canal, and mastoid cells are merged into a large abscess-cavity communicating with the cavity of the cranium: in this abscess-cavity the facial nerve lies exposed; *w*, remains of the mastoid process.

mastoid process is of much diagnostic importance in relation to caries. It is usually dependent on gravitation of pus derived from carious disease on the inner aspect of the process, or in the region of the incisura mastoidea. A careful examination of the region should never be omitted, especially in cases of middle-ear affections of long duration, since the swelling is sometimes very slight in the beginning, and may therefore be readily overlooked.[1]

The after course of caries and necrosis depends mainly upon the site of the disease, the general condition of the patient, and upon his age in its

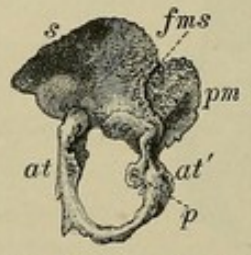
[1] Compare *Bezold*, "Erkrankungen des Warzentheiles." Archiv für Ohrenheilkunde xiii. Bd.

relation to the stage of development of the temporal bone. In very young children, the disease takes usually a more acute course than in older patients. At a somewhat later age, the necrosed bone is usually thrown off more easily, though sometimes even then the process becomes very chronic, and ends ultimately either in recovery after exfoliation of all the diseased parts, or else terminates fatally in some way. Death may ensue upon an intra-cranial inflammation; or pyæmia; or it may be due to exhaustion from prolonged suppuration; or damage to nerves, the integrity of which is essential to life; or lastly, it may result from hæmorrhage caused by ulceration of large blood-vessels—*e.g.* the carotid artery, jugular vein, or sinus sigmoideus.

Exfoliation of a necrosed portion of the temporal bone, as in all other regions, takes place by detachment of obvious sequestra, or of very small particles (bone-sand). Generally it is large pieces of the mastoid portion which are thus thrown off, but sometimes parts also of the squamous or of the petrous portion become separated; while instances have even occurred in which the entire temporal bone became gradually destroyed.

Fig. 126.

Annulus tympanicus, with part of the squama and pars mastoidea (exfoliated through the external auditory canal).



s, Pars squamosa; *pm*, pars mastoidea; *fms*, fissura mastoideo-squamosa; *at*, *at*,' annulus tympanicus; *p*, osseous outgrowth from the tympanic ring.

The natural fissures and sutures of the bone have an unmistakable influence upon the delimitation of the necrosing process. Cases nevertheless occur, as *Hartmann* has noted, in which the dead bone is not thus circumscribed. In the sequestrum represented in Fig. 126, which was removed by the author from the external auditory canal of a syphilitic child suffering from otorrhœa, the mastoideo-squamosal fissure is seen within the necrosed piece of bone.[1]

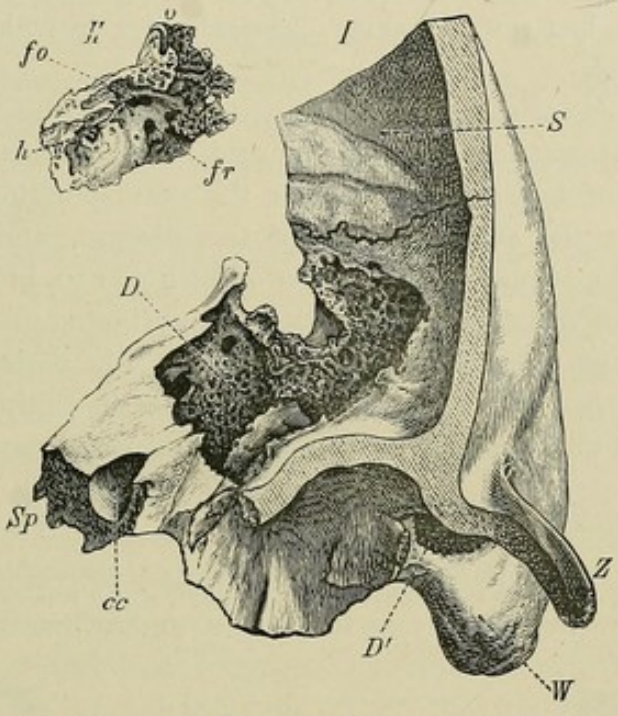
The more compact portions of bone are usually thrown off as sequestra on account of the greater facility with which the spongy substance breaks down. For this reason parts of the labyrinthine capsule are sometimes found exfoliated. In a phthisical patient aged forty-two, who was under the care of the author, and who had suffered for many years from suppurative middle-ear disease, paralysis of the facial nerve appeared five weeks before he died. The changes in the bone are represented in

[1] Besides the preparation here referred to, the author possesses a similar one which he removed from an abscess which had developed behind the auricle of a child nine months old. Both sequestra represent the complete annulus tympanicus, a part of the squamous portion, and a small part of the posterior section of the pyramidal portion of the bone. Recovery ensued in both cases, and the facial paralysis, present in both during the course of the disease, completely disappeared.

Fig. 127. The pyramid showed caries necrotica, through which the entire bony labyrinth was separated from its connections, and lay as a sequestrum in the suppurating cavity.

Fig. 127.

I. Carious temporal bone. II. Sequestrum.



S, Squama; *W*, mastoid process; *Sp*, apex of the pyramid; *cc*, internal opening of the carotid canal; *Z*, zygomatic process; *D*, *D*,' a large cavity caused by caries necrotica, in which the sequestrum (II) lay quite loose. On the sequestrum is seen: *fo*, foramen ovale; *fr*, the recess of the foramen rotundum; *o*, superior semicircular canal opened up; *h*, apex of the cochlea, also open in the uppermost coil of the hamulus Scarpæ.

Fig. 128.

Necrosed bone from the left petrous portion: *a*, bony cochlea; *b*, portion from the pars petrosa in the region of the vestibule (twice the actual size).

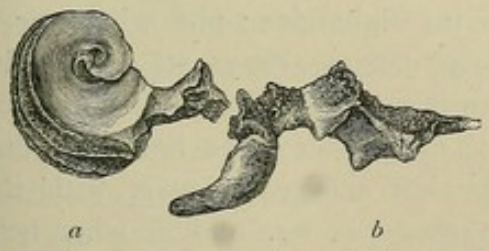


Fig. 129.

Piece of necrosed bone from the right pars petrosa, containing almost the entire cochlea (twice the actual size).



Of the greatest interest are those cases in which large portions of the pars petrosa have been exfoliated through the external auditory canal, or through fistulous tracts in the mastoid region, and the patients have yet lived. In all the cases known up to the present time, only one temporal bone was affected; and besides deafness of the corresponding ear, paralysis also of the facial nerve was almost always left behind.

In a case observed by the author, and reported in detail in the year 1864 in the Vienna General Medical Journal, exfoliation of both right and left cochleæ took place (Figs. 128 and 129). The boy escaped with his life, and without any resulting paralysis of the facial nerves. Since this, a number of cases of necrosis and exfoliation of the cochlea have been reported; there has not, however, been another in which both cochleæ were thrown off.[1]

Two other cases of necrotic exfoliation of the cochlea, occurring in the author's hospital practice, presented considerable interest on account of a certain degree of hearing capacity in the corresponding ear which was retained during the entire course of the disease, and even after the exfoliation. The sequestrum represented in Fig. 130, in which is seen the upper two coils of the cochlea, came away on syringing the ear after removal of a polypus which grew from the tympanum. The patient, aged fourteen, had suffered for four years from suppurative median otitis of the left side, with perforation of the tympanic membrane, and facial paralysis of the same

Fig. 130.

Necrotic portion of cochlea, containing the upper two coils, which was exfoliated by way of the external auditory canal (twice the actual size).



Fig. 131.

Capsule of the cochlea, containing all the coils, which was exfoliated by way of the external auditory canal (twice the actual size).



side. On the right side, the watch was heard at a distance of 145 *cm.*; on the left, on contact over the mastoid process before the removal of the sequestrum. An ordinary tuning-fork, if struck strongly, was also audible when held before the left auditory canal. When the tuning-fork was placed upon the vertex, it was heard on the right side; and whenever it was pushed over somewhat to the left, the patient always stated that he heard it on the left side. So also when it was placed upon the mastoid process, or on the zygoma. After the necrotic cochlea had been discharged, the watch was heard on the left side on contact with the zygoma or the mastoid process. The tuning-fork was audible when held before the auditory canal, if only struck with moderate strength, and in its correct pitch. The tuning-fork (*a'''*) represented on p. 129, of the presence of which the patient could have had no knowledge, was heard

[1] *Bezold* has collected the reported cases of labyrinthine necrosis with exfoliation, (Zeitschrift für Ohrenheilkunde, vol. xvi.). The number up to the year 1886 amounts to 46, to which another case recently observed by the author is to be added, and which will be referred to directly. Of the 47 cases, 9 died from secondary affections, and 37 recovered.

quite distinctly before the left ear, when the right auditory canal was completely closed.

The patient's eyes were of course closed by an assistant during these observations, which were frequently repeated. In the author's acoustic test (*vide* p. 137), the tuning-fork was invariably heard on the left side, and the louder the nearer it was brought to the ear. The patient remained under observation for nearly four months, during the last three weeks of which there was no otorrhœa. The facial paralysis had disappeared before this, and the hearing capacity on the left side continued unaltered.[1]

The second case was that of a labourer thirty years of age, named Stikler Dionisius, from Potschach, in Lower Austria, who on June 12th, 1885, was admitted into hospital under the care of the author, with a chronic purulent inflammation of the right middle ear. The affection arose from a severe cold ten years previously, and was at the first attended with much pain and with tinnitus. Otorrhœa soon followed, upon which the pain abated, and after some months the discharge also ceased. Seven months before he was first seen by the author, the otorrhœa recommenced; but to this, like his deafness, he paid no attention. It was only when periodical hæmorrhage came on some weeks before his admission, and lagophthalmus appeared during the previous week, that he resolved to seek advice. On examination, he heard the watch at a distance of 57 *cm.* on the left side; on the right it was *not* heard on contact with the auricle, but apparently when placed on the zygoma and mastoid process. A vibrating tuning-fork held before the right external auditory canal was not audible by the right ear, but faintly perhaps when placed upon the right zygoma or mastoid process. Upon the vertex, or right frontal tuberosity, it was heard on the left side.

Upon inspection, the left tympanic membrane was partially thickened, and slightly retracted; on the right were the appearances of a chronic suppurative median otitis. The auditory canal was filled with inspissated secretion, in syringing out which a moderately firm polypus about as large as a sweet pea, and with a very slender pedicle, came away; this being followed by slight bleeding. On re-inspection, a sequestrum could be made out in the depths of the auditory canal; it was readily removed by syringing, and proved to be the defective cochlear capsule. It contained the entire spiral, as shown in Fig. 131, and the lamina spiralis ossea is well preserved as the boundary of the two scalæ.

The hearing was tested immediately after the removal of the sequestrum, and showed no difference on the right side. The watch and tuning-fork were, as before, audible upon contact with the zygoma or the mastoid

[1] The complete history of this case was published in the Monatsschrift für Ohrenheilkunde, etc., xix. Jahrg. S. 225.

process. With the author's method, the tuning-fork was heard on the right side the more distinctly, the nearer it was placed to the ear upon the inserted finger. With the help of an ear-trumpet, the patient could clearly distinguish with the right ear words spoken with a moderate degree of loudness, the left ear having been closed; on the other hand, he made frequent mistakes concerning the direction of the sound, when both auditory canals were left open, and the eyes closed. He was dismissed improved on July 3rd, 1885, the otorrhœa having been reduced to a minimum; there was, however, no diminution in the facial paralysis. For the slight otorrhœa still present, instillations of a solution of boric acid in spirit were prescribed.

About two years afterwards—that is, in June 1887—the patient, at the author's request, paid him a visit. His general condition was good; the facial paralysis had somewhat diminished, but had not quite disappeared. The tympanic mucous membrane on the right side was not sclerosed, but secreted very little. When asked, he said that he heard with the right ear just the same as when he left; that once only had he heard worse "in the right ear," and that was when he had a severe cold in the head, but that this passed away again. He was kept under observation at the hospital for eight days, during which numerous tests of his hearing power were applied, and they all confirmed his previous statement.

Recent publications, both before and after the report of the first case of the author's, supply a series of cases in which, after necrotic exfoliation of the cochlea, the patients still retained some hearing capacity in the corresponding ear. The reports referred to are furnished by *Cassells*,[1] *Christinneck* and *Schwartze*,[2] *Lucæ*,[3] *Burckhardt-Merian*,[4] *Bezold*,[5] *Hartmann*[6] and *Stepanow*.[7] Particular mention must be made of *Stepanow's* case. It was that of a man aged twenty-three, in whom, as a sequela of the left chronic suppurative median otitis, the upper section of the cochlea (containing the upper coil and a half), was exfoliated by way of the external auditory canal. Hearing tests, made on various occasions, showed that the patient could not only hear with the corresponding ear, but after careful testing "with all tones within the limits of perception of the human ear, from the lowest up to the highest," that he exhibited no defect in the perception of tone. The solitary conspicuous symptom manifested in this, as in the author's cases, was that Weber's test yielded a negative result.

[1] Archiv für Ohrenheilkunde, ix. Bd.
[2] *Ib.*, xviii. Bd.
[3] *Ib.*, x. Bd.
[4] Bericht über behandelte Ohrenkranke.
[5] "Labyrinthnecrose und Paralyse des Nervus facialis." Zeitschrift für Ohrenheilkunde xvi. Bd.
[6] Bericht der 59. Naturforscher-Versammlung, Berlin, 1866. Otiatrische Section.
[7] "Zur Frage über die Function der Cochlea." Monatsschrift für Ohrenheilkunde, etc., xx. Jahrg., p. 116, *et seq.*

The observations which have been cited afford, it is obvious, very apposite material for shaking the doctrines prevalent up till now concerning the function of the labyrinthine structures. In the report on his first case of this kind, the author maintained the view that partial disease of the labyrinth, even when leading to destruction of the particular portions of the structures which are regarded as sound-perceiving, does not necessarily occasion total deafness. Notwithstanding the objections to this opinion raised by *Bezold* and *Hartmann*, he still holds it in its entirety. No ground exists which would absolutely exclude its correctness: on the contrary, the facts of comparative anatomy, as well as further clinical observations, tend to support this view. The objection advanced by the defenders of the old theories, that patients with defect of the cochlea cannot localise their acoustic sensations, and that they refer to the diseased ear the perception made with the sound one, is entirely opposed to the every-day observation that individuals deaf on one side are, on the contrary, much more disposed to refer the auditory perception to the healthy ear.

In a case again of extreme unilateral nervous deafness, in which the patient states that he hears the watch on contact with the ear, and with the cranium, what criterion, the author would ask, have we for estimating his hearing capacity except his own testimony? and why are his statements to be accepted in every other case, and only not when he has lost his cochlea? The author is inclined to believe that if any one taking the opposite view in this matter were to examine one of the above-described cases without being aware of its nature, and in response to his tests should obtain from the patient the statements recorded, he would entertain no doubt as to the hearing capacity.

To what are we reduced if the patient's statements are not accepted as of any value? The author willingly admits that complete proof of the position which he supports will be more fully obtained when a like observation shall have been made in a case of bilateral necrotic exfoliation; but the objections lodged up till now are not sufficient to alter his opinion. Further observations on this subject will doubtless be forthcoming.[1]

These cases of necrosis and exfoliation of the osseous parts of the labyrinth have occurred almost without exception in young individuals; a fact due to the looser, more spongy texture in them of the outer stratum of the labyrinthine capsule.

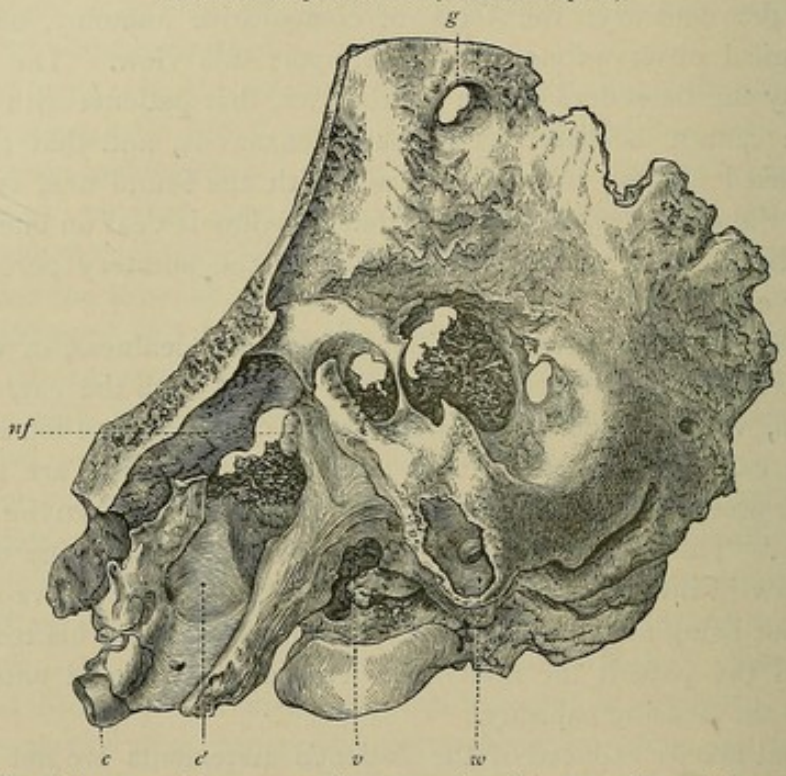
Exfoliation of the cochlea is moreover more readily brought about than a similar process in respect of the semicircular canals; perhaps on

[1] *Lucæ* (Bericht über die otiatrische Section der 59. Versammlung Deutscher Naturforscher und Aerzte in Berlin, 1886) observed a case of necrotic exfoliation of the first cochlear coil in a patient who was also very deaf in his other ear. He undoubtedly heard the tones c''' and c'''' distinctly by aërial conduction.

account of the different position of these structures, as well as from a difference in origin of the vessels supplying the various sections of the labyrinth.[1]

Hæmorrhage from the large vessels may occur from perforation of their walls after carious destruction of the parietes of the bony canals which surround them; principally of the posterior wall of the carotid canal; of the lamella dividing the sinus sigmoideus from the mastoid cells; or of

Fig. 132.
Carious temporal bone (external aspect).



The cells of the mastoid process, the external auditory canal, and the tympanum are merged into one irregular cavity, communicating at several places with that of the cranium. At *w*, an opening into the mastoid process is seen; *c*, *c'*, the carotid artery with extremely thickened walls; at *v*, the lamella of the sulcus jugularis has been destroyed, but the walls of the bulb of the jugular vein here are of four times their normal thickness; at *nf* is seen the remains of the facial nerve with its sheath greatly hypertrophied; an abnormal vascular foramen is observed in the squamous portion at *g*.

the fundus tympani. Should a congenital defect exist in the wall of a canal, erosion will be more readily brought about. Side by side with the destruction of bone in cases of chronic caries, a new tissue formation generally occurs, which provides a barrier against ulceration of the vessels, and thus prevents the fatal hæmorrhage which would otherwise happen much more frequently.

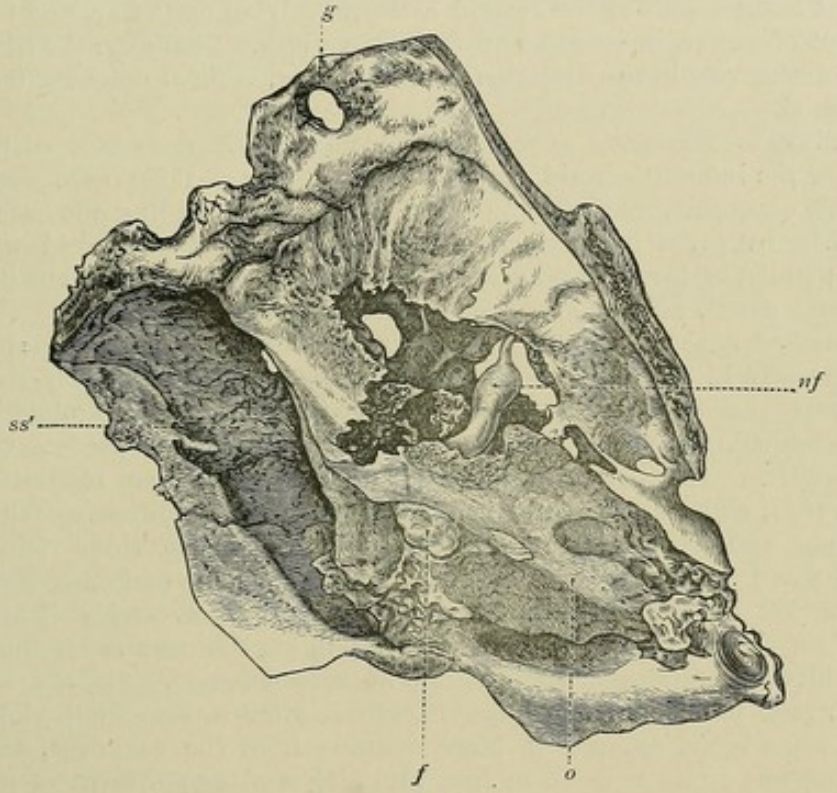
Figs. 132 and 133, which represent a preparation of the author's,

[1] Compare *Boeter's* Inaugural Dissertation, Halle, 1875; also *Moos*, "Necrotische Ausstossung eines Knöchernen (des oberen?) Halbzirkelganges," etc. Zeitschrift für Ohrenheilkunde, xi. Bd.

will serve to illustrate what has just been said. The case was that of a patient of *Haller's*, from whom the author removed a sequestrum from the interior of the mastoid process, after this had been opened. The patient survived the operation nearly a year and a half, succumbing finally to tuberculosis. In spite of the great destruction, from which both the carotid artery and the bulb of the jugular vein projected free into the

Fig. 133.

The temporal bone of Fig. 132 (internal aspect).



In order that the parts may be better recognised, it may be stated that *g* represents the abnormal vascular foramen of the squama, and *o*, the upper border of the petrous portion. The hyperplasia above mentioned is most marked at the sulcus sigmoideus, *ss'*, where it led to extensive formation of osteophytes; also in the internal auditory meatus, where it was so pronounced on the nerve sheaths of the facial and auditory nerves as to form a true fibrous tumour, *f*. There was also an apparent hypertrophy of the sheath of the rest of the facial nerve, of which the horizontal part still remained, though much altered, while the descending portion was lost.

suppurating cavity, and were for a long while bathed in pus, no serious hæmorrhage ever took place.[1]

Slight hæmorrhages from the ear are often observed, apart from such as are caused by injuries. They may occur in the course of the various forms of inflammation, but more particularly in connection with polypoid growths in the ear, which may either bleed spontaneously, or more commonly after syringing, or the introduction of the probe, or after spontaneous separation. The sources of such

[1] Further details concerning this case will be found in the hospital report by the author for the year 1865.

hæmorrhages may almost always be determined from inspection, though in many cases this is not possible, as for example if the bleeding should come from some neoplasm in the tympanum where it cannot be seen. Local application of the hæmostatic remedies in ordinary use, as a rule soon arrests the bleeding in these cases. It is otherwise when large vessels, especially the internal carotid artery or a sinus of the dura mater, are eroded.

When hæmorrhages such as these take place, the blood does not always come through the tympanic cavity, but may pass round this. Thus, in the case in which *Billroth* ligatured both internal carotids, the blood found its way, according to the report of *Pilz*,[1] through an abscess situated near the lower jaw, and burst through the floor of the cartilaginous portion of the auditory canal. On examination post mortem, the inferior wall of the carotid artery was lying quite free, and was eroded to the extent of 8 *mm.* in length and 6 *mm.* in width. Similarly, the hæmorrhage may occur exclusively in the direction of the pharynx, without touching the external auditory canal.

According to *Hessler's* account, who collected all the cases of perforative ulceration of the internal carotid reported up to the year 1882, there were thirteen in which this diagnosis, made during life, was verified; including one case observed by himself.[2] In seven other cases, hæmorrhage from the carotid was merely diagnosed; whilst in three others, the artery lay exposed after carious destruction of the carotid canal, without hæmorrhage having taken place.

Yet another case of carotid hæmorrhage, likewise confirmed post mortem, occurred recently in the author's hospital practice. A brazier, thirty-six years of age, with pronounced pulmonary tuberculosis, was attacked with purulent inflammation of the left middle ear, which, after three months' duration, led to caries with facial paralysis. The patient was admitted under the care of the author on Nov. 17th, 1884, and treated in the usual manner. His condition so far improved that the pain and discharge from the ear diminished. On Nov. 16th, however, there took place for the first time, and without obvious cause, a hæmorrhage through the left auditory canal: it was not very profuse, and was arrested by the author's assistant, *Dr. J. Neumann*, by plugging the canal. On the following night the bleeding recurred, but was again soon stopped. On the evening of Dec. 18th, very profuse hæmorrhage occurred after a somewhat violent fit of coughing, when blood escaped in large quantity from the ear, nose, and mouth. The bleeding was again arrested by firm plugging and employment of perchloride of iron, but the patient seemed subsequently much reduced, and complained of headache. On Dec. 22nd a still more abundant hæmorrhage took place, and could only be checked by injection of a strong solution of alum through the tube, and by filling the auditory canal with finely powdered alum and by plugging. No further hæmorrhage took place up to the day of the patient's death, which occurred on Dec. 25th.

On post-mortem inspection, extensive pulmonary phthisis was found; the brain and its membranes anæmic, but without signs of secondary affection. Examination of the left temporal bone showed entire loss of the drum-membrane and all the auditory ossicles, in consequence of the middle-ear inflammation. The cavity of the tympanum appeared enlarged on account of carious erosion of its inner and posterior walls. Of the osseous substance forming the posterior wall of the carotid canal and the inner wall of the tympanum, an irregular portion, almost 5 *mm.* in length and 3 *mm.* wide in places, was seen to be separated. This sequestrum was

[1] Inaugural Dissertation, Berlin, 1865.

[2] "Ueber arrosion der Arteria carotis interna in Folge von Felsenbeincaries." Archiv für Ohrenheilkunde, xviii. Bd.

very pointed at its lower end, which was found lodged in an opening almost 2 *mm.* long, and with irregular fimbriated edges, in the posterior wall of the carotid artery. In the vessel itself there was a tolerably firm coagulum ; and there can be no doubt that its presence, as well as the impaction of the sequestrum which brought it about, must have favoured the arrest of the hæmorrhage.

Bennett May gives a report of two cases of hæmorrhage from ulceration of the carotid observed by him. In one of them the bleeding ceased after ligature of the carotid, and the case recovered ; in the other one the child bled to death before a ligature could be applied to the artery.[1]

Hæmorrhages from the sinuses of the dura mater have been observed much more rarely than from the internal carotid, although the bone limiting the sigmoid sinus is one of the parts which suffer most frequently from caries. The cause lies in the disposition to thrombus-formation in the venous system, on account of which the sinus readily becomes blocked. Accordingly we sometimes find in a case of long-standing caries, a thrombosis of the sinus sigmoideus side by side with well-marked signs of previous disease during life, without any considerable hæmorrhage having taken place.

Mention must also be made here of the fact that destruction of the temporal bone may occur in such a way that blood from diseased vessels may likewise be effused into the cranial cavity, and rapidly bring about death by compression of vital parts of the brain. Such a result occurred in the case of a very weak infant in the Foundling Hospital (Vienna), in whom extensive gangrene of the soft structures in the aural region occurred in the course of a middle and external otitis. The squamous became separated from the pyramidal portion of the temporal bone as a result of the gangrene, whereby a large blood-vessel was opened ; internal hæmorrhage took place, and the blood was for the most part poured out into the cavity of the cranium. The autopsy revealed a considerable accumulation of coagulated blood in the middle and posterior cranial fossæ, with corresponding depression of the brain substance.

Wreden[2] observed a case of suppurative inflammation of the middle ear, developed as a sequela of typhoid fever, in which two openings in the transverse sinus were produced, causing internal and external hæmorrhage.

The theory of vicarious hæmorrhage from the ear may be relegated to the category of legends.

Of great interest also is a case described by the author, of exfoliation of almost the whole of the mastoid portion of the temporal bone in a girl fifteen years of age. She had suffered for five years from suppurative median otitis, occurring in the course of scarlet fever. An abscess formed behind the right auricle, from which, on being opened, a sequestrum was removed later, which represented almost the whole of the mastoid portion. The sinus sigmoideus, which bounded the abscess-cavity internally, was exposed, but no hæmorrhage occurred. After healing of the abscess, fresh osseous material was formed in the place of that lost, so that on external examination merely a shallow furrow indicated where the portion of bone had been thrown off. On the right side, where the drum-

[1] Monatsschrift für Ohrenheilkunde, xix. Jahrg.

[2] "Ein Fall von innerer und äusseren Blutung aus dem Querblutleiter des Hirns in Folge von Otitis media purulenta." Monatsschrift für Ohrenheilkunde, iii. Jahrg.

membrane and auditory ossicles had been already lost, no hearing power existed, and the osseous auditory canal appeared somewhat narrowed. Nothing unusual was to be observed in the position of the patient's head; the sterno-cleido-mastoid muscle acting just as well as before.[1] *Zaufal*[2] also observed a case of discharge of a sequestrum showing a part of the sulcus sigmoideus, without the occurrence of hæmorrhage.

As in the vascular walls, hyperplasia also occurs in other structures adjacent to the focus of disease in cases of chronic caries. On the non-carious bone, this is seen in the extensive development of osteophytes, as well as in a more or less distinct sclerosis of the tissue. The soft structures, including the nerve sheaths, exhibit a similar hypertrophy.

The hyperplastic process, so beneficial in its results as regards the blood-vessels, may, however, be very injurious in respect of the structures concerned directly in the auditory function.

The *prognosis* in caries and necrosis of the temporal bone is dependent on the site of the disease, upon the destruction it has caused, and upon the general condition and age of the patient. Should the influence of the suppuration have manifested itself upon the general organism by the appearance of serious symptoms, such a secondary affection will necessarily affect the prognosis. With regard to the localisation of the disease, experience shows that caries of the pars mastoidea is, on the whole, the least dangerous. Much more serious is disease of the pars tympanica; while recovery from a carious or necrotic process involving the pyramid is extremely rare. The age of the patient is significant, since exfoliation of necrosed portions of the temporal bone is brought about much more easily in young individuals than in those of maturer age. It may be considered one of the greatest rarities for a child to die from an affection secondary to a caries and necrosis; and it is very exceptional for an intra-cranial complication, due to extension of the bone disease, to bring about a fatal termination. It is likewise rare for death to result from a sequela of caries in this region in advanced years. The sclerosing process, which is always present in chronic cases (*Volkmann*) in the vicinity of the disintegrating osseous tissue in the suppurating centre, forms round the latter a natural barrier against the extension of the disease to the brain and its membranes. Carious processes dating from youth lead extremely seldom to dangerous consecutive conditions at a more advanced age.

The preparation from the author's collection which is represented in Fig. 134 is from the case of a woman, sixty-eight years of age, who died from marasmus, and was said to have suffered from otorrhœa since her youth. The greater part of the petrous bone and mastoid process had been

[1] Monatsschrift für Ohrenheilkunde, etc., xiii. Jahrg., Nr. 10.

[2] Summarischer Bericht der Otiatr. Klinik des *Prof. E. Zaufal* für das Jahr 1880, von *J. Habermann*, Archiv für Ohrenheilkunde, vol. xviii.

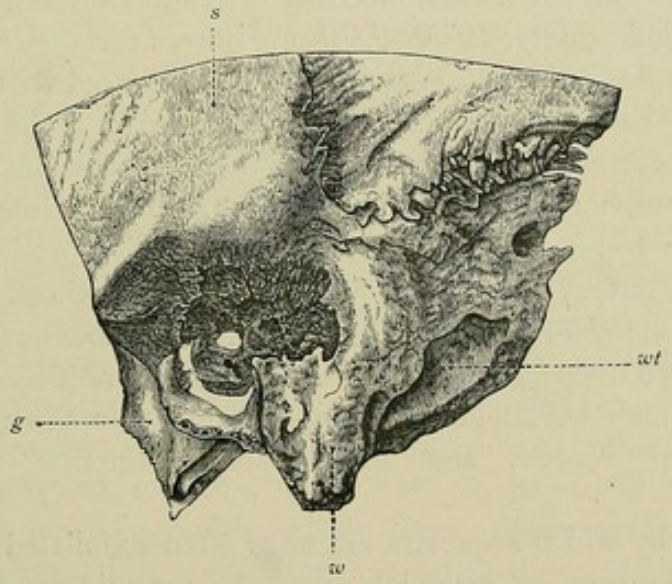
destroyed, and nothing could be discovered post mortem which could be considered as a consequence of the caries necrotica which was present.

All the above-mentioned elements in the prognosis must be taken into account in respect of the question as to the patient's chances of life. Concerning the hearing power and the other symptoms, the principles previously unfolded in connection with the subject of inflammation of the middle ear will be valid also in these cases.

The *treatment* must be in accordance with ordinary surgical principles; its chief indications being to check the inflammation, and to prevent extension of the carious process and the development of secondary complications. As with caries in other regions, the greatest care should

Fig. 134.

Carious temporal bone from a woman aged sixty-eight.



s, squamous portion; *wt*, mastoid portion; *w*, mastoid process; *g*, external auditory canal.

be exercised in regard to cleanliness of the diseased parts. Purulent accumulations must be evacuated early, and proper openings provided for satisfactory drainage. When an external or median otitis exists, the rules laid down in speaking of those affections must be followed. The lumen of the external auditory canal and that of the Eustachian tube should be maintained as wide as possible, so as to facilitate the escape of discharges. Abscesses in the walls of the auditory canal, or in the neighbourhood of the ear, should be opened at the earliest opportunity; and if, on examination, the bone should then be found to be affected, the further treatment must be regulated in accordance therewith.

If the bone turns out to be carious, it will be best to expose the diseased parts freely, and remove with a sharp spoon the softened bony

tissue, as well as any granulations which may be growing on the abscess-walls. The parts should then be washed out abundantly with an antiseptic solution, a drainage tube introduced, and the wound dressed with iodoform gauze, upon which Bruns' cotton-wool and some gutta-percha tissue may be placed, the whole being secured by a suitable bandage. The dressing need not be changed for a time, unless the cotton-wool should become soiled, or fever come on; or unless perhaps the wound should be painful, or bleeding take place from it. Particular attention must always be directed to the neighbouring parts, with reference more especially to the development of gravitation-abscesses, the presence of which is generally betrayed by pain or tension, but chiefly through swelling of the structures. If such a condition be recognised, the dressings should be at once removed, and the retained pus evacuated; if necessary by enlargement of the abscess-opening.

With superficial caries and necrosis in the external auditory canal and in the tympanic cavity, *Weber-Liel*[1] and others recommend the use of sulphuric acid, a drop of which is applied to the diseased part by means of a small piece of cotton-wool affixed to a silver probe. The place should be afterwards covered with a little cotton-wool soaked in oil. *Woakes* employs dilute sulphurous acid (1 in 8), which he drops into the auditory canal, and allows to remain there for half an hour.

As pointed out by *Wilhelm Meyer*,[2] obstinate otorrhœa is often kept up by the presence of carious spots on the promontory, which are frequently covered over by granulations. For this condition the sulphuric acid treatment may be adopted; or the carious places may be scraped away by sharp spoons, and the antiseptic method subsequently carried out.

The routes by which sequestra are most often exfoliated are abscess-openings—spontaneous or artificial—over the mastoid process, fistulous canals in this region, and the external auditory canal. If a piece of necrosed bone should be found in a fistulous channel, or after opening an abscess, an attempt should be made to remove it as soon as possible, and anything tending to impede its escape should be removed. It will therefore be necessary, in many cases, to incise the structures covering abscesses, to dilate fistulous channels, and to reduce the size of sequestra.

If the bone disease be accompanied by considerable swelling over the mastoid process, in which case either an abscess of the bone or a sequestrum is generally present, *perforation of the mastoid process* will be indicated. Reference has already been made to this operation in

[1] "Die Behandlung superficieller Caries und Necrose im äusseren Gehörgange und in der Paukenhöhle mit Schwefelsäure." Monatsschrift für Ohrenheilkunde, etc., xix. Jahrg.

[2] "Ueber das Wesen der chronischen Trommelhöhleneiterung. Eine Studie." Archiv für Ohrenheilkunde, vol. xxi.

connection with otitis media purulenta, and it will be spoken of in greater detail later on.

It sometimes happens that purulent accumulations caused by a caries or necrosis of the osseous portion of the auditory canal exist for a long time between the bone and the soft structures without breaking through the latter. As a result of this, the most severe pain occurs, and the auditory canal becomes contracted. These pus-deposits are connected most commonly with caries of the parts where the tympanico-squamosal fissures are found. The swellings do not always represent true abscesses; but the possibility even of such, more than justifies early incisions, made longitudinally, and penetrating the soft parts down to the bone. Even if no pus be present, the result will be beneficial from the relaxation of tissue thus brought about.

With the chronic, painless, so-called sympathetic swelling of the soft structures of the canal, which sometimes accompanies caries or necrosis of various parts of the temporal bone, pressure may be employed with the view of distending the narrowed passage. If the narrowing depend on granulations or polypi, these should be removed as early as possible. As with carious or necrotic affections of other regions, all channels for discharges should be kept open until every morbid product is separated and thrown off from the bone.

It is unnecessary to speak further of the need for special treatment of consecutive pathological conditions accompanying the bone disease. It may, however, be more particularly noted that such processes are sometimes seen in the structures of the pharynx, and that the latter region therefore calls for careful observation during the whole course of the affection.

More particular mention seems only to be called for in regard to alleviation of the intense pain which often accompanies deeply invading carious processes. The remedial measures already indicated are in these cases useless; and the application to the skin of more severe irritants, the actual cautery if necessary, renders good service.

The author is not at all inclined to attribute to the potential cautery any special action upon the limitation of the morbid process; nor does he believe that protection can be afforded to the brain and its membranes by the establishment of an inflammation on the external parts. It is nevertheless a fact that insupportable pains, raging day and night, and defying all other treatment, sometimes cease at once and for a long period on the employment of very strong irritants, so that the patient wonderfully improves, and his life may be considerably prolonged in spite of the progress of the disease. The author still vividly remembers the first case he treated in the late *Prof. Türck's* wards, in which the most violent pains continued in spite of all opiates and other narcotics, while the application of the cautery-iron caused them rapidly to disappear. The patient, after

the course of a few weeks, being again attacked by the pains, begged earnestly that the cautery might be reapplied. This was done with an equally successful result, and he soon after left the hospital to follow his usual occupation, although necrosis of the petrous portion of the temporal bone still existed. Instead of the cautery-iron, the author now uses the galvano-cautery, making with it several punctures in the region of the mastoid process. After the sloughs have separated, the wounds may be dressed with such medicaments as may be indicated (quinine, opiates, etc.).

Particular attention should be paid to the possibility of hæmorrhage. Slight bleeding may be arrested by simple pressure, with or without the employment of hæmostatics. The author uses alum (1 to 2 parts in 100 of water) instilled as may be needed into the auditory canal; or the latter may be plugged with cotton-wool soaked in the solution. Powdered alum may be also used for this purpose. With more copious bleeding, the perchloride of iron may be employed: a piece of Bruns' cotton-wool saturated with this being pressed on the bleeding spot, so that an eschar may be formed. If the source of hæmorrhage cannot be reached in this way, the perchloride diluted with water may be poured into the auditory canal, which should then be plugged with cotton-wool.

In the event of hæmorrhage from a perforated carotid or a cerebral sinus, compression of the carotid in the neck must instantly be made in the attempt to check the flow of blood, and then if the above-mentioned means prove insufficient to arrest it, the vessel must be ligatured. Even this does not always succeed; although, as in *Billroth's* case, both vessels are tied. It must, however, always be undertaken; and it therefore behoves the aural surgeon to acquire a thorough knowledge of the operation.

CHAPTER XIV.

PERFORATION OF THE MASTOID PROCESS.

The province of Surgery is ruled throughout at the present day by the beneficent doctrine of the antiseptic treatment; and under its guidance the surgeon can now fearlessly and hopefully undertake the performance of operations which the boldest operator of former times scarcely dared to contemplate. The advantageous results have been seen, as elsewhere, in the practice of otology; and the history of the operation of opening up the mastoid process demonstrates this fact. Though formerly so dreaded, it is now done in all cases in which it may be indicated. It is, however, not alone to the introduction of antiseptics that this is owing; but also to zealous investigations in the domain of the normal and morbid anatomy of the ear, which have thrown light upon the great importance of this operation in practice. There is thus no longer any question as to the utility or advantage of the measure, but merely as to the indications for and methods of its performance, and the nature of the after-treatment.

In regard to the indications for cutting into the mastoid process, the history of the operation shows that its originators had in view two quite distinct objects.[1] Some, and amongst them *Johann Riolan* the younger, who first proposed the operation more than a hundred and fifty years ago, as well as later, the Prussian army surgeon *Jasser*, proposed to improve the hearing and remove subjective auditory sensations by this means.[2] Others, *e.g. Petit*, advised the procedure for caries with purulent collection in the mastoid process. It appears to have been very seldom performed with the first-named object. The Danish court physician *Berger*, moreover, who suffered from violent vertigo, headache, and tinnitus, underwent the operation and lost his life in consequence; upon which it was entirely abandoned, even when the above-mentioned rational indication was present.

In more recent times, the attention of aural surgeons was again turned

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[1] Compare *Lincke's* Handbuch der Ohrenheilkunde, 1840, ii. Bd., p. 81, *et seq.*

[2] *Johann Riolan* recommended the operation for deafness and tinnitus aurium when these ailments are due to obstruction of the Eustachian tube, "ut detur exitus spiritibus ibi tumultuantibus."

to this operative measure by *Von Tröltsch*, who gave as indication for its performance: "Otitis media with collection of pus in the mastoid cells, which, even with co-existent perforation of the drum-membrane, cannot be otherwise evacuated, and the symptoms are too urgent to justify waiting for spontaneous opening of the abscess." The operation has been performed on these grounds with more or less good results by *Von Tröltsch*,[1] *Turnbull*,[2] *Pagenstecher*,[3] *Follin*,[4] *Schwartze*,[5] *the author*,[6] *Mayer*,[7] *Jacoby*,[8] and others. It first came into more extensive practice, however, in consequence of *Schwartze's* zealous advocacy. Subsequently to having made, in conjunction with *Eysell*, a thorough study of the anatomical relations of the temporal bone, he performed the operation on a large number of patients, and thereby was in a position to formulate with precision the indications for the procedure, as well as to perfect the method of operating. He published a large series of successful cases, and thus interested the profession so much in the operation, that it gradually became established as a valuable addition to aural practice.

The *indications* given by *Schwartze*[9] for perforating the mastoid process are:—

1. Acute inflammation of the mastoid process with retention of pus within the mastoid cells, when a permanent remission of the symptoms has not been brought about by Wilde's incision. The operation ought to be performed without waiting for symptoms of cerebral irritation or pyæmia.

2. Recurrent swelling of the mastoid region, which has undergone temporary recession; or has led to abscess formation with or without fistulous opening in the integument; even though no threatening symptoms exist at the time.

3. When after discharge of an abscess in the mastoid region, examination with the probe reveals a fistulous passage in the bone.

Besides these generally recognised indications, the author considers the operation to be called for—

4. If, with inflammatory processes in the ear, severe pains which resist all other treatment, be present in the corresponding side of the head, even though no inflammatory appearances can be detected over the mastoid region.

Experience shows that in certain cases of this kind, the violent pains are

[1] Virchow's Archiv, xxi. Bd.
[2] The Med. and Surg. Reporter, Philadelphia, 1862.
[3] Archiv für Klinische Chirurgie, 1863, Bd. iv., S. 523, *et seq.*
[4] Gazette des Hôpitaux, 1864.
[5] Praktische Beiträge zur Ohrenheilkunde, 1864.
[6] Record of aural patients treated in the Vienna General Hospital during the year 1865, in the general hospital report.
[7] Archiv für Ohrenheilkunde, i. Bd.
[8] *Ib.*, iii. Bd.
[9] *Ib.*, xiv. Bd., S. 202.

alleviated or completely removed by chiselling into the bone, even when no pus is found there. Pains present even in other situations in the head, at some distance from the ear, may depend upon changes in the mastoid portion of the bone, and may sometimes be relieved by the operation in question. *Tilden Brown*[1] trephined in a case of discharge from the mastoid process in which there was complete absence of sensibility, heat and swelling of the structures covering the diseased part, with constant pain, however, in the region of the occipital protuberance. After the mastoid process had been perforated to the depth of 1½ *cm.*, about 5 grammes of pus was evacuated. The patient recovered in spite of an attack of erysipelas which occurred during convalescence.

5. In cases of tedious otorrhœa, the obstinacy of which is not sufficiently accounted for by the condition of the Eustachian tube and tympanum, and which resist long-continued and approved treatment on the ordinary lines, the discharge being offensive and mixed with cholesteatomatous masses or bony particles, even where no conspicuous changes can be discovered in the mastoid region, the author has recourse to operation; experience having taught him that after removal of the cholesteatomatous masses or granulations which are frequently present in the antrum or mastoid cells, the otorrhœa ceases and recovery takes place. Sometimes, moreover, small circumscribed areas of inflammation exist in the mastoid process, which maintain the otorrhœa, and are inaccessible to ordinary modes of treatment. These are exposed by the operation, and recovery is thus brought about more readily.

In connection with the two last-named indications, the operation acquires an exploratory significance; and, under the modern favourable auspices of surgical treatment, it may the more readily be undertaken, on account of the danger which is always associated with a continuance of the disease.

Hotz[2] proposes to make an incision down to the bone when, in the course of an acute purulent median otitis, the mastoid region becomes red, swollen, and painful, and the symptoms do not disappear under ordinary treatment. If the periosteum is found to be in an inflammatory condition, nothing further is to be done: but if on the other hand the signs of acute periostitis are absent, trephining is to be performed at once. Clinical experience is, however, in no way favourable to this proposal. With or without the signs of periostitis, changes may be present in the bone itself which necessitate the operation; in other words, the state of the periosteum is no criterion.

In regard to *counter-indications*, certain differences of opinion still exist, for the removal of which more extended clinical observation is needed. As absolute counter-indications may be reckoned, extreme prostration of the patient, or the concurrent presence of some other affection, which destroys all prospects of recovery.

[1] Zeitschrift für Ohrenheilkunde, xiii. Bd.

[2] "Die frühzeitige Perforation des Warzenfortsatzes bei Otitis media purulenta acuta complicirt durch acute Entzündung der Warzenzellen." Zeitschrift für Ohrenheilkunde, x. Bd.

It must be specially noted, however, that neither a local tuberculosis of the bone, nor a perhaps further advanced co-existent pulmonary tuberculosis, is *per se* an absolute reason for not operating. On the contrary, recovery from the caries after operation is in certain cases observed to be followed by gradual improvement in, or even cessation of, the pulmonary disorder. In corroboration of this view, the author can adduce cases in his hospital practice in which recovery took place after operation. *Wolf*[1] operated with good results in cases of caries necrotica tuberculosa of the mastoid process and of the hip-joint. *Schwartze* showed in the otological section of the German Society of Naturalists in Berlin, the case of a man who was cured by operation of tuberculosis of the temporal, parietal, and occipital bones; and *Gilette*[2] likewise brought about recovery in a patient, the mastoid process of whom he opened up on account of violent pains, and who suffered from pulmonary tuberculosis with already developed cavities.

The presence of symptoms which usually precede or accompany the dreaded secondary results of a suppurating process in the temporal bone—*e.g.* rigors, vomiting, vertigo, cervical pain, and high fever—furnish reasons for, rather than against operating. Focal symptoms on the other hand, such as aphasia, unilateral contraction, or paralysis of the extremities or clonic spasms, are good grounds for relinquishing it, as insisted on by *Schwartze*, unless extraordinary circumstances should enjoin otherwise. It will scarcely be too much to say that the symptoms mentioned as contra-indications for operation will in the course of time be probably held to be of less significance in this respect. Nevertheless, caution in this direction must always be advisable, in order that the procedure may not be brought into discredit.

Methods of operation.—It must in the first place be noted that perforation of the mastoid cells is at the present day performed almost invariably from without—*i.e.* behind the auricle in the region of the mastoid process; and but very seldom from the external auditory canal, as recommended by *Wolf* and others. The latter method is indicated only in those extremely rare cases in which, with extensive destruction of the tympanic membrane, the mucous membrane of the cavity of the tympanum is dry, while pus oozes through a carious fistula on the posterior wall of the auditory canal; or when under similar circumstances the posterior wall, as a result of inflammation, appears considerably swollen up, thus narrowing the canal very much, and the swelling resists ordinary treatment for an unusually long while. The operation through the canal is especially indicated when the morbid changes there are associated with long-continued pains;

[1] "Zur Eröffnung des Warzenfortsatzes." Berliner klinische Wochenschrift, 1877.
[2] "Ann. des mal. de l'or., etc.," v., p. 249.

or when abscess-formation has repeatedly occurred in this situation; as experience proves that such a state of things is sometimes dependent upon a circumscribed suppuration in the bone, the site of which may perhaps be reached most easily from this direction.

Instances occur, it is true, in which, although the above-mentioned changes in the canal are present, it is yet advisable to operate from without, as *Schwartze* has shown; and the author would unconditionally recommend the latter operation where, with such a fistula as is above alluded to, there exist at the same time external signs pointing to mastoid disease. Experience confirms *Kiesselbach's* opinion that retention of pus is more likely to happen when the operation is performed through the external auditory canal; and on this account again is the preference to be given to perforation of the bone from the outside.

The operation itself is at the present day almost always performed, as *Schwartze* recommends, with the hammer and chisel; very few surgeons employing drills or trephining instruments. The author now always operates with the chisel or with sharp spoons.

The preparations necessary comprise hæmostatics, such as ice and perchloride of iron, besides the arrangements for anæsthesia; antiseptic materials; the needful apparatus for washing out the middle ear and the external auditory canal; and the special instruments for the operation. Regarding the cleansing processes, several sponges should be at hand in a 5 per cent. solution of carbolic acid, and a larger number of small wads of Bruns' cotton-wool, about the size of a hazel nut. The latter are also to be saturated with the carbolic solution, and then squeezed out. They are to be held with the forceps, and are very suitable for freeing the wound from blood and other matters during the operation. Besides these, there should be some ordinary cotton-wool; drainage tubes of different sizes; several Eustachian catheters; Weber's catheter for the tympanum; vessels for the discharges; some ear-syringes; a glass syringe with nozzle for injection through the catheter; an irrigator; and some 2 per cent. carbolic acid solution, both warm and cold.

For the operation itself are needed: a razor; a strong scalpel; a sharp knife for incising the soft structures; a pointed bistoury for dividing up possibly existing fistulæ upon a director; a blunt-pointed bistoury; a strong raspatory for scraping the periosteum from the bone; two blunt and, if necessary, two sharp hooks for keeping apart the edges of the wound; some blunt-pointed metal and whalebone probes; a director; several straight chisels and gouges of various sizes (2-10 *mm.*); a surgical hammer; sharp spoons of different forms and sizes, amongst them one or two curved ones, as shown in Fig. 135. The author employs these by preference, after having penetrated the bone to a greater depth than 1 *cm.* If in using them the sharp edge be directed somewhat laterally, there will be less risk

of injuring the structures of the cranial cavity. There will be required besides, some blunt spoons; at least three catch-forceps; a small and a large dissecting forceps; several needles, with antiseptic silk (placed in a 5 per cent. carbolic solution); a corresponding number of similar sutures; a needle-holder; a small and a large pair of scissors; and a proper dressing —iodoform gauze, Bruns' cotton-wool, gutta-percha tissue, and a calico bandage 8-10 *m.* long. Care must of course be taken that everything else is at hand which may be required in a major operation, in order to meet emergencies.

Fig. 135.

Sharp spoon (two-thirds the usual size).



The *operation* is performed in the following manner: The hair in the region and for a small distance beyond is first removed with the razor, and the skin well washed with a 2 per cent. carbolic solution. Anæsthesia having then been induced, the patient's head is placed in such a position that the affected ear is directed towards the operator standing at the side, and is well illuminated. An assistant fixes the head, and at the same time draws forwards the auricle. The surgeon now divides the soft structures down to the bone with the scalpel. If these are quite intact, the author makes the incision, almost like *Schwartze*, at a distance of 5 to 10 *mm.* from the attachment of the auricle; commencing about 1½ to 2 *cm.* above the auditory canal, and dividing the soft parts along the whole mastoid process. If a fistulous opening already exist, it will possibly be necessary to cut through this; and in general it may be stated that the pathological conditions present must govern both the situation as well as the direction and extent of the incision.

The author considers it inadvisable to make the incision close to the attachment of the auricle, as the separation of the periosteum from the bone is thus rendered more difficult. The latter may be exposed much more readily when the raspatory can be used in two directions; and this is not practicable if the incision be made as described. *Politzer's* proposal to make a transverse cut backwards from the upper extremity of the longitudinal incision and at right angles to this, and then to loosen up the flap thus made from the bone, cannot be recommended. Pus may easily gravitate beneath such a flap; and besides this, it is often necessary, in the course of the operation, to elongate the incision in different directions, whereby by this plan a complicated and unfavourable wound would be produced.

The soft structures having been divided, any hæmorrhage which takes place must be arrested by pressure or torsion, or if necessary by ligature, and the wound washed with some carbolic solution. An examination with the probe is then made to determine the condition of the bone, previous to

laying it bare for trephining. In many instances, although the soft parts have exhibited no trace of disease, yet the underlying bone is denuded of periosteum to a considerable extent. In other cases, however, the periosteum is firmly adherent, and must be raised from the bone with the raspatory. The process should be carried out thoroughly but carefully, in order to preserve the connection of the periosteum with the soft parts; and for a good distance, so as to render the subsequent chiselling easier of performance.

The bone having been properly exposed, the edges of the wound are to be held apart with hooks by an assistant, and the probe again employed to ascertain whether any opening in or softening of the bone may exist through which a passage may be gained into the deeper parts. If so, it will be best to advance through such a place; but if not, then it is advisable to penetrate the bone in the direction of the antrum mastoideum in order thus to reach the tympanic cavity. *Schwartze* recommends the opening to be made at the level of the external auditory canal, close under the linea temporalis. The author generally observes the rule whereby the upper third of the perforation—which should not measure more than 15 *mm.* across—lies above an imaginary line drawn horizontally backwards from the upper margin of the external auditory meatus. He exceeds the limit just mentioned only if the probe reveals a cavity in the bone which can be enlarged outwards without danger: usually, however, he makes the necessary enlargement downwards, or towards the auditory canal. The perforation of the cortical substance of the bone is to be made with the chisel and hammer, and very little at a time. During the process occasional examination should be made with the probe, in order to ascertain the condition of the deeper parts. If spongy or carious bone be found, a sharp spoon should be used instead of the chisel to make a way through this if possible. In proceeding thus inwards, one should advance from behind forwards in the direction of the external auditory canal, as in this way there is less danger of penetrating into the cranial cavity, perhaps into the sinus sigmoideus. If the bone has been perforated to the depth of $1\frac{1}{2}$ *cm.* or more without having reached the site of disease or the antrum, it is particularly advisable, in proceeding further, to advance more towards the auditory canal, and if necessary to establish a direct communication between the antrum and the canal by perforating the posterior wall of the latter.

Frequent exploration with the probe during the course of the operation, with the view of gaining information as to the condition of the deeper parts, has been already insisted upon; and it is obvious that the necessity for doing so will be the more, the greater the depth to which the bone has been penetrated.

When the site of the disease has been reached, all unhealthy tissue

should be removed. Carious bone, as well as luxuriant granulations, are to be carefully scraped away with the sharp spoon; and any sequestra present should be taken away, their size having been first diminished if necessary. Cholesteatomatous and other retention-products are to be removed by syringing or by the spoon.

In the further course of the disease, it is advisable in all cases in which one has to deal with inflammatory conditions in the middle ear, to advance into the antrum mastoideum if the operation has been successful, and in this way to establish a communication externally with the tympanic cavity. Diseased parts may be in this way more easily removed, and the irrigation of the middle ear more readily carried out. It is not in all cases essential to penetrate as far as the antrum, since the bone affection is sometimes limited to the mastoid process; in which case it is sufficient to have reached the site of disease.

As shown in the previous chapter, the mastoid process sometimes consists entirely of diploëtic structure without a trace of air-containing cells. In other cases it is actually eburnated, in consequence of a chronic inflammatory process in the bone. We possess no mode of examination which affords any tolerably trustworthy evidence of the existence of this unfavourable condition. Neither palpation, percussion, nor auscultation of the region yields the slightest information in this matter (*Laenec*). Sometimes very large mastoid processes are completely sclerosed; while, at times, small ones enclose remarkably large cavities filled with pus. It may thus readily happen that, although the indications for operation are most distinct, and the operation itself carried out correctly, the bone may be penetrated deeply without coming upon an air-cell, or pus, or any other morbid product. Cases occur likewise in which the antrum itself is completely closed up, and in which, after all, the establishment of a communication with the tympanum would afford no further advantage. On the other hand, with a more extensive perforation, the facial nerve or the labyrinthine structures might easily suffer injury. On these grounds it is in such cases advisable to penetrate only up to a certain depth, and then to desist from any further exploration if the required object has not been attained. *Schwartze* is of opinion that one should not penetrate to a greater depth than 25 *mm.* (1 inch), and this rule ought in general to be observed.

It is not at all a rare occurrence that, although the bone has been perforated to a sufficient depth, the communication between the wound and the cavity of the tympanum is not manifest immediately after the operation; liquid injected through the Eustachian tube or external auditory canal does not at once flow through the wound, nor *vice versâ*; while, however, this is the case in a few hours or a day later.

Certain unpleasant *accidents* may occur in the course of the operation.

Among these may be mentioned: profuse hæmorrhage from the bone; opening up the Fallopian canal, with injury of the facial nerve; injury to the structures of the labyrinth; injury to the dura mater or the brain-substance; or opening up the sinuses of the meninges. Still, none of these mishaps necessarily occasions a fatal result.

Knapp[1] had the misfortune to open up the transverse sinus, though he had penetrated to the depth only of 6 *mm.*, upon which copious hæmorrhage occurred. The case recovered. *Hessler*[2] exposed and penetrated the dura mater in a boy eight years old during the removal of a carious piece of bone. In a second case he exposed the sinus transversus. In neither instance did a bad result ensue. In the first case, death took place later in consequence of an idiopathic abscess in the occipital and temporal lobes, and the dura mater was at the autopsy seen to be cicatrised, but not inflamed. In the other patient, respiration ceased during the operation for more than half a minute. *Hessler* attributes this to a laceration of the transverse sinus produced in the extraction of the sequestrum. The pulse remained strong. The case is recorded in the twenty-second volume of the "Archiv für Ohrenheilkunde."

In spite of numerous and thorough investigations respecting the relations of the mastoid cells to the different intra-cranial structures, and especially to the sinus sigmoideus, we are still unable to obtain satisfactory information regarding them during life. It may therefore readily happen that the most experienced operator, though perforating the mastoid process with the greatest care, may penetrate into the cranial cavity, and wound the dura mater or open the sigmoid sinus. *Körner*[3] has recently endeavoured to acquire some data for estimating the topographical relations of these structures in the living body, and they are here appended on account of the importance of the subject.

According to *Körner*, the floor of the middle cranial fossa in dolicocephalic skulls lies higher above the external auditory meatus and the spina supra meatum than in those of the brachycephalic order. In the latter, the sinus transversus is placed more externally than in the dolicocephalic, and on the right side is situated on the average farther externally than on the left; this being independent of the form of the skull. He obtains an expression of the cranial formation by measuring with the calipers the distance from the bridge of the nose to the most prominent point of the occiput, and also that of the parietal tuberosities from each other. The first measurement being then divided by the second gives a number called by *Körner* the cranial index.

With a cranial index 1·55 to 1·40, the floor of the middle cranial fossa lies, according to this author, 11·5 *mm.* on an average above the external auditory meatus, at the most 17 *mm.*, and at the least 7 *mm.*; with a cranial index 1·39 to 1·30 the average distance is 8·8 *mm.*, at most 15 *mm.*, and at least 4 *mm.*; with cranial index 1·29 to 1·20 the average is 5·1 *mm.*, maximum 9 *mm.*, minimum 2 *mm.*; with cranial index 1·19 to 1·07, average 4·8 *mm.*, maximum 7 *mm.*, minimum 2 *mm.* With a cranial index 1·55 to 1·40 the floor of the middle cranial fossa is situated above the spina supra meatum 15·3 *mm.* on the average, at the most 17 *mm.*, and at the least 10 *mm.*; with a cranial index 1·39 to 1·30 the

[1] "Aufmeisseln des Warzenfortsatzes in einem Falle von chronischem Ohrcatarrh mit intactem Trommelfelle. Eröffnung des Sinus transversus. Heilung per primam intentionem." Zeitschrift für Ohrenheilkunde, xi. Bd.

[2] "Casuistische Beiträge zur operativen Behandlung der Eiterungen im Warzenfortsatze." Archiv für Ohrenheilkunde, xxiii. Bd.

[3] "Ueber die Möglichkeit, einige topographisch wichtige Verhältnisse am Schläfenbeine aus der Form des Schädels zu erkennen." Zeitschrift für Ohrenheilkunde, xvi. Bd.

average distance is 12·1 *mm.*, at most 17 *mm.*, and at least 7 *mm.*; with cranial index 1·29 to 1·20 the average is 7·6 *mm.*, maximum 12 *mm.*, minimum 5 *mm.*; with cranial index 1·19 to 1·07, average 5·8 *mm.*, maximum 9 *mm.*, minimum 4 *mm.*

With a cranial index 1·55 to 1·50, the thickness of the osseous wall of the sulcus transversus, in its thinnest parts on the mastoid process, amounts on an average on the right side to 7·83 *mm.*, at the most to 9 *mm.*, and at the least to 7 *mm.*; on the left the average is 10 *mm.*, the maximum 11 *mm.*, and the minimum 9 *mm.*: with cranial index 1·49 to 1·40 the average on the right side is 8·22 *mm.*, maximum 15 *mm.*, and minimum 4 *mm.*; on the left the average is 9·72 *mm.*, maximum 12 *mm.*, minimum 7 *mm.*: with cranial index 1·39 to 1·30, average on the right 6 *mm.*, maximum 14 *mm.*, minimum 3 *mm.*; on the left, average 7·86 *mm.*, maximum 15 *mm.*, minimum 3·50 *mm.*: with cranial index 1·29 to 1·20, right side, average 5·05 *mm.*, maximum 7·50 *mm.*, minimum 2 *mm.*; left side, average 7·34 *mm.*, maximum 11 *mm.*, minimum 1·75 *mm.*; with cranial index 1·19 to 1·07, average right side 4·22 *mm.*, maximum 5·50 *mm.*, minimum 2·30 *mm.*; on left side, average 5·50 *mm.*, maximum 8·50 *mm.*, minimum 3·10 *mm.*

The average difference between right and left, in favour of the left side, is 2·17 with a cranial index 1·55 to 1·50; with index 1·49 to 1·40 it is 1·50; with index 1·39 to 1·30, 1·86; with index 1·29 to 1·20, 2·29; and with index 1·19 to 1·07, 1·28.

Körner proposes to perforate in all cases as far forwards as possible: in adults with a cranial index of 1·30 and less, before the line of attachment of the auricle, if this can be done. The author does not approve of the proposal, because then the bony substance of the posterior wall of the auditory canal which remains would become greatly thinned, and in this way prejudicial to recovery.

If the operation has been successful in establishing a communication between the opened mastoid cells and the tympanum, the cavities should be washed out copiously with an antiseptic solution by way of the Eustachian tube with the aid of a catheter, in order to remove all morbid products. If necessary, a Weber's catheter for the tympanic cavity may also be employed for this purpose. In those very rare cases in which the drum-membrane is not already perforated, it should be incised before the irrigation (*Voimaud*).[1]

When the injected solution has flowed away quite clear for some time and all bleeding has ceased, the parts may be dried and a proper dressing applied. A suitable piece of drainage tube, previously placed in a 5 per cent. carbolic solution, is first introduced as far as possible into the wound: it should be cut obliquely at the inner end, and perforated at several places along its length. The space around the tube is then to be filled up with strips of iodoform gauze. If hæmorrhage has occurred or is threatened, it is advisable, before inserting the drainage tube, to plug the whole cavity firmly with the gauze, only introducing the tube on renewing the dressing, and when the danger of hæmorrhage has ceased. After plugging the wound, it is to be covered with several layers of iodoform gauze, which should extend for some little distance around it. Upon this a layer of

[1] "Des Abscès mastoidiens et leur traitement." Thèse de Paris, 1877.

Bruns' cotton-wool or several thicknesses of carbolic gauze, covered over with a piece of gutta-percha tissue, are spread, and the whole fastened by several turns of a calico bandage carried round the head. Lastly, the external auditory canal should be loosely plugged with iodoform gauze.

Truckenbrod recommends as a dressing small cambric bags filled with wood-wool. Before use they are to be placed in hot water (80-90° C.), and then allowed to cool. It is unnecessary to render these pads antiseptic, since they already possess this property from the evaporating resins and ethereal oils which they contain. ("Der Waldwollenverband." Archiv für Ohrenheilkunde, xxii. Bd.)

The patient should under any circumstances keep his bed during the first few days, even though no fever be present. The diet is to be regulated in accordance with his general condition. The dressing must be changed as required. It may remain untouched for from one to three days, but ought at any rate to be changed then. Should, however, otorrhœa continue after the operation, or the dressing become soiled with the discharges, or the patient complain of severe pain in the wound, or if the neighbouring parts become reddened and swollen, or the temperature sensibly increased, the dressings must be removed earlier. With each renewal of the dressing, the cavities of the middle ear must be thoroughly washed out with an antiseptic solution, and in general, everything done which the state of the aural structures and wound at the time may demand.

The excavation in the bone must be kept open as long as any disease is present therein and suppuration still goes on, even though the latter may have considerably diminished. If an elastic drainage tube does not suffice to maintain an open passage, it should be replaced by a suitable silver tube, or the lead spigot recommended by *Schwartze* may be employed. Fresh sequestra should of course be extracted, and any granulations which may fill the channel are to be removed, and their re-development retarded. The treatment, in short, must be regulated according to the ordinary rules of surgery, and the wound should only be permitted to close when the inflammatory process and all morbid changes in the deeper parts have disappeared.

Ballance[1] has recently reported four interesting cases of septic thrombosis of the lateral sinus caused by suppurative middle-ear disease associated with caries. The otitis was in each case of long standing, and the onset of the pyæmic symptoms was preceded for a short time by cessation or diminution of the discharge. The condition was very grave; there being present high fever with great diurnal oscillations, headache, repeated rigors and vomiting, pain in the ear and neck, and drowsiness. He trephined the mastoid over the region of the lateral sinus, one inch behind and a quarter of an inch above the middle of the osseous auditory meatus,

[1] "On the removal of pyæmic thrombi from the lateral sinus." Lancet, Nos. xx. and xxi., vol. i., 1890.—Eds.

and cut away the portion of bone in which the groove for the sinus runs. Foul air and fœtid pus escaped, and was washed away with perchloride of mercury solution (1 in 2000). The internal jugular vein was ligatured in two places and divided between them. The lateral sinus was slit up, and the pyæmic thrombus removed as far as possible by syringing and by the curette. Complete recovery took place in two cases; while in the others, though marked improvement followed upon the operation, the constitutional infection had gained so great a hold that they terminated fatally. *Ballance* gives the following as the signs to be especially looked for in suspected septic thrombosis of the sinus, and states that when present together they constitute a group of symptoms pathognomonic of the disease: (1) A history of purulent discharge from the ear for a period of more than a year; (2) the sudden onset of the illness, with headache, vomiting, rigor, and pain in the affected ear; (3) an oscillating temperature, reaching to 103° or 105° F., and then dropping, say, below 100°; (4) vomiting, repeated day by day; (5) a second, third, or more rigors; (6) local œdema and tenderness over the mastoid, or in the course of the internal jugular vein; (7) tenderness on deep pressure at the posterior border of the mastoid and below the external occipital protuberance; (8) stiffness of the muscles of the back or side of the neck; and (9) optic neuritis.

CHAPTER XV.

ON CERTAIN SECONDARY RESULTS OF INFLAMMATION IN THE REGION OF THE MIDDLE EAR.

1. Changes in the Membrana Tympani.

Inflammatory processes in the middle ear sometimes leave behind them changes in the tympanic membrane resembling such as are dependent on myringitis. Those observed most frequently consist in secondary thickenings due to a new connective-tissue formation, or to variously metamorphosed inflammatory infiltrations. More rarely are noticed alterations which owe their origin to duplicature of certain portions of the membrane, with subsequent adhesion of the folded parts to one another. The segments referred to mostly correspond to the posterior folds of the drum-membrane, which have become more strongly developed as a consequence of defective ventilation of the tympanic cavity. Less commonly they result from marginal duplications, chiefly on the posterior superior section of the membrane quite near the external auditory canal, and proceed from a relaxation of the tissues.[1] With regard to the significance, the prognosis, and the general treatment of these conditions, the remarks made in connection with myringitis are equally valid here. The operative treatment, however, yet remains for consideration.

In other cases the drum-membrane appears atrophic, or cicatricial, or perforated; the most diverse secondary changes being often found combined in the same case. Plate II., Fig. 13, represents an atrophic membrane remaining after a chronic catarrh of the tympanic cavity. Plate II., Fig. 20, shows a membrane which, after a similar process, had become internally adherent, partly cicatricial and partly atrophic. Fig. 21 depicts a partially calcified membrane in which great loss of substance had resulted from inflammation. A cicatrix was subsequently developed, which was so lax and movable that, on Valsalvan inflation, it was driven outwards to the extent represented in Fig. 28, Plate II.

The relaxations of the tympanic membrane sometimes left after

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[1] Compare *Gruber*, "Ueber eine eigenthümliche Randtrübung am Trommelfelle und deren Bedeutung." Monatsschrift für Ohrenheilkunde, xii. Jahrg., Nr. 9.

inflammations of the middle ear are of much interest. They may be either partial or total, and occur both in cicatricial and in otherwise normal membranes. The change is in many instances a consequence of a long-existing tubal contraction. If the membrane happen to be situated at some distance from the inner wall of the tympanum, the obstacle presented by the latter to its inward displacement is lacking, so that on narrowing of the Eustachian tube it is not only forced inwards, but also distended by the persistent pressure, and a permanent relaxation of tissue thus results. Such a relaxation takes place the more readily if the rest of the membrane should be thickened or abnormally adherent. Conditions (relaxation with atrophy) which have originated in this manner are of common occurrence, and have been described by *Toynbee*.

In other cases, the relaxation is often the consequence of long-continued or frequently induced pressure from the side of the tympanic cavity. In this way is to be explained relaxation of the membrane in individuals who have for a long time been subject to nasal catarrh, and who blow the nose repeatedly and forcibly; likewise in patients with whom the air-douche has been very frequently employed; or in those who, having wide Eustachian tubes, have suffered a long while from severe pulmonary catarrh, with violent paroxysms of coughing.

Under the above conditions it is the posterior-superior quadrant which becomes first of all relaxed, and to the greatest degree, since it is most exposed to pressure from a powerful condensation of the air in the tympanum. The relaxation of the membrane is attended with an attenuation of its structure (atrophy). The relaxed posterior-superior quadrant very often moves so far inwards as to be obscured by the margin of the auditory canal. It appears as a dark depression, from which, on Valsalvan inflation, the membrane bulges outwards. In other instances the relaxed portion of the membrane lies in folds, which are turned either towards the auditory canal or towards the tympanic cavity.[1]

If, with patent Eustachian tubes, such pathological conditions exist in the naso-pharyngeal space as disturb respiration, these may also bring about relaxations of the drum-membrane. With extreme stenosis or total atresia of the naso-pharynx, the forced inspiration or expiration which then prevails, produces abnormal pressure variations in the tympanic cavity. The air in inspiration is forcibly aspirated from the middle ear, while with expiration it is forced through the tube into the tympanum. The membrane may in this way become so relaxed in the course of time that the effect of the movements of respiration upon it may be distinctly recognised. With each inspiration the drum-membrane is seen to sink

[1] *Stifter's* contention as to the impossibility of relaxation of the drum-membrane being brought about by immoderate employment of the air-douche, is contradicted by facts. Bayr. ärztl. Intellig.-Bl., xxiii. Jahrg.

inwards, and with each expiration to move outwards. Figs. 12 and 13, Plate II., represent such membranes displaced inwards.

Since the conditions just described may be combined with more or less pronounced atrophy, or with partial thickening, with synechiæ, etc., it follows that the actual appearance of the membrane may be very different in different cases, and that the exact diagnosis must rest upon the results of the various methods of examination.

Plate II., Fig. 26, represents the thickened and partially relaxed left tympanic membrane; and Fig. 27, the same patient's right membrane bulged out like a bladder, and very relaxed and attenuated, especially on its posterior segment. The relaxation may possibly have been due to the air-douche, which had been employed by the patient himself and his medical attendant during two years. The right Eustachian tube was so wide that the respiratory movements could be distinctly seen on the drum-head. The latter is depicted during a strong expiration, and shows lines of light-reflex running obliquely on the posterior segment. Fig. 28 exhibits a drum-membrane with considerable relaxation of the posterior-superior quadrant, which is partly folded, partly displaced inwards. Upon Valsalvan inflation it assumed the appearance represented in Fig. 29. Fig. 30 shows relaxation of the posterior segment, with distinctly developed folds directed outwards near the posterior margin and lower segment. Fig. 31 is the same membrane on Valsalvan inflation. Fig. 32 depicts a case of considerable relaxation of the posterior segment. The posterior-superior quadrant is drawn inwards, and so much thinned that the descending process of the incus and the chorda tympani are distinctly visible. When the middle ear was inflated by Valsalva's process, the membrane appeared as in Fig. 33. On the membrane represented in Fig. 34, a white cord could be distinctly seen running obliquely backwards from the lower part of the handle of the malleus; and above and below this, the membrane was depressed inwards for some distance, appearing partially folded. On Valsalvan inflation, the relaxed part bulged out towards the auditory canal on the posterior segment in the form of a bladder about the size of a sweet pea and obliquely grooved, as seen in Fig. 35. The groove on the bladder corresponded to the white cord previously mentioned along the posterior segment, which must probably be considered as the line of attachment of a false membrane connecting the drum-head with the inner wall of the tympanum.

The subjective symptoms associated with relaxation of the membrana tympani are to be referred to the impairment of function of the membrane itself, and likewise to the secondary changes which the condition brings about in the adjoining structures—*e.g.* the auditory ossicles. They consist in deafness in varying degree, in subjective auditory sensations, in vertigo, etc. It is not at all uncommon for patients of this kind

to make instinctive efforts to improve the hearing for the moment by various manœuvres. For example, they may inflate the middle ear by the Valsalvan method; or, by blowing the nose, force some of the air through the Eustachian tube, and so further stretch the drum-membrane. The hearing power does not, however, always improve by condensing the air in the tympanic cavity in this way. Sometimes, indeed, it is made even worse, and only becomes better again when by an energetic movement of deglutition the membrane is restored to its previous position. The increased defect in sound-conduction is due in such cases partly to the extreme tension of the membrane produced by the forcible pressure, and partly to the associated changes brought about in the deeper structures.

That *excessive tension of the tympanic membrane*, with all the resulting subjective and objective changes, may be induced by a middle-ear inflammation, needs no further demonstration. Amongst its most frequent causes are to be enumerated thickenings of the membrane, abnormal adhesions implicating it (synechiæ), and persistence of an abnormally developed posterior fold occasioned by adhesion of its duplicatures.

2. Abnormal Adhesions of the Structures of the Middle Ear.

As mentioned in the description of inflammations of the middle ear, it not unfrequently happens during their course that abnormal connections of different parts are brought about, either by direct adhesion of displaced structures which have remained in contact for a lengthened period, or by union of new connective-tissue formations derived from various situations in this region.

Such abnormal adhesions sometimes persist throughout life without producing any auditory derangement or any other morbid symptoms, so that neither the patient nor the examining surgeon may have had any suspicion of their presence. In other instances, on the other hand, they may occasion very considerable disturbance of function, partly by displacement of structures from their natural position, partly by impeding these in their movements, and partly by dislodgment of the media concerned in the normal conduction of sound. Under these circumstances they then become a proper object for aural treatment.

(*a*) *Abnormal Adhesions of the Membrana Tympani.*

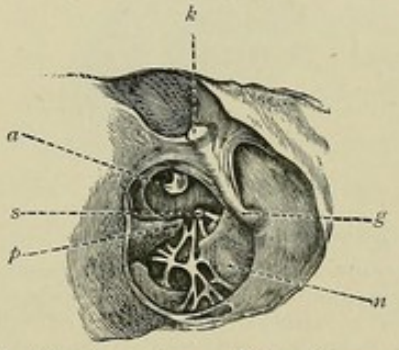
These are the most common of all the varieties of morbid connections between the different structures of the middle ear, and may be present when the membrane is in other respects normal, or also when it is perforated, cicatricial, or in other ways the subject of pathological changes.

The adhesions most often exist between the promontory and the

central portion of the membrane; or between the posterior-superior quadrant of the latter and the descending process of the incus: more rarely in other situations. Synechiæ of this description are frequently combined with stenosis of the Eustachian tube. If perforation of the drum-membrane has occurred, union of the deeper structures with the margin of the aperture may arise, or with a cicatrix, if this has been formed. In this way it sometimes happens that the cavity of the tympanum is subdivided into spaces communicating with each other, or with neighbouring passages, such as the Eustachian tube or the external auditory canal, or the mastoid cells. In the case, for example, represented in Fig. 136 and in Fig. 11, Plate II., the posterior segment of the membrane had been almost completely lost as a result of the inflammation; the anterior segment together with the malleus was still preserved, but adhered so intimately to the promontory that upon Valsalvan inflation the remains of the membrane was puffed out without the air escaping from the tympanic cavity, in spite of the absence of the posterior segment. There was likewise present, as seen in the figure, a dislocation between the incus and stapes, as well as much newly formed connective tissue in the posterior half of the tympanum. The watch was heard quite distinctly on contact with the ear and with the adjoining bone, and no subjective auditory sensations were present.

Fig. 136.

Synechiæ between the anterior segment of the membrane—between which and the malleus the connection remained—and the internal wall of the tympanum. The posterior segment of the membrane has been lost. (Twice enlarged.)



k, Short process of the hammer; *g*, handle of the hammer; *a*, descending process of the incus; *s*, stapes; *p*, eminentia pyramidalis (the tendon of the stapedius has disappeared); *n*, cicatricial tissue.

Fig. 137 exhibits the appearances in another case, in which several spaces were separated from one another; the most anterior communicating with the tube, the most posterior with the mastoid cells, and both with the external auditory canal. This patient also heard the watch on contact with the auricle. There was in addition violent tinnitus, due probably to a new connective-tissue formation in the region of the fenestra ovalis which involved the stapes and incus, and in this way had doubtless an injurious effect upon the labyrinth.

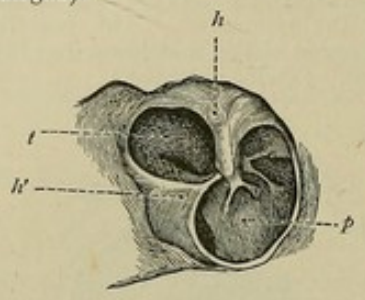
The *subjective symptoms* produced by irregular adhesions of the tympanic membrane declare themselves by impaired conduction of sound, as well as by the phenomena of increased intra-auricular pressure which may follow. With the resulting diminution in hearing capacity, internal noises and other troublesome consequences may arise, with which we have already become sufficiently acquainted.

Adhesions of the drum-membrane with the inner wall of the tympanum, or with the descending process of the incus, are as a rule very easy to diagnose. Inspection of the membrane before and after inflation of the middle ear, examination with Siegle's speculum, and auscultation during the employment of the air-douche, yield tolerably conclusive data.

Before inflation with the air-ball, the drum-membrane appears very concave, with the handle of the malleus drawn directly inwards, inwards and forwards, or inwards and backwards, even perhaps till it appears horizontal (*s*, Fig. 16, Plate II.). If the membrane be adherent to the promontory, a yellow, more or less rounded disc with faded margins is generally to be seen marking the adherent area. If the union be an indirect one by means of a band of connective tissue, the concavity of the membrane is less conspicuous, and instead of the above-mentioned yellow disc, one or more white spots of various size are visible on the membrane, indicating the points of attachment of the connective-tissue bands.

Fig. 137.

Adhesion between the remains of the tympanic membrane and the inner wall of the tympanum (twice enlarged).



h, Malleus in connection with a residual portion of the drum-membrane, and *h'*, posterior-inferior quadrant of membrane, both firmly adherent to the inner wall of the tympanum; *p*, anterior-inferior section of the inner wall of tympanum (promontory); *t*, posterior-superior section of the tympanum. The auditory ossicles are imbedded in the mucous membrane of the tympanic cavity, which is thickened by connective tissue.

If the membrane be united with the descending process of the incus, the latter appears through it as a whitish-yellow streak; and if in addition an abnormal connection exist between the lower end of the incus and the malleus, these form an angle opening upwards, or the tissue connecting them fills up the interspace, and may be recognised as a whitish-yellow spot.

After employment of the air-douche, the appearances will be considerably altered, if air can enter the tympanum. If the adhesion be strong enough to resist the current of air, no change will appear on inspection on the adherent sites; but in the surrounding parts, or in certain other areas, the membrane will be forced outwards, and this may be recognised by different reflex-phenomena. If, however, the abnormal connection be broken through by the force of the inflated air, then the membrane which is pressed outwards will exhibit an appearance more nearly approaching the normal; and in certain cases the hæmorrhage resulting from the rupture of the adhesion may be distinctly seen.

When the process of the incus is adherent to the membrane, and the structures are separated by the air-current, the image of the incus will

disappear; if, however, the parts are not thus disconnected, the appearances remain much the same after as before the inflation.

Auscultation will in many instances give fuller information regarding what has been perceived on inspection. With adhesion between the membrane and the inner tympanic wall, if the posterior portion of the latter be separated from the anterior, the inflated air will not advance so far as usual, and this may be recognised by a practised ear. When on inflation abnormal connections become separated by the pressure of the air, the auscultating ear may distinguish quite distinctly, even if less clearly than the patient himself, the short sound associated with the rupture, which resembles that produced by tearing threads or membranes. Lastly, protracted secondary auscultation-sounds likewise furnish information as to the condition present. When with abnormal connections of the drum-membrane, inflation of the middle ear is practised, the various free portions of the membrane are pressed outwards to a greater or less extent, and then return to their previous positions, though not all exactly at the same moment, from which arises a prolongation of the secondary sound. More delicate adhesions may be broken down by inflation of the middle ear, without the rupture giving rise to any recognisable auscultation-sound, even though they may have occasioned distinct morbid symptoms. The fact that such symptoms have either diminished or quite disappeared after the employment of the air-douche, renders such an explanation probable in the absence of other cause for the improvement.

In the majority of cases, the use of the air-douche will bring about the division of abnormal adhesions of the drum-membrane. For this of course a varying amount of force is requisite in accordance with the kind of connection which exists. Instances, however, occur in which even a powerful current of air from a force-pump apparatus is unable to sever the adhesion, the membrane itself being ruptured instead. In these cases, division of the adhesion may be attempted by operative measures, which will be referred to later.

A permanent shortening of the tendon of the tensor tympani muscle readily takes place in long-standing cases of its relaxation brought about by long-existing synechiæ of the drum-membrane. The presence of this secondary retraction of the tendon, together with the tendency of the adhesions to reunite after separation, renders frequent employment of the air-douche necessary, with the view of preventing their reunion. If the contraction of the tendon should render nugatory the effect of the air-douche in obviating a fresh adhesion, its division will be indicated.

The author cannot here omit to record that he has in certain cases succeeded in separating such synechiæ by direct injection of fluid into the middle ear, as described at page 199, after the strongest air-currents had failed to produce this result. The air-douche can in general only bring about a separation of abnormal

connections when the force of the air-current does not take effect in a direction parallel with the uniting tissue, or when the latter is so delicate that it gives way even before the side pressure, as, for example, on the membrana tympani yielding towards the external auditory canal. Stronger bands of tissue, the direction of which is more parallel to the drum-membrane—*e.g.* between the malleus and incus—remain usually intact upon inflation through the tube.

Upon rupture of such adhesions, whether they be in the course of the tube or in the tympanum, an artificial emphysema may easily be produced when inflation is practised, by the passage of air through the lacerated tissues at the place of attachment of the adhesion into the neighbouring areolar tissue. This accident may happen to the most skilful operator, even when the inflation is made merely for purposes of diagnosis, and quite apart from any lesion caused by a catheter. Abnormal defects, particularly in the mastoid process, or ulcers in the Eustachian tube, the presence of which cannot be ascertained, favour the occurrence of the emphysema. The air generally passes into the submucous tissues of the pharynx, and thence into the areolar tissue of the cheek and the neck, from which it may naturally spread still further. When the air finds its way into the submucous tissue of the pharynx, a sensation as of the presence of a foreign body is produced; and with a high degree of emphysema, disturbances of respiration may readily occur. The speech may become nasal on account of swelling round the posterior nares, but there is rarely more than a feeling of tension present. No further injurious consequences are as a rule developed. The imprisoned air may be pressed by massage-like movements in the direction of its inlet; or, if there should be a great degree of swelling of the pharyngeal structures, the mucous membrane may be pricked with some pointed instrument at various places, upon which the air usually escapes. In still severer cases, the above treatment may be supplemented by the use of gargles and cold compresses. In the majority of instances, however, all symptoms pass away in the course of twenty-four hours.

J. Pollak[1] found as the result of his experiments that with laceration of the lower wall of the Eustachian tube, the air passed between the tensor and levator palati into the fossa retro-maxillaris, as well as beneath the mucous membrane of the soft palate, by the arch of which it was limited. It then spread along the inner surface of the internal pterygoid muscle, and reached as far as the submaxillary fossa. With a further extension it proceeded over the lower jaw, and from the retro-maxillary fossa into the face. If the posterior wall of the pharynx be wounded, then the air advances by the side of the large blood-vessels, and may reach the mediastinum. Emphysema of the larynx is *never* thus produced. These experiments best rebut the view of those who are of opinion that in the two cases observed by *Turnbull*, in which death followed upon the employment of the catheter with inflation by the air-ball, the fatal termination was to be connected with the establishment of a laryngeal emphysema. *Voltolini* made the observation that, with an artificially induced emphysema in the rabbit, the air collected round the epiglottis and closed the entrance into the larynx. This never occurs in the human being.

It is clear that, since normal adhesions of the membrane imply no special primary affection, they may be combined with the most diverse changes in other parts—*e.g.* in the Eustachian tube, in the closing structures of the fenestra ovalis and fenestra rotunda, in the labyrinthine structures,

[1] "Ueber die Verbreitung submucöser Emphyseme in der Gegend der Eust. Ohrtrompete." Wiener allgemeine medicinische Zeitung, 1887.

etc. From this it follows that the result of treatment of such conditions cannot be determined with certainty beforehand, and that in general the measures employed must have due regard to other possible alterations in the auditory organ.

(*b*) *Abnormal Connection of the Auditory Ossicles with one another, and with the neighbouring structures.*

Besides the previously mentioned abnormal union of the auditory ossicles as they occur combined with synechiæ of the drum-membrane, those are still to be considered which are observed with loss of the tympanic membrane, as well as such having special reference to the articular connections of the ossicles.

If the membrana tympani has been destroyed as a result of inflammation without loss of the malleus, it sometimes happens that the latter remains for many years without any further adhesion. Much oftener, however, it is drawn inwards by the tensor tympani muscle, and in that case adhesion with the promontory is brought about, as previously described. An abnormal connection of this kind existed in the case represented in Fig. 18, Plate II. Cicatricial connective tissue, reflecting the light in different ways, passed from the margin of the auditory canal to the sclerosed but tolerably vascular mucous membrane of the promontory. The malleus was intimately united with the latter; and the articulation between the incus and stapes, as well as the depression of the fenestra rotunda, were visible.

In other cases the handle of the malleus may be so displaced that its lower extremity comes into contact with the head of the stapes, and appearances are presented like those seen in Figs. 14 and 15, Plate II.

In Fig. 14 the tympanic membrane was almost completely lost, and the mucous membrane of the promontory was sclerosed. In Fig. 15 the handle of the malleus was drawn into the horizontal position after destruction of the drum-membrane, and in the course of time became fixed by connective tissue. A condition is depicted in Fig. 19, Plate II., which was observed by the author in a patient who had for many years suffered from purulent inflammation of the middle ear, and in whom, after cessation of the otorrhœa, the following changes were to be seen:—At the upper part a portion of the membrane, crescentic in shape, was still left, and exhibited two apertures placed one above the other (foramina Rivini). Directed downwards from the free border of the crescentic residue was to be seen the handle of the malleus, and behind this was the lower end of the incus, lying exposed externally. The handle of the malleus, with the remains of the membrane, had been drawn inwards and grown to the promontory.

Abnormal union of the malleus with the promontory may occasion considerable disturbance by reason of the associated movements of the auditory ossicles. The changes in the structures closing the fenestra ovalis and fenestra rotunda, and in the labyrinth, which frequently occur in conjunction with the preceding, may increase the subjective symptoms. Separation of the adhesions of the malleus may be accomplished with the aid of the air-douche, or with cutting instruments.

If symptoms of severe labyrinthine pressure accompany abnormal union of the malleus with the process of the incus and the stapes, resection of the handle of the malleus may possibly be of service.

The abnormal connections which have for us the chief importance, however, are such as involve the articular extremities of the small bones, and in their highest development produce *ankylosis of the auditory ossicles.* Adhesions of this kind, originating in an inflammatory process, may depend upon hypertrophy of the articular capsules, or upon false membranes, or upon an osseous inflammatory new formation. *Politzer*[1] describes a case of ankylosis of the stapes, brought about by a new formation of bone, which arose from a periostitis on the external wall of the vestibule. *Toynbee* had previously observed similar conditions.

Ankylosis of the auditory ossicles is chiefly developed at a somewhat advanced age, but it also occurs in younger individuals. A patient of *Toynbee's*, who died at the age of twenty, had complete ankylosis of the base of the stapes, which was demonstrated post mortem. Rheumatic affections are stated to be of common occurrence in patients with such conditions. The position assumed by the ossicles in ankylosis is characteristic and interesting. In a preparation in the author's collection, represented in Fig. 138, all the articulations are ankylosed; and in addition the head of the malleus and the crown of the incus are united by bone with the roof of the tympanum. The descending process of the incus is placed almost horizontally, and is thus far removed from the malleus. *Toynbee* states that he has found the articular surfaces of the ossicles enlarged when the joints were ankylosed.

The greatest pathological interest certainly attaches to ankylosis between the foot of the stapes and the fenestra ovalis. According to the results of post-mortem examination, however, complete immobility of these parts appears to be much more rare than between the malleus and incus, or than between the incus and the head of the stapes.

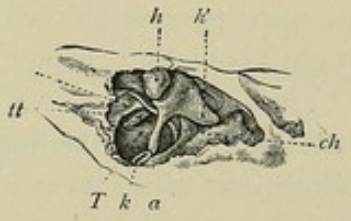
The symptoms of commencing ankylosis of the stapes are very similar to those of hypertrophic inflammation of the mucous membrane of the tympanum, from which, as is well known, it frequently results. It is, as a rule, developed very gradually, so that at the commencement the

[1] Allgemeine Wiener medicinische Zeitung, 1862, Nr. 24 und 27.

patient scarcely recognises his imperfect hearing capacity. If the ankylosis be complete, the hearing power is generally so much diminished that conversation can be no longer followed, even with the assistance of an ear-trumpet, or when shouted loudly into the ear. The author cannot, however, agree to the view according to which an ankylosis of the foot of the stapes is supposed to cause complete deafness. He has known patients, even with both ears affected in this way, still able to perceive simple tones and loud noises, provided that no other morbid changes in the labyrinth or the brain were present to completely annul the hearing capacity. Not at all infrequently, indeed, they manifest auditory hyperæsthesia, so that every loud sound induces unpleasant sensations, and leads them to request one not to call loudly into the ear in testing their hearing power. Speech, however, they cannot follow, and subjective auditory sensations are almost invariably present.

Fig. 138.

Ankylosis of all the articulations of the auditory ossicles, and union of these with the adjacent structures. The roof of the tympanum has been removed, and the tympanic cavity is visible from above.



h, Head of the malleus united with the crown of the incus; *h'*, horizontal process of the incus; *g*, handle of the malleus; *tt*, tensor tympani muscle; *T*, membrana tympani; *a*, connection between the descending process of the incus and the stapes *k* (the process of the incus is far removed from the handle of the malleus); *ch*, chorda tympani.

According to *Toynbee*, the hearing is said to become suddenly better after a sharp, loud cry or tone is produced; the improvement then quickly disappearing again. So long as merely diminished mobility, but not complete ankylosis, exists, speech is still heard better than anything else. If however several persons speak at once, the patient can distinguish nothing. At later stages, the previously mentioned symptom—known as paracusis Willisii—is said by *Toynbee* to make its appearance, and is explained by him on the supposition that, after a concussion of the muscles and ossicles, they are better fitted to take up further vibrations.

The *objective appearances* vary greatly, in accordance with other co-existent changes which may be present. The ankylosis is stated by *Toynbee* to be very often accompanied by relaxation and ossification (?) of the membrana tympani, but this the author has not been able to find. It is not usually betrayed during life by any objective symptom, so that the diagnosis is only a more or less probable one, resting on the history, the subjective symptoms, and perhaps also upon certain objective signs.

The existence of ankylosis of the foot of the stapes may be conjectured with most probability when the patient hears better on the affected side without an ear-trumpet than with the aid of such an instrument. The ankylosed auditory ossicles being unable to conduct sound, the greater

volume of waves collected by the ear-trumpet will have no effect in magnifying the auditory impulse, while at the same time fewer will impinge upon the cranial bones to be thence transmitted to the labyrinth. To this diminished auditory stimulus will consequently correspond a diminished auditory perception. When, on the other hand, the ear-trumpet is not employed, the sum of the sound-waves which strike the cranial bones is greater, and the auditory sensation is thereby increased.

The *prognosis* in cases of abnormal union of the auditory ossicles is generally very doubtful. If the adhesion be brought about by means of soft tissue, and this happen to be arranged in such a manner that it can be ruptured by the use of the air-douche, a good result may be attained in many instances. When, however, the ankylosis is due to firm, unyielding tissue, the prognosis will be in the highest degree unfavourable. The employment of the air-douche may furnish information as to the condition present, since in cases in which the abnormal connection is produced by yielding tissues, an improvement, though perhaps only to a small extent, is at once perceptible, which is not the case with a complete ankylosis brought about by a firmer binding material.

The *treatment* has for its aim the dissolution of the abnormal union, or at least the weakening of the ill effects produced. To this end the air-douche is of all measures the most valuable. In its action it resembles in many cases the treatment by means of methodical movement adopted with abnormal connections of other joints. By the frequent movements brought about by the use of the air-douche, a relaxation of the connecting tissues may sometimes be attained, and the condition thereby improved. The effect may be reinforced by systematic condensation and rarefaction of the air in the external auditory canal. In general, the various remedial measures described in the treatment of plastic inflammation of the middle ear may be tried in such cases.

An apparatus called a *Tragus-pressor* has been recommended by *Hommel* in chronic inflammation of the middle ear, especially with defective mobility of the sound-conducting structures. By this the tragus is methodically pressed towards the lumen of the auditory canal, and released again. The arrangement, has, however, not proved serviceable according to the testimony of practical judges.[1]

Lucæ[2] employs an apparatus contrived by himself with the view of increasing the mobility of the auditory ossicles in cases in which this is diminished, the capacity for following conversation much impaired, and Rinne's experiment yields a negative result. It consists of a steel rod

[1] *Vide* Bericht über die otiatrische section der Naturforscherversammlung in Berlin, 1886.

[2] "Ueber eine Methode zur mechanischen Behandlung der chronischen Beweglichkeitsstörungen im schallleitenden Apparate des Gehörorganes." Archiv für Ohrenheilkunde, xxi. Bd.

or pin, at one end of which is a small conical depression for the reception of the short process. The pin goes through a conducting tube, and its other end touches a spiral spring fixed into the handle of the instrument, and yielding readily to pressure. In employing this "pressure-probe," the patient's head is first fixed, and the instrument introduced under a good light along the upper wall of the auditory canal towards the short process. The latter is received in the hollow at the inner end of the probe, and sharp taps are then made against it—at first, one or two only; later on, more, up to perhaps ten. The manipulation is to be repeated in accordance with the result obtained. *Lucæ* asserts that after the employment of this instrument the air-douche may be used with success, though previously ineffectual. The instrument may certainly be tried in cases in which both the air-douche and methodical condensation of the air in the auditory canal are unavailing. Unfortunately, most patients experience severe pain upon its application, and submit very unwillingly to its repetition. Excoriations on the short process also may readily be produced, even with the most careful manipulation, so that it can then only be used again after a long interval.

(*c*) *Relaxation and Separation of the Connections of the Auditory Ossicles.*

The luxations and dislocations of the ossicles which are sometimes left after inflammatory processes in the middle ear, may be recognised with accuracy if the structures are accessible to inspection. Under other circumstances, and especially if the tympanic membrane still remain, a precise diagnosis can be made neither with the aid of the "diagnosticating rod" recommended by *Erhard*,[1] nor that of the modified artificial tympanic membrane introduced by *Toynbee* shortly before his death. The separated structures may perhaps be momentarily brought into contact by these means, and an inference as to the nature of the case drawn from an improvement in the hearing power which may possibly ensue. The expedient, however, is not always successful; and even if it should be, an improvement in hearing does not always take place. Nevertheless, if a dislocation of the incus from the head of the stapes be recognised (Fig. 136), an attempt should be made to bring them into direct or indirect contact with the help of the artificial drum-membrane.

(*d*) *Secondary Changes affecting the Internal Muscles of the Ear.*

The abnormalities which inflammations of the middle ear, especially when chronic, may induce in the *tensor tympani* and *stapedius muscles* consist in solution of continuity of their tendons, with loss of substance to a

[1] Klinische Otiatrie.

variable extent; irregular adhesion of the tendons with adjoining structures; shortening of the tendons; and fatty degeneration, or other deterioration of the substance of the muscles. The genesis of these various conditions has been already described in the account of inflammations of the middle ear.

Moos and *Steinbrügge* found pathological changes in the fibrillæ of the tensor tympani, similar to those described by *Friedreich* as occurring in progressive muscular atrophy. Whilst at one part, transverse striation was still visible, at another, longitudinal striation only was present. At a further stage, the fibrillæ appeared swollen, diffused, and filled with a finely granular, molecular, or quite homogeneous wax-like material. Many were twisted, and exhibited constrictions and expansions. In many places they appeared to have been completely absorbed, merely the empty sarcolemma remaining, reduced here and there to a minimal lumen.

The *subjective symptoms* which such changes in the muscles may produce, have long remained but imperfectly ascertained. It would appear that a shrinking of the tendons may induce subjective symptoms dependent on the secondary labyrinthine affection thus occasioned, which are disproportionately more severe than when a complete division of these structures exists.

The diagnosis of such conditions of the muscles of the middle ear is sometimes rendered very difficult, and is at best to be made only with some degree of probability. Division of the tendon of the stapedius may occasionally be recognised with accuracy by inspection; with destruction of the posterior-superior quadrant of the tympanic membrane, the head of the stapes is distinctly visible, and in such cases no trace of the insertion of the tendon is present (Fig. 136). Secondary retraction of the tendon of the tensor tympani muscle has been already fully considered (p. 398).

For the diagnosis of changes in the tensor tympani dependent upon its complete paralysis, the electrical method may be employed. For this purpose an elastic catheter is introduced into the Eustachian tube, and fixed by means of the "frontal forceps" (Fig. 73). A copper wire is then passed through, and for a short distance beyond, the inner end of the catheter, so that the projecting portion lies in the first part of the Eustachian tube. The outer end of the wire is connected with one pole of an induction apparatus. The head of the patient being placed in an inclined position, a little tepid water is dropped into the external auditory canal, and a hard rubber plug, through which a manometer tube passes, is then introduced. A second wire, somewhat longer than the plug, also passes through it so as to project into the auditory canal as well as on the outside. The outer end of this wire is now connected with the other pole of the induction-apparatus.

[1] "Ueber die histologischen Veränderungen im knochen und in den Weichgebilden des mittleren und inneren Ohres bei Caries des Felsenbeines." Zeitschrift für Ohrenheilkunde, x. Bd.

The current will then pass through the structures existing between the two poles, and in this way the tensor tympani muscle is made to contract. In consequence of this, the tympanic membrane is drawn inwards, followed by the fluid in the external auditory canal and that contained in the manometer. The latter movement is made perceptible by the coloured fluid in the tube. If the tensor tympani be incapable of contraction, no effect is produced upon the manometer.

It is quite true that in this procedure, secondary currents are produced by which other muscles undergo contraction; but the analysis of the possible effects of these shows that the result would be quite contrary to the above. Co-existent pathological changes in the middle ear may, however, interfere with the experiment. For example, over-rigidity of the membrane may prevent its retraction, as well as any impediments to its movement which may be offered by conditions present in the tympanic cavity. The result therefore of the electrical test must be accepted with much circumspection.

The intra-tubal application of electricity, as above described, may be employed to improve the condition of the weakened muscles; and *Weber-Liel* praises its beneficial effect in this connection. For shortening of the tendon, tenotomy may be practised.

CHAPTER XVI

ANOMALIES OF THE EUSTACHIAN TUBE.

Imperfections of the tube may be either congenital or acquired. *Excessive formation* has so far been observed only in certain situations, and chiefly in the cartilaginous portion, of which the part projecting into the pharynx is sometimes found inordinately developed. *Complete absence* of the Eustachian tube is of congenital occurrence, and is invariably accompanied by other malformations of the ear and cranium. *Partial defect* is more often of acquired than of congenital origin. In such cases it is usually the pharyngeal portion which is wanting; having been lost either through ulceration, or occasionally as a result of operative measures.

The abnormalities above mentioned are extremely rare in comparison with such as relate to the direction and extent of the tube.

Deviations of slight degree frequently exist as regards the normal direction of the tube. For example, the angle between the cartilaginous and the osseous portion may be straightened out, so as to resemble more the condition in the infant. On the other hand, the bend at the junction of the two sections of the tube may be more pronounced; or other simple or multiple deviations may exist in its course, in either the osseous or cartilaginous part. Anomalies of this kind may impair the function of the tube, and so occasion morbid symptoms. Their chief importance, however, lies in their influence upon the course of affections of the Eustachian tube or the tympanic cavity. In the treatment also of middle-ear disease, when it is necessary to employ the bougie, an abnormality of direction, especially if multiple, may be extremely troublesome.

The *diagnosis* of such an irregular course of the tube during life may be very difficult, but may be made with a certain degree of probability by a careful consideration of the combined results of the various methods of examination. The chief evidence of such a condition is afforded by employment of the air-douche, with or without the catheter; by the use of the Eustachian bougie; and by rhinoscopy.

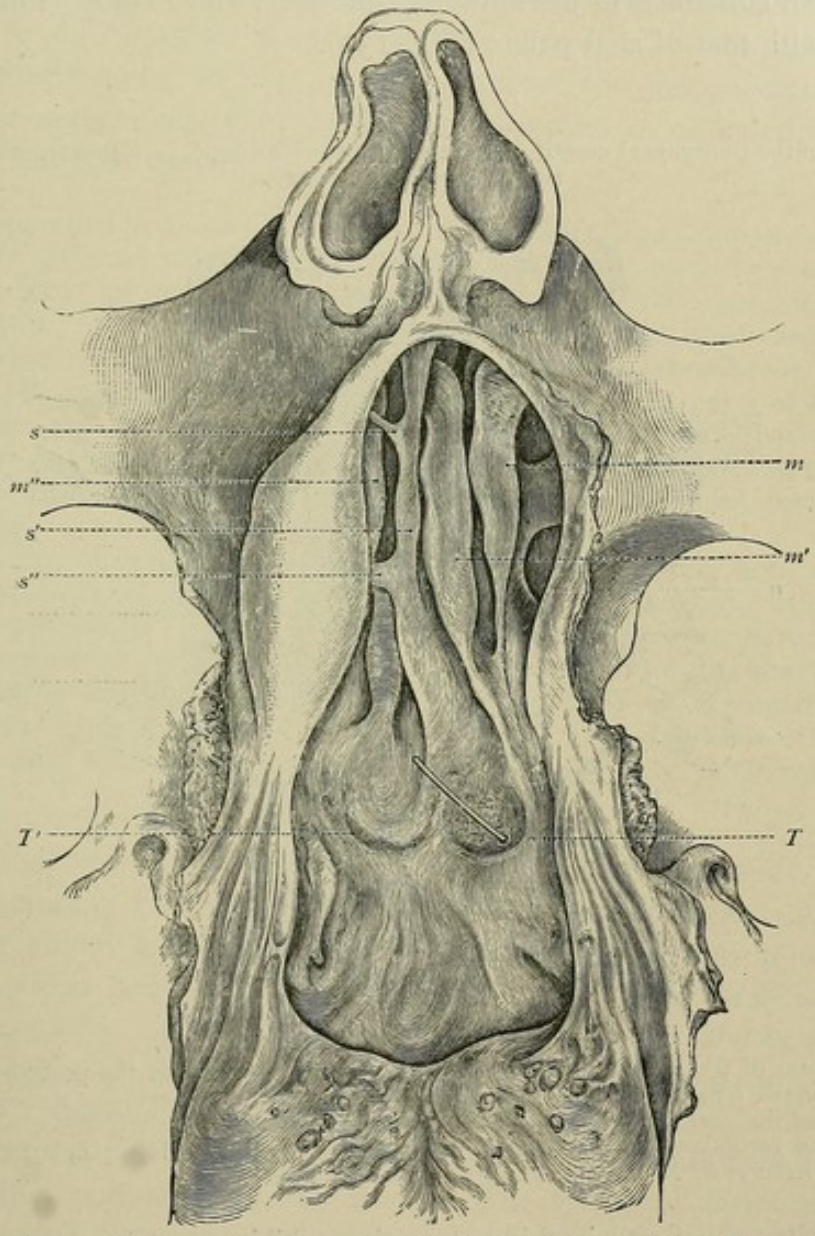
Unusual conditions of the lumen of the tube are in their origin congenital or acquired; the latter far preponderating in number. We distinguish (1) *narrowing*, or *stenosis*; and (2) *occlusion*, *atresia*, or

obliteration. In reference to the latter condition, the lumen may be occluded either at some part, or throughout the entire length of the tube.

The affections which may lead to stenosis or to obliteration of the

Fig. 139.

Atresia of the right, and extreme stenosis of the left Eustachian tube, in a case of cleft palate.



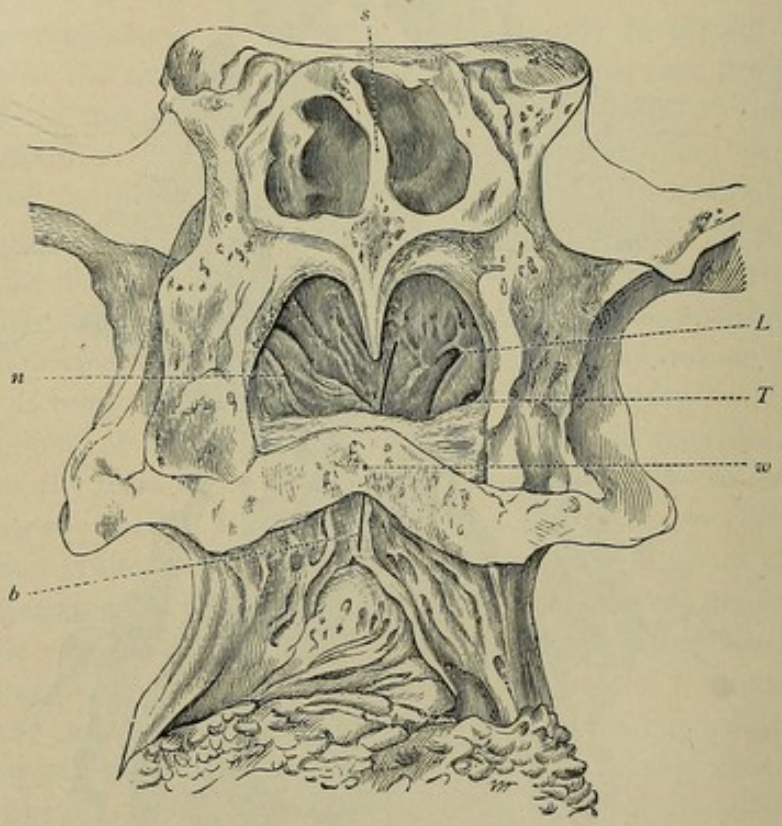
s, *s'*, *s''*, Rudimentary nasal septum; *m*, *m'*, *m''*, turbinated bodies; *T*, opening into the left tube, through which a bristle has been passed; *T'*, small papilla in the situation of the mouth of the right tube, the latter being absent.

Eustachian tube have been already discussed. They comprise chiefly the various inflammatory processes affecting the mucous membrane of the middle ear and pharynx. The degree of contraction, as well as its structural cause, will vary in accordance with the objective changes which

the membrane has undergone. An occlusion of the walls of the canal, closing it completely for a greater or less distance, may be brought about by a simple hyperæmic swelling of the structures. A similar result may be produced by the development of new tissue in connection with a plastic inflammation; and so forth. Atresia of the tube may be also, as before mentioned, of congenital origin. The adjoining figure represents a preparation contained in the author's collection, and exhibits this condition coupled with that of cleft palate (Fig. 139).

Fig. 140.

Occlusion of the pharyngeal mouth of the right Eustachian tube, resulting from the cicatrisation of syphilitic ulcerations.



s, Septum of the sphenoidal sinus; *w*, soft palate, adherent to the posterior pharyngeal wall (the bristle *b* passes through the opening remaining in the middle, through which the upper half of the pharynx communicates with the lower); *n*, cicatricial tissue in the situation of the limbus cartilagineus and the mouth of the right Eustachian tube; *L*, left limbus cartilagineus; in front of it, *T*, pharyngeal orifice of the left tube.

The pharyngeal wall in this preparation exhibits smooth mucous membrane, *not cicatricial*; otherwise nothing except a somewhat flat tubercle, the rudimentary limbus cartilagineus. On the left side, a round aperture is seen representing the pharyngeal opening of the Eustachian tube, and large enough to admit a medium-sized hog's bristle. The orifice leads to a canal, through which the bristle can be passed into the tympanic cavity, and thence into the external auditory canal. The limbus cartilagineus is wanting also on this side, so that Rosenmüller's fossa is absent on both sides. In both ears the tympanic cavity appears very contracted from the presence of connective-tissue, mucous and fatty matters, and the membranes

much retracted and wasted. The muscles of the malleus have also undergone great fatty degeneration. On the one side is partial defect and complete atresia; while on the other is defect with extreme stenosis of the tube. The preparation came accidentally into the possession of the author, who did not have an opportunity of examining during life the old woman from whom it was taken, nor could he gather any information regarding the symptoms which had existed.

Acquired obliteration of the Eustachian tube arises almost without exception after ulcerative inflammatory processes, most frequently after healing of syphilitic ulcers of the pharynx. Here, as in the case of the preparation represented in Fig. 140, the whole of the limbus cartilagineus is destroyed, and the pharyngeal orifice of the tube is occluded by newly developed cicatricial tissue.

The preparation represented in Fig. 140 was taken from a man twenty-two years of age, affected with hereditary syphilis, in whom ulceration in various parts of the body, as well as in the structures of the naso-pharynx, occurred in early childhood. When the author first saw the patient in the wards of *Dr. Standthartner*, the ulcerative process had quite ceased; its previous existence being indicated only by the presence of cicatrices in various parts of the body, by the sunken nose, and by adhesion of the soft palate with the posterior wall of the pharynx; merely a small aperture (2‴ in diameter) being left corresponding to the position of the base of the uvula, which had likewise been destroyed by ulceration.

The patient, when he came under observation, was suffering from advanced pulmonary tuberculosis, to which in a short time he succumbed. His hearing capacity was perfectly good on the left side; but on the right, the watch was heard only on contact with the auricle and cranium, and he was plagued by a constant noise in this ear. The tympanic membrane was quite normal on both sides, the right being, however, somewhat retracted. The diagnosis of the case was made during life, as described below, and was entirely confirmed by the autopsy.[1]

Atresia of the upper sections of the Eustachian tube may proceed from long-standing inflammatory processes in the middle ear. Adhesion takes place either along the entire length of the tube, or at a certain part only. Fig. 141 represents a case of this kind, and is drawn from a preparation in the author's collection, for which he is indebted to *Dr. Schopf*. It exhibits similar abnormalities in both ears, and is taken from a deaf-mute who died in his sixtieth year. He had been able to hear up to his sixth year; then became deaf as a result of bilateral otitis, and subsequently dumb. The tympanic membranes are for the most part destroyed on both sides; likewise the auditory ossicles,

[1] Similar cases, not however always arising from syphilis, are described by *Otto* ("Seltene Beobachtungen zur Anatomie, Physiologie, und Pathologie," Breslau, 1816, S. 3). Also by *Josef Beck* ("Die Krankheiten des Gehörorganes," Heidelberg und Leipzig, 1827). The diagnosis in this case, however, seems somewhat open to doubt; *Virchow* (Archiv für pathologische Anatomie, xv. Bd., S. 313); and *Von Lindenbaum* (Archiv für Ohrenheilkunde, i. Bd., S. 295). The cases above recorded are described in greater detail. Less recent ones are also reported, the diagnosis of which is less trustworthy.

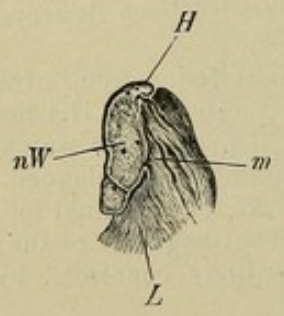
which, with the remains of the membranes, lie embedded in the thickened mucous membrane. In both mastoid portions of the temporal bone abnormal cavities were present, filled with retention-masses. These cavities were the sequelæ to carious processes, from which recovery had taken place.

Schwartze[1] likewise found complete adhesion of the tube in an individual twenty-eight years of age who had suffered from caries; and *Bezold*[2] verified atresia in a man who was wounded in the left ear by a stab from a knife in such a way that it passed behind the maxillary articulation into the pharynx. He supposes that the tube was cut through at the junction of the cartilaginous with the osseous portion, and that the atresia resulted from cicatrisation of the wound.

Stenosis as well as atresia of the Eustachian tube may be brought about also in the osseous section by a new formation of bony matter. This depends either upon a chronic inflammatory process of the periosteum, whereby the newly formed bone is diffused over the entire osseous portion of the tube, or only at a circumscribed spot—generally at the isthmus tubæ; or the new formation occurs as a more defined growth of bone—single or multiple—resembling the exostoses of the external auditory canal. The author has frequently observed patients with great stenosis of the osseous section of the tube, in whom exostoses of the external auditory canal were likewise present; and he considers that this fact indicates that the two conditions may be not rarely combined.

Fig. 141.

Obliteration of the Eustachian tube, by adhesion of the membranous with the cartilaginous wall. The section is made perpendicular to the long axis of the tube (natural size).



nW, posterior wall of the Eustachian tube; *H*, cartilaginous hook or hamulus; *m*, *L*, anterior (membranous) wall of the tube completely adherent to the posterior wall, no passage remaining at any part.

No morbid symptoms would necessarily result from stenosis or even from complete obliteration of the Eustachian tube. These are only brought about by conditions arising secondarily to the absorption of air in the tympanic cavity—viz. depression of the membrane and auditory ossicles, with consequent increase of the intra-labyrinthine pressure. They consist, as already described, chiefly in impairment of hearing in various degrees; in constant subjective auditory

[1] "Casuistik zur chirurgischen Eröffnung des Warzenfortsatzes." Archiv für Ohrenheilkunde, xiii. Bd.

[2] "A case of punctured wound of the ear, in which a criminal action was brought, with a subsequent indictment of the prosecutor for supposed simulation and perjury." Berliner klinische Wochenschrift, 1833, Nr. 40.

sensations of different kinds; in a feeling of fulness; and in vertigo when a high degree of intra-labyrinthine pressure exists.

According to *Toynbee*, an improvement in the hearing often occurs in cases of obstruction of the pharyngeal orifice of the tube, due to swelling of the mucous membrane, if the patient lays his head upon a pillow, or if he turns his head round as in looking backwards. Many patients, it is true, hear better with the head in a certain position, but it cannot be admitted that this is characteristic of the affection in question.

The *diagnosis* of stenosis or of occlusion of the Eustachian tube may be made with accuracy, if the various available methods of examination be correctly employed. On inspection of the drum-membrane are observed the appearances depending upon the previously mentioned inward displacement of this structure. These are never wanting, provided other possible abnormal conditions of the membrane or in the tympanic cavity do not oppose this movement. Since, however, these appearances may accompany other morbid processes besides those under discussion, they are naturally not conclusive signs of their existence. Auscultation with the air-douche, and with or without catheterisation, but chiefly tactile examination with the bougie, and rhinoscopy, will, on the other hand, furnish evidence upon which a well-grounded diagnosis may be easily based.

The *prognosis* as well as the *treatment* will in a large measure depend upon the nature of the essential changes by which the stenosis or obliteration of the tube is brought about. If the condition be due simply to inflammatory swelling of the mucous membrane, a good result may generally be attained; while such as are connected with hyperplastic processes are more difficult of amelioration, and mostly admit only of a transitory improvement. If complete adhesion exist, the prognosis is most unfavourable.

If the stenosis is to be attributed to the presence of an active inflammation, the treatment of the tubal condition forms part only of that indicated for the middle-ear affection, and this has been already thoroughly described. If, however, the inflammatory process has ceased, and we have to do with a stenosis depending upon hypertrophy of the mucous membrane, then the employment of bougies will be advisable. For this purpose the author uses celluloid bougies, or if a successively increasing dilatation be desirable, those made of catgut or laminaria material. The air-douche will naturally come also into application, and in appropriate cases injection may be likewise adopted. In obliteration of the tube, methodical rarefaction of the air in the external auditory canal may be tried with the view of temporarily alleviating the subjective symptoms. Recourse may be had to myringectomy if severe manifestations should occur.

Lindenbaum directed attention to the subject of operations on the tube, and expects better results from such measures conducted with the

aid of the pharyngoscope, than from myringectomy. So far as is known to the author, operations of this kind have not hitherto been undertaken, and would be advisable only where division of the tissues at the mouth of the Eustachian tube was indicated. The employment of cutting or perforating instruments higher up, he considers to be very dangerous, on account of the proximity of the carotid artery.

CHAPTER XVII.

ON CERTAIN OPERATIONS ON THE MEMBRANA TYMPANI AND THE STRUCTURES OF THE TYMPANIC CAVITY.

[Single and multiple incision of the tympanic membrane.—Division of the posterior fold of the tympanic membrane.—Removal of a portion of the tympanic membrane.—Separation of abnormal adhesions of the tympanic membrane and of the auditory ossicles.—Division of the tendon of the tensor tympani muscle.—Division of the tendon of the stapedius muscle.—Removal of the auditory ossicles.]

1. *Incision of the Tympanic Membrane* (*Artificial perforation of the tympanic membrane, Paracentesis of the tympanic membrane, Paracentesis of the tympanum, Myringotomia simplex*).

The operation of incising the drum-membrane has been already thoroughly described with the treatment of exudative inflammations of the middle ear. Its beneficial effect is manifest, not only under such circumstances, but in many cases of conditions secondary to middle-ear inflammation; and it further appears probable that it may be performed still more frequently at no distant period, *if the direct treatment of labyrinthine affections should ever come into practice.*

Collecting here all the indications for simple myringotomy, inclusive of those already referred to in speaking of exudative median otitis, they will be found to be mainly as follows:—

(*a*) Cases in which it is desirable to evacuate foreign matters—such as exudations, extravasations of blood, etc.—from the tympanic cavity, and this result cannot be attained in a less radical manner.

(*b*) As a preliminary to other operations on the deeper structures.

(*c*) As an exploratory procedure. In support of the validity of this indication, it should be borne in mind that the conditions of tension of the membrane may be altered in many ways by various changes to which it may be subject, partly to be recognised by the eye, partly imperceptible. Inasmuch now as the conducting capacity of the membrane is also dependent upon its tension, it will readily be seen that after incision in a certain situation the conditions may be altered in such a way that the conducting function—and with this the hearing power—may be improved. Considering, then, that the measure is quite free from danger, and that in

most cases healing of the wound takes place by first intention, myringotomy will under such circumstances acquire the significance of an exploratory operation. The incision unfortunately is apt to cicatrise very quickly, and the improvement thus gained to disappear. Instances do occur, however, in which the cicatrisation permanently modifies the tension relations of the membrane, and the improvement is maintained. When the subjective symptoms are mitigated after the operation, but become worse again upon cicatrisation, recourse may possibly be had to one of the operative procedures to be mentioned later.

2. *Multiple Incision of the Membrana Tympani* (*Myringotomia multiplex*).

Multiple incision of the drum-membrane was recommended by the author as the best treatment for excessive tension, brought about by pathological changes in the structure itself.[1] In carrying this out, the idea occurred to him that a permanent reduction in the tension of the membrane might possibly be effected if indirect union could be attained by means of interstitial tissue. It is advisable, to favour the development of such a cicatrix, that the edges of the wound be kept apart as long as possible ; and this is most likely to be accomplished by the frequent concomitant employment of the air-douche.

The operation is to be performed just like a simple myringotomy, the structure merely being incised in several places. The author makes four, five, or more cuts, and when considered desirable connects the individual incisions with one another so as to resemble the letter H. He generally divides the membrane from the malleus towards the periphery. Nevertheless, some other direction may be indicated, should a displacement of the segments with contraction of the tissues have occurred. If the object of the operation be kept in mind, the most suitable direction for the incisions will be easily determined.

Although the pathological changes which may produce excessive tension of the tympanic membrane are accurately known, as well as the objective appearances by which this condition may be recognised, the information thus gained is insufficient to determine whether or not an existing impairment of hearing or other morbid symptoms present are due to this cause. Such morbid changes in the membrane are usually combined with other abnormal conditions of the deeper structures, to which all the symptoms complained of may equally be attributed. For the determination of this question the author has introduced a method of examination, which may be here briefly described.

[1] "Die mehrfache Durchschneidung des Trommelfelles als Heilmittel gegen primäre oder mit Trübung einhergehende übermässige Spannung desselben." Allgemeine Wiener medicinische Zeitung, 1873.

It has long been known that, if a vibrating tuning-fork be held near the auditory canal, and the middle ear be then inflated by the Valsalvan method, the sound is heard by a normal ear worse during the inflation than either before or after this process. The cause is mainly, though not exclusively, due to the fact that the inflation increases the tension of the tympanic membrane, and its sound-conducting power is thereby impaired. If, on the other hand, the tuning-fork be placed upon the vertex, then the sound is, under normal circumstances, heard better during than before or after the inflation. In this case the increased tension of the membrane impedes the departure of sound from the labyrinth, from which results an augmented volume of sound-waves, and a consequently more intense auditory perception.[1]

These phenomena being valid under normal conditions of hearing, deviations will occur both with excessive tension and with unusual relaxation of the membrane; the results being to a certain extent of diagnostic value. In the case of an extremely relaxed drum-membrane, if the relaxation be the cause of impaired hearing power, a vibrating tuning-fork held near the auditory canal should be heard better, and when placed upon the vertex it should be heard worse during a successful act of Valsalvan inflation than either before or after this, in consequence of the augmented tension of the membrane which is temporarily brought about during the process. If, however, the state of the membrane be one of excessive tension, and if this cannot be still further increased, the tuning-fork held before the auditory canal should be heard as well during the inflation as either before or after it; or possibly it is somewhat less distinctly audible during the Valsalvan process if an increase of the abnormal tension may still be produced. When placed then upon the vertex in the former case —*i.e.* when the tension of the membrane is not capable of further increase —the tuning-fork will not be heard louder during than either before or after inflation; or it may perhaps be heard a little more distinctly, if an augmented tension should actually be induced.

The above method of examination has the advantage that the results obtained by the second part serve as it were to control those yielded by the first step of the procedure. Should, for example, a patient with a flaccid tympanic membrane state that he hears a vibrating tuning-fork held before the auditory canal better during Valsalvan inflation than he does before or afterwards, then he ought not to hear it so well during inflation if it be placed upon the crown of the head; and so forth. It is nevertheless obvious that many sources of fallacy attach to the examination, and to these the author has drawn attention in his first communication on the subject.

[1] Compare p. 135, Weber's experiment.

In the first place it may be pointed out that the process of inflation may itself interfere with the result of the procedure. This is especially the case when a relaxation of the drum-membrane exists, since it may become stretched by the inflation to a degree beyond that of the normal tension. The result will then be that when the tuning-fork is held near the ear, the sound will appear weakened or no louder during the Valsalvan process; whereas it would perhaps have been rendered more distinct had the inflation been made less forcibly, so that the tension of the membrane more nearly approached the normal. Further, it is quite conceivable that the result of the examination may in some cases not depend upon alterations of tension in the membrane, but perhaps upon changes induced in the other aural structures.

Notwithstanding, however, the possibility of error from such causes, the method must be admitted to possess a certain practical value, provided all the existing conditions are accurately recognised and correctly estimated. Where the results of examination are doubtful, other symptoms may possibly be present from which assistance may be derived in arriving at a conclusion; and in cases in which a positive inference obtained by the examination is in accordance with independent evidence as to the condition furnished by some other method, an operation may be undertaken with fair hope of success.

The *after-treatment* of multiple incision of the membrana tympani is similar to that of simple myringotomy. Immediately after the operation, any blood present must be removed, and the ear stopped with a little iodoform gauze. The air-douche is then to be employed for some days: its use, indeed, should be continued for some time after the wounds have cicatrised. Should inflammation of the drum-membrane set in—a very rare event, however—the treatment ought to be conducted in the manner described under myringitis.

Politzer[1] asserts that the tension of the tympanic membrane is augmented by the cicatrisation of incisions. According to him, multiple incision may be thus a most appropriate measure in cases of atrophic relaxation. The erroneousness of this view is sufficiently proved by the experience of aural surgeons in paracentesis of the membrane, the frequent performance of which they deprecate especially on the ground of the *relaxation* of the structure which frequently follows. After incision of the membrane, healing generally takes place by first intention, without secondary change; or a cicatrix is formed which is distinctly visible. The presence of several such cicatrices may readily bring about relaxation of the membrane.

[1] Lehrbuch der Ohrenheilkunde, S. 438.

3. *Division of the Posterior Fold of the Tympanic Membrane (Plicotomia).*

This operation, which was first performed by *Lucæ* in 1868,[1] and described later by *Politzer*,[2] has for its aim the improvement in the mobility of the malleus, when hampered by excessive development of the posterior fold. The increased development is, as is well known, the result almost exclusively of the inward displacement of the membrane and the lower part of the handle of the malleus, which occurs in middle-ear inflammations with concomitant narrowing of the Eustachian tube. The farther this part of the hammer sinks inwards, the more, *cæteris paribus*, does the fold become developed; and the longer the malleus remains in this abnormal position, the more marked become the secondary changes already described as coming about in the tympanic membrane, and more particularly in the folds, which then, as tense bands, fix the malleus and impede its movements.

Lucæ was the first who attempted to restore the mobility of the hammer, by making an incision close to the short process and perpendicularly across the fold. An improvment in the hearing and a mitigation of the subjective symptoms is actually to be gained in many cases by the performance of this simple operation. The author makes several such incisions, in order that the desired relaxation may be more readily induced and lasting, since it has been found that after section of the fold, the edges of the incision may easily reunite by first intention.

A careful study of the changes in the position of the different segments of the drum-membrane which are associated with inward displacement of the malleus, and of the direction and form of the posterior fold which are intimately connected with the former, has convinced the author that perpendicular division of the fold is in many cases not attended with the desired result. This is especially true of those instances in which the malleus has been displaced inwards and backwards. The posterior segment is in these cases folded over and apparently diminished in size. Should this state of things last long, the tissue contracts, the folded layers become adherent, and the air-douche is no longer capable of producing a permanent adjustment of the condition. In such cases the author has made *the incision along the posterior fold*, and with much greater success. The myringotome is inserted, under a good light, close to the short process, and the fold is then divided in the longitudinal direction.

As a rule the hæmorrhage is so trifling in these operations that nothing in particular is necessary to be done afterwards. All that is

[1] S. Archiv für Ohrenheilkunde, vi. Bd., S. 152; ferner, "Die Durchschneidung der hinteren Trommelfellfalte." *Langenbeck's* Archiv, Ed. xiii.

[2] Wiener medicinische Wochenschrift, 1870.

needful is to be careful not to damage the chorda tympani which is found in this situation, and this is best obviated by not inserting the instrument too deeply. Division of the nerve is, however, not accompanied by any permanent injury, as, the author has observed in two cases of this kind. The anomalies of taste which ensue, disappear in a few days after the divided ends of the nerve have reunited. *Oscar Wolf*[1] and *J. Pollak*[2] have reported similar cases.

Attention should be directed towards keeping the edges of the wound apart as long as possible after the operation, since a direct union without the intervention of interstitial tissue generally nullifies the benefit gained. In fact, this occurs very often. With this object the air-douche should be frequently employed, as well as methodical condensation and rarefaction of the air in the external auditory canal.

Although it is not to be denied that good results may sometimes be derived from plicotomy, yet in a given case success cannot be predicted. It should, however, always be tried in suitable instances, since the operation is both insignificant and free from danger.

4. *Removal of a Portion of the Tympanic Membrane (Myringectomia).*

Myringectomy has for its object not merely perforation, but likewise the removal of a portion of the tympanic membrane. The operation had for more than twenty years been relinquished by aural surgeons, when it was again introduced into practice by the author in the year 1863.[3] It is indicated, in the author's opinion, under the following circumstances :—

(*a*) *In atresia of the Eustachian tube, if this be not remediable by other means, and causes very severe symptoms.*

The intra-auricular pressure is in these cases greatly increased by the depression of the tympanic membrane and of the chain of auditory ossicles. If a portion of the membrane be excised, this pressure diminishes, as the author has demonstrated by experiment, and the symptoms are thereby relieved.

To prevent misunderstanding, the author wishes to say that he has arrived at the conviction that no operation or any other means has hitherto been discovered by which a perforation made in the tympanic membrane can be kept permanently open. It may, however, be maintained so for a certain time, provided the patient remains

[1] "Zur Function der Chorda Tympani." Zeitschrift für Ohrenheilkunde, ix. Bd.

[2] "Ueber den Werth der Operationen, die den Schnitt des Paukenfelles erheischen." Allgemeine Wiener medicinische Zeitung, 1880.

[3] "Die Myringectomie als Heilmittel gegen Schwerhörigkeit und Ohrensausen." Wiener allgemeine medicinische Zeitung, 1863 und 1864.—With regard to the history of this operation, the work of *Martell Frank* may be consulted, "Praktische Anleitung zur Erkenntniss und Behandlung der Ohrenkrankheiten," Erlangen, 1845; also the frequently cited treatise of *Lincke*; and the first edition of this work, p. 582.

under constant observation; and in this way, a temporary improvement may be gained. If, therefore, the above-mentioned indications be present, and the conditions favourable, the operation may always be undertaken, and in suitable cases may be repeated.

(*b*) *In thickening or in calcification of the membrane when there is much impairment of hearing, and other circumstances do not preclude a mitigation of the subjective symptoms as a result of the operation.*

If even *Itard's* assertion be accepted, that, although deafness is often associated with thickening of the drum-membrane, it is yet seldom due to this condition, it nevertheless cannot be denied that with a high degree of partial or total thickening, some of the sound-waves must be reflected, and consequently that the hearing may improve if an improvement can be brought about in the state of the membrane. Even should a renewal of the excised portion take place, the morbid symptoms may possibly be relieved, since a cicatrix is always thinner than a thickened membrana tympani.

(*c*) *With relaxation of the tympanic membrane, or possibly with cicatrices, if the morbid subjective symptoms depend upon these changes, and the operation should be indicated by the results of the examination described at page* 467.

Myringectomy is at the present day performed only with the galvano-cautery.

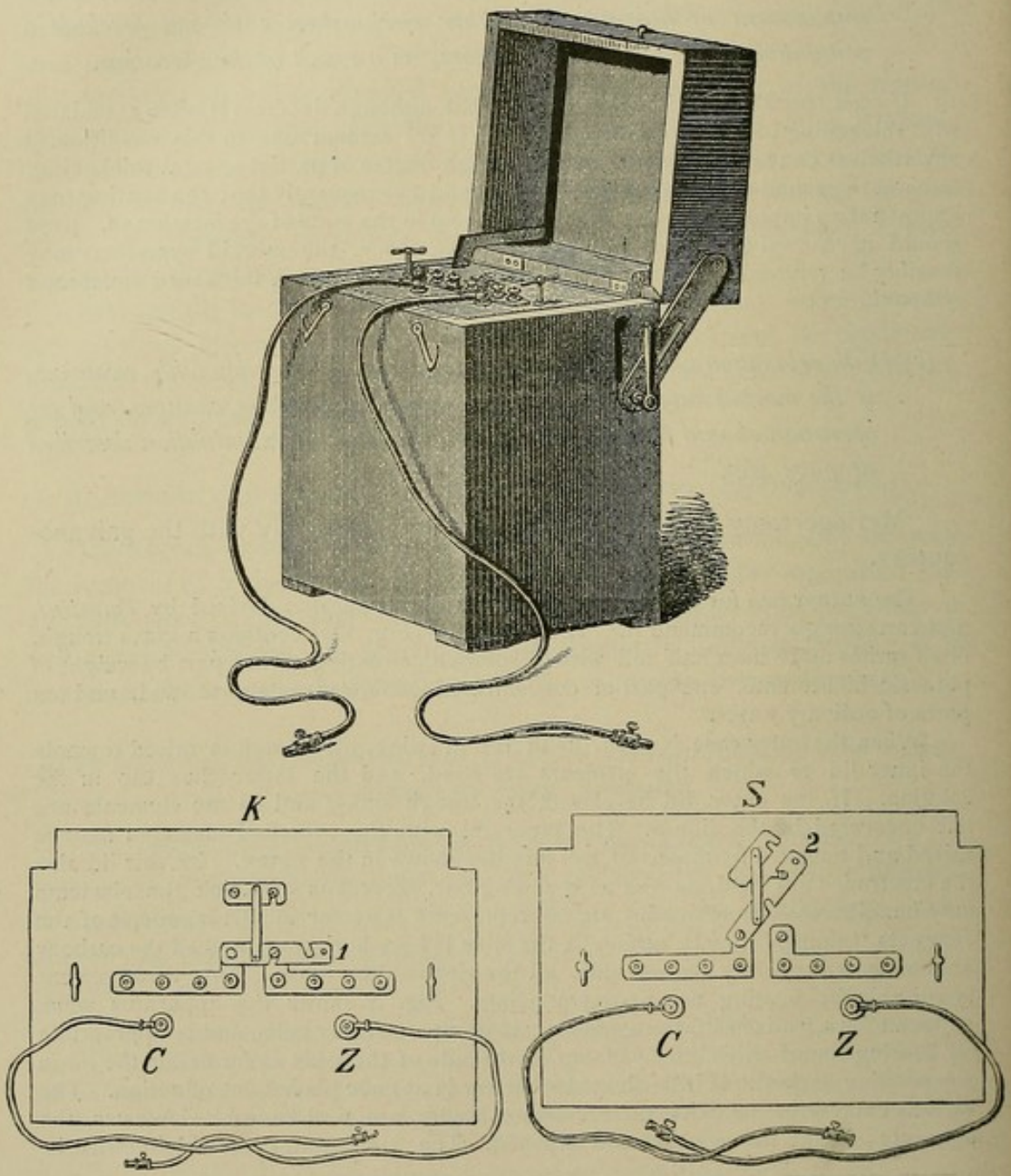
The author has for some years employed the apparatus devised by *Voltolini*, and can strongly recommend it.[1] The outer case (Fig. 142) contains a glass trough, filled rather more than half full with a solution consisting of one part by weight of potassic bichromate, one part of concentrated odourless sulphuric acid, and ten parts of ordinary water.

When the outer case is open, as in the drawing, the trough is raised towards the inner lid to which the elements are fixed, and the latter thus dip in the solution. If the outer lid be closed, the trough sinks, and so the elements are left uncovered by the liquid. The inner lid with the attached elements may be raised and removed by means of two handles shown in the figure. On this lid also the electrodes are fixed, as well as a sliding bar, by means of which the elements may be differently combined. Fig *K* represents it as for an arrangement of the elements "simply" or "in surface": the slide is here horizontal, and all the carbons are connected together on one side, all the zincs on the other. This arrangement is suitable for heating flat platinum points. Fig. *S* shows the apparatus when adjusted for a "mixed" arrangement, "in groups" of four cells, and is appropriate for heating round wires. The clamp on the side of the case is for fixing the lid in any position desired. If it be shut, the battery is at once placed out of action. The various cautery points, with their common holder, are well known. After use, the elements should be removed and washed. The zinc plates should likewise be

[1] It was first made in a highly satisfactory manner by *Herman Brade* of Breslau. In Vienna it is now made by *Reiner* and *Leiter*. This apparatus has been advantageously modified by *Schall*, 55, Wigmore Street, W. For galvano-caustic operations the translator prefers an accumulator supplied by the same maker. The employment of such secondary batteries is, however, practicable only in large towns, where they can be conveniently recharged.—Eds.

re-amalgamated from time to time (every six to eight weeks). For this purpose the brass screws on the lid to which the elements are fixed should be unscrewed, the plates taken away, and placed in a vessel containing some dilute sulphuric acid (1 to 7 or 10); then some quicksilver is poured over them. To incorporate this more

Fig. 142.



intimately with the zinc, it may be rubbed in with a brush. When the plates have been well amalgamated they should be washed with water, and allowed to remain for some time in a vessel, so that the excess of quicksilver may drain off.

With regard to the particular part of the tympanic membrane to be

burnt away, this may generally be decided by a consideration of the objective appearances. With partial relaxations, the flaccid portion (;) and in cases of thickening, the part manifesting this alteration, should be destroyed. If it be indifferent in what situation the cauterisation should be made, it will be best to select the posterior segment of the membrane, as reunion takes place less readily in this region.

The *mode of operation* should be as follows :—

A careful examination of the membrane having been made, in order to decide upon the site of the operation as well as the size and shape of the portion to be destroyed, a cautery point should be chosen and adjusted so as to correspond with this. It should be bent over at a right angle with the axis.

The apparatus should then be tested to see whether it is in proper working order. As wide a speculum as possible is now introduced into the auditory canal, and the tympanic membrane illuminated by means of the forehead mirror. The operator fixes the speculum with his left hand, and with his right he introduces the cautery point, and brings it quite near the part which it is proposed to burn out. This being done, the patient is instructed to inflate his ear by the Valsalvan process, or an assistant employs the air-douche, so that the membrane is bulged out towards the canal. The knob on the cautery handle is now pressed, and the membrane burnt through in the manner desired.

The pain of the operation is usually very severe, but it is only experienced at the moment of cauterisation. As soon as this is completed, the pain likewise ceases. No hæmorrhage, as a rule, follows, or at most it is only trifling.

The *after-treatment* is in general to be directed in accordance with the aim of the operation. The aperture in the membrane can unfortunately but seldom be maintained permanently open. So long as the patient remains under observation, this may be accomplished in various ways; but when he is then left to himself, the opening almost invariably closes up after a longer or shorter time. As already mentioned, however, in discussing the indications for the operation, it is not always requisite to maintain an opening; while in other cases this is desirable, so that the after-treatment will differ in different instances.

Under all circumstances it is advisable to use antiseptic precautions and to obviate as far as possible the tendency to inflammation. The auditory canal should be filled with iodoform-gauze, and the patient cautioned against all injurious influences.

If it be desired to keep the aperture open, the air-douche should be frequently used, and the edges freed also by means of a blunt probe previously dipped in a carbolic solution, as soon as the wound shows signs of contracting. If this manœuvre be practised every day, or every

other day, the aperture in the membrane may be kept open for years.[1] This, however, necessitates the patient always remaining under the observation of the surgeon, which is not always practicable. It follows that the least favourable results ensue in those cases in which the operation aims at the production of a permanent opening.

The chances of success are better when the operation has been undertaken on account of a thickening or a relaxation of the drum-membrane. In such cases, the amelioration of the symptoms may continue after closure of the aperture; since, as previously mentioned, the conducting capacity of the membrane may be improved by the presence of a cicatrix, and other objective changes may also be favourably influenced.

The older aural surgeons devised various methods with the view of keeping permanently open an artificial aperture in the drum-head, but all without any success, as shown by the history of the operation (*vide* the previously quoted works of *Martell Frank* and *Lincke*). *Frank* states that he inserted small gold cannulæ in the opening, and *P. H. Wolff* recommended for the same purpose small indiarubber tubes (*vide* his appendix to *Lincke's* Text-book of Otology, 1845). *Philippeaux*[2] made use of caoutchouc bougies, and the author employed small pieces of laminaria fastened to long threads. All of these contrivances failed. *Politzer*[3] tried anew to attain the desired object by inserting small india-rubber "eyelets" fastened to a thread, but again without result. *Bonnafont*[4] met with no better success with his aluminium "eyelets," which he introduced into the aperture with the aid of a small special cannula. These foreign bodies not infrequently increase the inflammation; and they always escape from the opening in the membrane, without preventing cicatrisation.

Voltolini[5] likewise failed in endeavouring to keep the aperture open by placing a thin ring-shaped gold or aluminium tube round the malleus and leaving it there. This tube also became displaced, upon which the incisions made for the ring in front of and behind the hammer healed up very rapidly. *Von Tröltsch's* proposal to cut a triangular flap in the membrane, push it in towards the tympanic cavity, and allow it to adhere there, was rational, but meets with insurmountable obstacles in execution.

Sphyrotomy, proposed by *Wreden*[6] as promising a greater probability against the reunion of the tissues, on account of the simultaneous resection of the malleus; as well as the later attempt to prevent union, by removal of a part of the bordering osseous wall of the auditory canal together with the portion of the membrane, were both equally unsuccessful. We are thus still dependent upon the air-douche and the employment of the probe, as before described, as the only means by which

[1] In one case the author was able to demonstrate to his students an artificial opening which had been made three years before. This patient was seen several times by the translator.

[2] Gazette médicale de Lyon, Septembre, 1863.

[3] "Ueber ein Verfahren zum Offenhalten künstlicher Perforationsöffnungen im Trommelfelle." Wiener medicinische Wochenschrift, 1868.

[4] "Note sur un cas de surdité ancienne guéri par un nouveau procédé de la trépanation du tympan." Ann. des Mal. de l'Oreille, 1877.

[5] "Ueber eine neue Operation am Trommelfelle zur Verbesserung des Hörvermögens." Monatsschrift für Ohrenheilkunde, viii. Jahrg.

[6] "Sphyrotomie, ein neues operatives Verfahren gegen gewisse Fälle von Taubheit und Ohrensausen." Monatsschrift für Ohrenheilkunde, 1 Jahrg., Nr. 2.

a perforation can be kept open—so long, that is, as the patient remains under observation. *Paquet* performed myringectomy in the posterior segment of the membrane, together with tenotomy of the tensor tympani, in two patients. The operation is said to have been successful in both cases (Internat. Med. Congress in London: Report of the Otological Section).

5. *Separation of Abnormal Adhesions of the Tympanic Membrane and of the Auditory Ossicles* (*Synechotomia*).

Division of abnormal adhesions of the tympanic membrane and of the auditory ossicles has in many cases been attended with brilliant results, in regard both to improvement in the hearing power and mitigation of the subjective auditory sensations. It may not infrequently be accomplished by the use of the air-douche; and when this fails, section of the tissues which bring about the adhesion is indicated. The synechotome of *Wreden*, represented in Figs. 102-6, is a convenient instrument for separating adhesions of the membrane with the inner wall of the tympanum. It is introduced into the latter cavity after incising the membrane with the myringotome, and the connecting tissue is then divided. Efforts to prevent reunion must be made by subsequent employment of the air-douche, though this does not always succeed.

Irregular adhesions of the ossicles, especially between the handle of the malleus and the descending process of the incus, may sometimes be diagnosed with accuracy, and separated by the myringotome. Nevertheless, the author has never seen a successful result from the operation, probably on account of the presence of other and more important morbid changes. Possible adhesions of the ossicles, other than those alluded to, are difficult of diagnosis, and consequently are not often the subject of operative treatment.

6. *Division of the Tendon of the Tensor Tympani Muscle* (*Tenotomia musculi tens. tymp.*).

Tenotomy of the tensor tympani, first performed by *Weber-Liel*, must be counted amongst those operations which have not only maintained their position in aural surgery, but of which the indications have certainly undergone an expansion. In his communication[1] dealing with this subject, *Weber-Liel* enumerates the different conditions which may seem to call for the operation, and to which *Hyrtl* had already drawn attention in his text-book of topographical anatomy. He there describes the instruments he employed, and also his method of procedure. Notwithstanding the previous publication of some cases which had been operated upon by him with good results, the report of another series of cases by *Carl Frank*[2] shortly after

[1] "Ueber die Zwecke, die Wirkung, und die Ausführung der Tenotomie des M. tensor tympani." Monatsschrift für Ohrenheilkunde, 1872.

[2] "Die Tenotomie des Tensor tympani." Monatsschrift für Ohrenheilkunde, vi. Jahrg. 1872.

the appearance of *Weber-Liel's* paper, in which the measure proved likewise satisfactory, as well as similar communications from other sources (*Laurence Turnbull, Gruber, Pomeroy*, and others), the operation nevertheless found its opponents.

Though the author appreciates all the arguments which have been raised against the proceeding, and would not support it upon vague indications, he still considers that a perfectly good ground for its performance exists in a shortening of the tendon. How this shortening is brought about, what symptoms it may induce, and how these are to be recognised, have been sufficiently discussed in the previous chapters.

This indication is on all hands admitted to be quite rational; yet a hesitation in undertaking the operation is manifested, from the belief that the co-existing morbid changes which are present may frustrate the aim of the procedure, and also that upon reunion of the divided extremities of the tendon, the old condition might return. In the author's opinion, these objections may be easily refuted.

In the first place, the presence of other pathological changes may be more or less easily diagnosed. If, then, they should be of such a kind as not to permit an improvement even with a perfectly successful tenotomy, the circumstance must be accounted a contra-indication for the operation. It may be suggested that we are not always in a position to diagnose with accuracy during life the existence of possible changes other than the shortening of the tensor tendon. That of course is true; but we possess a method of examination by which it may be determined *approximately* whether or not the contraction of the tendon contributes towards the production of the morbid symptoms. This method consists in the employment of the air-douche. Should a temporary, if only an extremely short, improvement ensue upon its application, and all other modes of treatment have been previously tried without benefit, it will be quite proper to perform tenotomy of the tensor tympani.

The author is perfectly aware that in such cases the amelioration is not always attributable to the momentary stretching of the tendon, but may depend upon other objective changes produced by the inflation. Considering, however, that no certainty on this point can be arrived at, and that the division of the tensor tendon involves no injurious consequences,—as is now proved by a large number of observations,—whilst, on the other hand, a continuance of the contraction induces a constant aggravation of the symptoms, the performance of the operation under such circumstances will be not only justifiable, but almost obligatory.

The objection concerning the reinstatement of the previous condition after reunion of the cut ends of the tendon, has still less foundation. After section, the extremities become separated from one another, and the separation is more pronounced when the tendon is retracted, on account

of its increased tension. If reunion then occur, this is brought about through interstitial tissue, by which means the tendon becomes more elongated.

It has been supposed that in cases in which the tenotomy has been successful, a simple myringotomy would possibly have proved equally efficacious. This may perhaps be correct in many instances; and the author has therefore, in nearly all his cases, actually performed a simple paracentesis as a preliminary to division of the tendon. He is, however, convinced that the latter operation is beneficial in certain cases where simple incision of the membrane is useless. It is clear that under ordinary circumstances a definite prognosis cannot always be made. It would, nevertheless, be a mistake entirely to relinquish the procedure.

The operation is performed by the author with his tenotome, which is also employed by *Weber-Liel.* The instrument has been modified by *Hartmann*[1]; but the author does not consider this modification to be an advantage, as the tendon is not thereby divided with greater certainty, while the instrument is more difficult to manage on account of its complicated curvature. *Frank, Schwartze,*[2] and many others have likewise devised special instruments for tenotomy; but, so far as is known to the author, they are but little used.

The preparations for the operation are the same as for myringotomy. The head being fixed, and the tympanic membrane well illuminated, the tenotome is introduced into the auditory canal, with its concave surface directed forwards if the incision is to be made behind the handle of the malleus; or with the concavity backwards, if the incision is to be made in front of the hammer. The membrane is then pierced immediately in front of or behind the handle of the malleus at about the level of its upper third. The instrument having penetrated into the tympanic cavity, the handle of the malleus is clasped by its concave surface, and an incision made upwards parallel with the handle, so as to divide the tendon, which runs from within outwards obliquely through the tympanum. In this division, if the membrane has been pierced behind the handle of the malleus, the point of the instrument should be directed farther forwards than when the membrane is pierced in front of it, because the tensor tendon, in crossing the tympanum, sometimes runs a good deal forwards from the malleus. At the same time, the precaution should be taken of somewhat lateralising the edge of the instrument by turning the point a little upwards, in order to avoid a possible injury to the wall of the carotid canal in front. The edge of the tenotome should be carried above the level of the short process, and afterwards also somewhat downwards, so as to make sure of dividing

[1] "Ueber die Operationsmethoden der Tenotomie des Tensor tympani." Archiv für Ohrenheilkunde, xi. Bd.

[2] "Zur Tenotomie des Tensor tympani." Archiv für Ohrenheilkunde, xi. Bd.

any fibres of the tendon which may possibly be inserted below the level at which the membrane was penetrated.

The spot at which the membrane should be pierced will be determined chiefly by the configuration of the external auditory canal. It is generally more certain to penetrate in front of the malleus. In many instances, however, the convexity of the anterior wall of the auditory canal is so considerable that the anterior segment of the membrane is hidden, and consequently the tympanic cavity must be entered through the posterior segment.

Section of the tendon is usually accompanied by a short, abrupt sound; and this, taken in connection with the disappearance of the resistance offered to the instrument, will point to the success of the operation. To make sure of this, a synechotome may be introduced through the opening in the membrane, and the short shank run up and down the handle of the malleus. If a portion of the tendon should remain undivided, and thus oppose the movement, the operation may be completed with this instrument. There is as a rule no hæmorrhage worth mentioning; and, if cocaine has been previously applied to the membrane, the pain may likewise be reduced to a minimum in many cases.

The subsequent treatment is the same as after myringectomy. The air-douche, however, should be used very frequently after tenotomy, in order to counteract the tendency to reunion of the divided ends of the tendon.

The result of the operation is very variable. The author performs it only upon the indication before mentioned, and in some cases with considerable benefit, especially as regards the subjective auditory sensations. In many instances these entirely disappeared, while in others they became diminished. The vertigo was completely lost in certain cases (*Weber-Liel, De Rossi*). Upon the acoustic faculty, however, the effect was less striking. As a rule no improvement in this respect followed the operation; and even in the rare cases in which the patient did hear better, the hearing distance was only increased by a few centimètres. It must nevertheless be admitted that, even when the above indication was present, the operation was sometimes fruitless. The author, on the other hand, has never seen serious consequences following upon tenotomy, though in very rare cases a purulent inflammation has been subsequently set up. He has therefore arrived at the conviction that when the indication alluded to exists, and other less radical methods of treatment have proved ineffectual, the measure should be undertaken after the patient has been made thoroughly acquainted with its nature. Even if a satisfactory result had been hitherto recorded in only a few instances, the proceeding would still be justified on the ground of the amelioration which may be brought about in respect of the severe subjective symptoms.

7. *Division of the Tendon of the Stapedius Muscle. Separation of the Incus-Stapes Articulation. Mobilisation of the Stapes.*

The attempt to remedy a condition of diminished mobility of the stapes by operation, was made in the first instance by *Kessel*,[1] upon the basis of experiments made by him upon pigeons, in connection with removal of the columella and escape of the labyrinthine fluid. The birds afterwards exhibited neither vertigo nor disturbances of co-ordination: carriage of the head, flying, and walking were perfectly normal. During the first eight days of the three weeks during which the animals were under observation, there was no response to ordinary stimuli, though the acoustic capacity subsequently returned (;) the fenestra ovalis having become covered over, as *Kessel* supposes, by a membranous structure. The removal of the columella having thus been followed by less injurious consequences than had been expected, he determined upon the introduction of surgical treatment of the stapes and its muscle in man; and, according to his communications, with beneficial results.

The operative measures to be here considered are:—*Tenotomy of the stapedius muscle; separation of the incus from the stapes; and separation of abnormal connections of the stapes itself.* The diagnosis of the morbid changes which call for these procedures is unfortunately less satisfactory than could be desired; and consequently their performance can only be undertaken with some hesitation on the part of the conscientious surgeon. It can yet scarcely be doubted that they will be included in the category of established aural operations in this region at no distant date.

With reference more particularly to tenotomy of the stapedius muscle, benefit may be looked for from the operation only when the foot of the stapes is not completely ankylosed. The determination of the degree of mobility of this bone by tactile examination alone is certainly not easy in all cases, and *Schwartze's* statement as to the occurrence of an auditory sensation on pressure upon the head of a movable stapes, is likewise not invariably true. All things considered, the author believes that an accurate prognosis after a tenotomy of the stapedius muscle is still more difficult than with that of the tensor tympani, and that for the present the procedure must be regarded as "remedium anceps," which in cases where all other modes of treatment have failed is, however, always "melius quam nullum."

The operation can of course only be performed when the tendon can

[1] "Ueber die Durchschneidung des Steigbügelmuskels beim Menschen, und über die Extraction des Steigbügels, resp. der Columella bei Thieren." Archiv. für Ohrenheilkunde, xi. Bd.

be seen. It is to be simply divided with the myringotome. The after-treatment should be antiseptic.

Urbantschitsch[1] reports two cases operated upon with success. The author has in several cases divided a greatly thickened tendon on account of very severe tinnitus, but without effect—perhaps because the foot of the stapes was too firmly fixed. There was, however, nothing to indiçate an operation in the vicinity of the foot, as an abnormal fold or band could nowhere be recognised (;) and the author has never been able to resolve upon an operation on the ligamentum obturatorium without being thoroughly convinced that it was called for by some actual objective change.

[1] "Zwei Fälle von Durchtrennung der Sehne des Steigbügelmuskels am Menschen." Wiener medicinische Presse, 1877.

CHAPTER XVIII.

NEW FORMATIONS IN THE MIDDLE EAR.—POLYPI.

New formations in the middle ear originate generally upon an inflammatory foundation. They are usually, therefore, from their first appearance accompanied by otorrhœa. Neoplasms, which are primarily observed in otherwise normal structures of the ear, are comparatively very rare. All new growths in the middle ear arise either in the region itself, or have encroached upon it from the neighbouring structures—*e.g.* the external ear, or the structures of the pharyngeal or cranial cavities.

1. *Fibroma.*—This may be developed in the most diverse parts of the middle ear, and grow in various directions; most often towards the external auditory canal, and thence outwards. It generally springs from the mucous membrane of the tympanic cavity; rarely from the mastoid cells, from which it sometimes appears in the mastoid region after exfoliation of a sequestrum, or emerges into the auditory canal after erosion of its posterior wall. In very rare cases it may originate from the commencement of the Eustachian tube, and extend into the pharynx (pharyngeal polypus). Sometimes the neoplasm becomes so large as to not only fill the external auditory canal, but also cover a portion of the auricle. Several such growths are sometimes found in the same ear.

A fibroma developes as a rule in connection with chronic exudative inflammations of the middle ear with destruction of the tympanic membrane, and is thus mostly accompanied by otorrhœa. It arises extremely seldom on the walls of the tympanic cavity in association with an intact drum-membrane, and in such a case it cannot be recognised, or only with difficulty, during life. The diagnosis is certain only when it becomes exposed after it has destroyed the membrane in its growth.[1]

The surface of a fibroma may be either smooth or coarsely lobulated. In the depths of the auditory canal the tumour nearly always has a dark

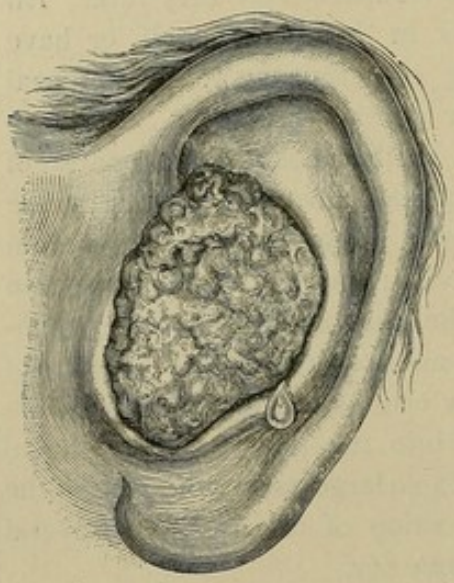
[1] According to *Zaufal* (Prager medicinische Wochenschrift, 1, 25 und 26), intra-tympanal polypi may occur more frequently with an intact tympanic membrane than is generally supposed. Incision of the membrane and subsequent examination with the probe may be practised with a view to a more sure diagnosis, and should the more readily be undertaken since failure to recognise their presence may entail dangerous consequences.

red appearance, and the nearer it approaches the external orifice the paler it becomes. It has sometimes several points of attachment to different parts of the middle ear, or to this and also to the auditory canal. This condition may be supposed to have arisen by the coalescence of distinct growths, or by adhesion of the tumour to adjacent parts on long-continued contact with them.

According to their consistence, we may distinguish firm and soft fibromata of the middle ear. The tissues of the former are closely interwoven, and but slightly vascular. Those of the latter sometimes exhibit a distinctly areolar structure, with an intermediate mucin-containing substance (*Kiesselbach*[1]). Fibromata not infrequently contain cystic spaces lined with various varieties of epithelium, and arising in the growing together of different lobules of the tumour—a circumstance to which *Wedl* has called attention in similar formations of the eye.[2]

Fig. 143.

Fibroma from the tympanic cavity. (natural size)



Certain of these neoplasms in the middle ear have an extremely rich vascular supply (angio-fibroma). The author has, however, never seen true angiomata in this region.

In some instances the tumour is enclosed by a more or less dense connective-tissue capsule, which differs widely in texture from the rest of the growth. Not infrequently the surface of a fibroma—especially if of the soft variety—is covered near the peduncle with ciliated epithelium, while the parts near the orifice of the auditory canal exhibit pavement epithelium.

2. *Osteoma.*—Mention has been previously made of osseous hyperplastic processes in the middle ear in connection with tedious inflammation there. Independent new formations of bone are however also, though very rarely, found in this region, which are analogous to the exostoses of the external auditory canal. The author has observed two such cases, in both of which recovery had taken place from exudative median otitis with destruction of the drum-membrane. The neoplasm was in each case

[1] "Beitrag zur Histologie der Ohrpolypen." Monatsschrift für Ohrenheilkunde, xxi. Jahrg.

[2] Atlas of the pathological histology of the eye, by *Prof. C. Wedl*, Leipzig, with the co-operation of *Prof. Stellwag von Carion*. Adnexa oculi I., Fig. 7, Trachoma.

of the size and shape of a sweet pea, and situated above and behind the recess of the fenestra rotunda. In both, also, the head of the stapes was in its normal position, but separated from the incus. The patients suffered from subjective auditory sensations and from deafness, which could not, however, be caused by the new formation. If situated in places more important as regards the hearing function, such growths might be fit subjects for operative treatment.

3. *Adenoma.*—The neoplasms which develope in the middle ear, and from their external characters have been described as "mucous polypi," are really to be considered as adenomata. On microscopic examination, they exhibit glandular structures — some fully formed, others in process of development, and some even showing cystic degeneration. These are found disseminated between the remaining tissues of the matrix, consisting of slightly fibrillated and cellular elements (Fig. 144). They not infrequently possess a dense capsule, made up of many layers of epithelium and a very delicate fibrillated material; next to this being a papillary structure. The epithelium covering the exposed parts of the tumour is of the stratified-pavement or cylindrical variety; while that found near its place of attachment is often a very fine ciliated epithelium, in which a lively movement may be observed when the growth is removed.

Fig. 144.

Section of an adenoma from the inner wall of the tympanic cavity.



d, *d'*, Gland follicles; *c*, *c'*, cystic dilated follicle.

These neoplasms appear as smooth, pear-shaped, sometimes lobulated tumours, of a pale-livid colour, highly elastic to the touch, and springing by one or more points of attachment from the underlying tissues. They usually develope in ears long affected with chronic inflammation, and grow mostly from the anterior sections of the tympanic cavity, whence they encroach upon the various neighbouring spaces—generally after antecedent destruction of the drum-membrane —*e.g.* into the external auditory canal; or, in very rare instances, into the Eustachian tube.

According to *Steudener* and *Kessel*,[1] the glands are developed from conical

[1] Archiv für Ohrenheilkunde, iv. Bd., 3. Heft.

involutions of the epithelium, the central portion of which undergoing disintegration and absorption, leads to the formation of tubules lined with cylinder-epithelium, which by the account of some observers, shows traces of cilia. Sections perpendicular to the long axis of the tubule appear as more or less wide circular spaces lined with epithelial cells; but not all such appearances are to be referred to a glandular new formation.

Cyst-like spaces are sometimes found in these growths (Fig. 144, *cc'*), derived according to *Meissner*,[1] from adenoid structures (retention-cysts). Not uncommonly they may be seen with the naked eye, and sometimes reach the size of a hemp seed.

Accidental conditions not infrequently occur in both fibromata and adenomata—chiefly as regards the cyst-like spaces mentioned, which owe their origin either to a metamorphosis of the new tissue itself, or to other changes. Thus, a colloid material is sometimes found in these spaces, which is undoubtedly due to alterations in the epithelial cells lining them. In others, variously shaped cells exist in addition to the colloid substance. In certain fibromata and adenomata again, cholesteatomatous masses occur (*Wagenhäuser*, *Moos*, *Steinbrügge*, and others), which in many instances at least were already present, and became accidentally enclosed during the growth of the tumour. The osseous material met with in many cases certainly depends upon a metamorphosis of the new formation.[2] Hæmorrhagic extravasations and products derived from them, especially pigment, are often found, and are in no way remarkable.

Sexton observed a case in which the whole petrous part of the right temporal bone with the exception of its apex, was found post mortem to be transformed into a tumour, portions of which also filled the middle ear. The membrana tympani, however, was intact. On microscopic examination, the growth proved to be a cylindrical-celled adenoma with hæmorrhagic effusion into a cystic dilated gland follicle, and sprung probably from the middle ear or labyrinth.[3]

4. *Papilloma.*—As a primary affection this is certainly one of the least common new formations of the middle ear. The author has repeatedly observed papillomata extending from the external auditory canal to the structures of the middle ear, especially to the mastoid cells; but he has never seen it in the middle ear as a primary development.

Hedinger[4] operated upon a papilloma proceeding from the middle ear,

[1] Zeitschrift für rationelle Medicin, 1853, S. 350.

[2] *Moos* and *Steinbrügge* found osseous infiltrations in an angio-fibroma. In a similar neoplasm occurring in a patient aged sixty-five, who died from an aural affection, partial osseous new formation with central cholesteatomatous deposit was observed ("Histologischer und klinischer Bericht über 100 Fälle von Ohrpolypen." Zeitschrift für Ohrenheilkunde, xii. Bd.)

[3] "Destructive Adenoma of the petrous portion of the temporal bone, involving the organ of hearing." New York Medical Journal, 1884,

[4] "Beiträge zur Pathologie und pathologischen Anatomie des Ohres." Zeitschrift für Ohrenheilkunde, xiii. Bd.

which had produced gravitation abscesses, and had grown through under the dura mater. Chiselling out the mastoid process was unsuccessful, and death occurred from cerebral œdema.

5. *Sarcomata.*—These formations occur in the middle ear still more rarely than in the structures of the external ear. A sarcoma developing in the external auditory canal or the pharynx may, however, spread after a time to the tissues of the middle ear. It may likewise appear as a secondary neoplasm in this region by extension from the parotid gland (*Knapp*),[1] or from the dura mater.

In regard to the symptoms, treatment, and prognosis, the remarks made in connection with sarcoma of the external ear hold equally here.

If the growth has reached the external surface from the middle ear, it developes with great rapidity, and readily ulcerates, leading thus to great destruction of tissue ; and under these circumstances always ends fatally in one or other of the usual ways.

Orne Green[2] observed a round-celled sarcoma in the external auditory canal, tympanic cavity, and mastoid cells, the origin of which could not be accurately ascertained. The tumour was 8″ long, 6″ wide, and 4″ thick on the mastoid process. During its growth, portions of the size of a hen's egg became separated from it. The patient sank from marasmus. *Hartmann*[3] treated a child three-and-a-half years of age, in whom, after a watery discharge from the ear had gone on for fourteen days, a polypus as large as a pea was observed, and removed with the snare. Chromic acid, as well as the galvano-cautery, were applied to the base of the growth ; but it continued to develope; abscesses formed ; convulsions and dysphagia set in ; and the child died comatose. On post-mortem examination, the tumour measured 14 *cm.* in length, 12 *cm.* broad, and 9 *cm.* in thickness, and projected beyond the external surface of the cranium. The external growth was connected with a similar one in the cranial cavity, 1·5 *cm.* thick, and extending over almost the whole of the squamous portion and over the outer half of the upper surface of the petrous portion of the temporal bone. Masses of the growth were seen to occupy the place of the mastoid cells, and perforating the bone between the antrum mastoideum and the posterior cranial fossa. The labyrinth remained unaffected. *Toynbee*[4] saw a like case in which the tumour was described as fungus hæmatodes, and caused death in fifteen weeks. The author has met with three cases of round-celled sarcoma in children, involving in each instance all three sections of the ear. The last came recently under observation in his hospital practice. The exact place of origin could not be determined. All these cases terminated fatally. In two patients in the prime of life who were under the author's care for a lengthened period, it was, however, made out with accuracy that the growths sprang from the farther side of the tympanic membrane. The sarcoma in both cases involved all the aural structures, and invaded the cranial cavity. In one of them, the new formation grew through the mastoid process towards the surface, and frequently came away in large pieces. In the other patient, the tumour extended in the direction of the pharynx. Both sank from

[1] "Ein Fall von bösartiger Parotis- und Trommelhöhlengeschwulst." Zeitschrift für Ohrenheilkunde, iv. Bd.

[2] "Rundzellensarkom des Ohres." Zeitschrift für Ohrenheilkunde, xiv. Bd.

[3] "Ein Fall von Rundzellensarkom ausgehend von der Trommelhöhle." Zeitschrift für Ohrenheilkunde, viii. Bd.

[4] Diseases of the Ear," p. 386.

exhaustion with symptoms of cerebral œdema. *Böke*[1] observed a case of osteo-sarcoma of the tympanic cavity, which grew into the auditory canal. The patient died from meningitis.

6. *Epithelioma* (Cancroid).—Epithelioma occasionally occurs primarily in the middle ear, though it more commonly extends to this region from without. Even where it is of primary origin, the mucous membrane has been in most instances already the seat of a chronic inflammation. The destruction it causes is sometimes enormous; and it generally spreads more quickly, and leads to a fatal termination more rapidly when it originates in the middle ear, than when the growth advances from without inwards.

With respect to the symptoms which accompany the disease, reference must be made to what has already been said on this subject in connection with the same formation in the external ear.

In the case of an old woman, the carcinoma destroyed the greater part of the auricle and of the external auditory canal, as well as the mastoid process and a part of the petrous portion of the temporal bone. It further encroached upon the dura mater, and exposed a portion of the brain, so that distinct pulsatory movements could be seen there from the mastoid region. Nevertheless, the patient in this condition came at least an hour's journey during the winter time to attend the author's out-patient department, and was almost entirely free from pain.

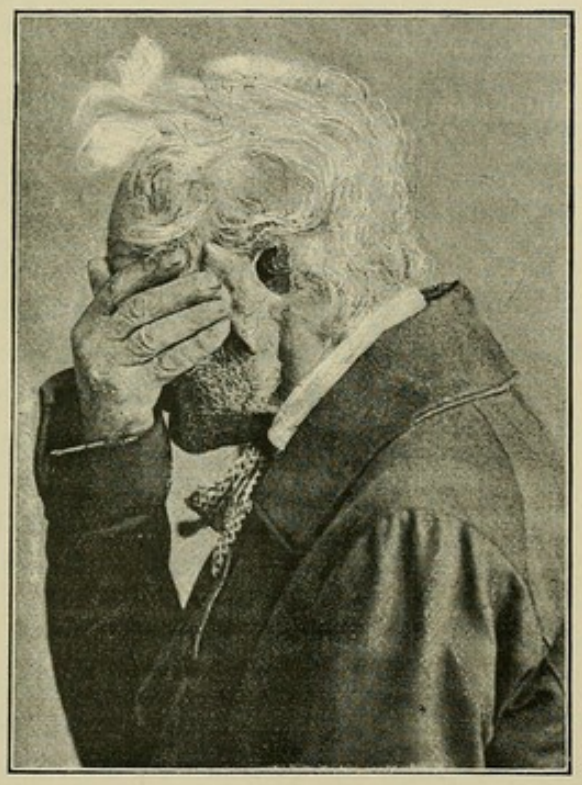
If, on the one hand, the history of the various neoplasms here enumerated be remembered—especially in regard to the different fundamental morbid processes present—and on the other hand, it be considered how these formations may modify the space-relationships of the ear, displace the functionally important structures from their normal position, separate them from the exterior, or destroy them to a variable extent—it will be evident that the symptoms produced must be of the most diverse kind, finding their expression—according to the nerves implicated—in pain, paralysis of various degree, derangements of the hearing, and internal noises of different kinds and duration.

Even if the epithelioma has already encroached upon the deeper structures, recovery may still take place in some instances, if the diseased part can only be reached. If the whole of the disease cannot be removed, it is generally best to avoid any irritation of the parts (compare p. 317). In the case of a man mentioned in the first edition of this work (p. 597), the epithelial carcinoma originated in the skin over the left mastoid process, the whole of which was destroyed to such an extent that a cavity existed behind the auricle, communicating both with the external auditory canal and with the tympanum. Local treatment was followed by complete recovery without recurrence. The old man, now over ninety years of age, presented himself again at the author's out-patient department on

[1] Wiener Medicinal-Halle, 1863.

July 17th, 1887, and was examined by him and by his assistants *Drs. Gomperz* and *Zerner*, as well as by *Dr. Edward Law* of London, and no return of the growth was found. The opening into the cavity behind the auricle measured 2·5 *cm.* from before backwards, and 4 *cm.* from above downwards. The cavity itself was 4·5 *cm.* in depth, passing in the direction of the long axis of the external auditory canal; its interior much narrower than the external opening, and lined almost in all parts by a thin, dry, connective-tissue membrane. Slight paresis of the left facial nerve was present, and the hearing power for the watch was lost in the ear

Fig. 144*a*.



of the affected side. Weber's experiment gave a positive result—*i.e.* he heard the tuning-fork placed on the vertex towards the left side.[1]

7. *Cholesteatomata.*—The temporal bone, as previously mentioned, is the favourite seat of these tumours, which develope mostly in the chronically inflamed mucous membrane of the middle ear. The malignant character of these formations can scarcely be questioned. The old view, that the cholesteatomatous masses mechanically erode the structures, even the bone, cannot be maintained in all cases. The author has examined preparations, and has some likewise in his collection, in which the masses

[1] The translator saw this ancient individual and very unique case again in 1888. His condition was then still the same: he came to the out-patient department with the cavity, which was about as large as a walnut, filled with cotton-waste. Professor Gruber has kindly sent him photographs, one of which is reproduced in the adjoining figure (144*a*).—Eds.

lay free in a cavity in the bone; the appearance of the latter indicating that the destruction was not by caries. The neoplasm is not infrequently found combined with others, chiefly granulomata. In many cases it is only developed in the mastoid cells; whilst in others it occupies all the spaces of the middle ear, and grows into the auditory canal after having perforated the tympanic membrane, or towards the cavity of the cranium. The author possesses several preparations in which the growth has penetrated the lateral wall of the sinus sigmoideus and proliferated into this. It likewise sometimes destroys the roof of the tympanic cavity, and extends to that of the cranium, where it may undergo further development.

It is obvious that the subjective symptoms associated with a neoplasm which may develope in such different ways may vary greatly, and that it may in particular induce severe cerebral manifestations.

The *diagnosis* is only to be made from the objective appearances, and since the existence of the formation cannot always be demonstrated on account of its sequestered situation, its recognition will in certain cases remain very uncertain.

The *treatment* is the same as with a similar condition in the external ear. The removal of the cholesteatomatous masses is, however, the more urgently indicated here, because their continued presence in the middle ear with concomitant suppuration in the region, may involve the most serious dangers. In cases of necessity, the opening of the mastoid process must not be delayed, in order that the growths may be removed.

8. *Cysts.*—*Schwartze*[1] found a cyst-like structure in the tympanic cavity of a child, the inner wall of which exhibited epithelium, and its contents fat-crystals (rhombic plates). *Schwartze* thinks it may have originated in a gland in the mucous membrane of the tympanum. The author's collection contains a preparation showing a cyst as large as a walnut on the limbus cartilagineus of the Eustachian tube. So far as could be determined from an exploratory puncture, its contents consisted of a viscid hyaline fluid without morphological elements.

9. *Granulation-tissue new formations.*—Amongst these are observed *tubercle*, *lupus*, and *syphiloma*.

(*a*) *Tubercle* is found primarily both in the mucous membrane of the middle ear, and in the spongy tissue of the petrous portion of the temporal bone. More often, however, it occurs as a secondary formation in connection with pulmonary or general tuberculosis. It is in the nature of the case that the Eustachian tube should furnish the most common path or atrium for the invasion of the bacillus. According to *Voltolini*,[2] who was

[1] 'Beiträge zur Pathologie und pathologischen Anatomie des Ohres." Archiv für Ohrenheilkunde, i.

[2] "Ueber Tuberkelbacillen im Ohre." Monatsschrift für Ohrenheilkunde, xviii. Jahrg.

the first to demonstrate the presence of tubercle-bacilli in discharges from the ear, this can be accomplished more easily here than in the sputa—especially in children, by whom the latter is usually swallowed. He observes that the chief seat of tuberculous aural affections is the mucous membrane of the tympanum, and that therefore the matters to be examined should always be taken from the deepest parts of the ear.[1]

Habermann[2] found tubercle-bacilli in the purulent discharge from the ears of five individuals who succumbed to tuberculosis. The mucous membrane of the tympanic cavity was in each case the part principally affected; in the osseous section of the Eustachian tubes the most prominent signs of disease were at the ostium tympanicum; less marked at the isthmus. *Habermann* thinks this may be explained by the presence of the ciliated epithelium in the tube, by the movements of which the bacilli may be carried onwards, while they are stopped in the tympanum.[2] That tubercle-bacilli may nevertheless be present in the aural secretions without tuberculous affection of the aural structures is evident, and must be taken into consideration in diagnosis.

Nathan[3] found tubercle-bacilli in the discharge in twelve out of forty cases of otorrhœa which he examined. In three only of these twelve cases were there no signs of pulmonary phthisis; but in these three, carious processes were present. *Moldenhauer*[4] analysed the reports of 294 phthisical patients treated during twelve months in the hospital practice of *Prof. Wagner* of Leipzig. In twenty-eight cases only (2·4 per cent.) was impairment of hearing noted, while tubercular disease of the larynx was stated to have existed in 29 per cent.

The symptoms connected with tuberculous disease of the middle ear are similar to those of suppurative inflammation with caries of the region. Microscopic examination is therefore necessary to establish a diagnosis. A negative result of a single examination must of course not be accepted as conclusive, but the secretion derived from the middle ear must be submitted to examination at intervals, in order to determine the nature of the case.

The *treatment* is to be ordered in reference to a possible co-existent general disease as well as to the local affection. For the latter the author

[1] *Voltolini* gives the following method of examination for the tubercle-bacillus:—A little pus is smeared upon a cover-glass, dried over a spirit lamp, and afterwards placed in a fuchsin solution. The solution is then warmed over the spirit lamp till it begins to smoke, and the cover-glass left in it for an hour or two. The latter is then taken out, and decolourised by putting it into some dilute nitric acid, to which a few drops of fuming nitric acid have been previously added. It is subsequently to be stained with malachite green.

[2] "Ueber die tuberculöse Infection des Mittelohres." Aus *Prof. Chiari's* path.-anat. Institute an der deutschen Universität in Prag., Zeitschrift für Ohrenheilkunde, vi. Bd.

[3] "Ueber das Vorkommen von Tuberkelbacillen bei Otorrhœa." Deutsches Archiv für klin. Med., 1884.

[4] "Zur Casuistik der Erkrankungen des Hörorganes im Folge von Lungentuberculose." Monatsschrift für Ohrenheilkunde, xix. Jahrg.

generally uses iodoform, besides the employment of the measures otherwise indicated in middle-ear inflammation. With tuberculous ulceration of the limbus cartilagineus, violent pains are sometimes present, shooting towards the ear. For this condition an ordinary gargle containing cocaine or tincture of opium may be used. *Bülau* recommends the part to be painted over with a 1 per cent. solution of creasote, dissolved in equal parts of spirit and glycerine; or, if this should not answer, then with absolute alcohol; or a subcutaneous injection of a carbolic acid solution may be made in the vicinity of the maxillary articulation.

(*b*) *Lupus* occurs only secondarily in the structures of the middle ear, and then by extension from the external auditory canal or the pharynx.

(*c*) *Syphiloma* has been observed in the commencement of the Eustachian tube in cases of constitutional syphilis. The new formation usually breaks down and forms ulcers, in the treatment of which much care is needed, in order to obviate occlusion of the tube. These growths probably occur likewise in other parts of the middle ear, but the diagnosis of such conditions is very uncertain. With the local treatment must be associated one directed towards the general disease.

Although the name "polypus" in general, and that of "aural polypus" in particular, which is employed for the most diverse kinds of growth, is anything but scientific, it has nevertheless maintained its position in ordinary use in practice. By the latter term is understood a neoplasm originating in the external auditory canal or in the deeper parts of the ear, which is pedunculated, and consists principally of histological elements of the soft connective-tissue order. Granulations springing from a broader base are generally described as *polypoid proliferations*, in contradistinction to the pedunculated new formations.

That the neoplasms denominated "aural polypi" always possess an epithelial covering is not quite correct. A simple large pedunculated granulation is often called a polypus, but it has no external epithelial layer. Polypus is generally but a name which serves for the moment, and until a more accurate investigation of its nature enables its precise character to be ascertained.

In accordance with what has been stated, aural polypi may be either malignant or non-malignant in character. We have further seen that such formations appearing as soft tumours are almost always developed from an inflammatory basis, and in the changes which their elements undergo, they sometimes furnish a fluid product. It thus happens that polypi and polypoid proliferations are nearly invariably associated with

otorrhœa, and may be accompanied by the most diverse subjective and objective symptoms.

Besides the particular nature of the neoplasm, the attachment of the growth, and the changes which may co-exist with it, both in the ear and in other organs, are points of special importance from a practical point of view.

The presence of the growth is in many cases manifested by easily recognisable signs. The malignant are generally much more painful than other varieties, especially upon examination with the probe (*Voltolini*); they usually also grow and disintegrate much more rapidly; but an accurate diagnosis is only to be made by the aid of the microscope. In doubtful cases this must be resorted to at an early date, as the result may be of great importance in regard both to treatment and prognosis. The author has found fibroma to be the commonest form of neoplasm, and next to this the ordinary granulation.

Information concerning the attachment of the polypus may in certain instances be derived from the history of the case; and sometimes—especially with small polypi—by ocular examination. Where the latter is insufficient, the probe will be found useful for this purpose. By its aid, and under a good light, the exact position and extent of attachment of small growths in the deeper parts may be made out. In the case of larger ones projecting far into the auditory canal, where such inspection is not possible, the probe should be introduced between the polypus and the wall of the auditory canal, in the direction of the long axis of the latter up to its inner extremity, and passed round the polypus, if this be practicable. If the growth spring from the wall of the canal, the probe will be stopped in the circular movement; whereas, if the insertion be at the end of the canal, on the tympanic membrane, or deeper still, the probe will not meet with obstruction. In the latter case, however, it cannot be determined in which of the three situations mentioned the polypus is inserted, since the differences between the distances of the structures referred to from the orifice of the canal is so variable that the measurement of the length to which the probe can be introduced is of no service. With respect to details, we are usually dependent upon inspection of the growth after its removal.

Weydner[1] believes that the epithelium covering the polypus corresponds to the tissue from which it arises, except in the case of the larger tumours. This opinion, however, the author is unable to confirm.

Polypi most commonly spring from the walls of the tympanic cavity, whilst polypoid proliferations are found more often in the external auditory canal. Of the hundred cases of aural polypi examined by *Moos* and *Steinbrügge*, twenty-five had

[1] "Ueber den Bau der Ohrpolypen." Zeitschrift für Ohrenheilkunde, xiv. Bd.

their insertion in the auditory canal (one quite close to the orifice, the others in the neighbourhood of the tympanic membrane); the remainder originated in the tympanic cavity; amongst them, one from the roof, and eight near the stapes. Not one came from the drum-membrane or from the malleus.[1] *Politzer* saw a polypus, one root of which came through the tympanic membrane and was connected with the malleus and incus, while a second was inserted on the inner and lower wall of the tympanic cavity. *Voltolini* found a polypus on post-mortem examination, which had developed from the ostium tymp. tubæ as far as the external auditory canal in the one direction; and in the other, almost to the ostium pharyngeum tubæ; the tube itself being dilated in the osseous portion.[2] *Moos*[3] removed from a boy five years of age, a polypus together with the malleus, to the handle of which it was attached. Cicatrisation of the membrane followed.

The *prognosis* will depend in the first place upon the nature of the neoplasm; and next, upon its place of attachment and upon the character of any concomitant changes present within or without the ear. With regard to the insertion of the polypus, experience shows that when arising from the auditory canal, it is in general easier to effect its radical removal than when it originates more deeply. Polypi with a broad base are less easy to treat successfully than those with thinner peduncles; and naturally those of which the attachment can be easily reached can be more readily removed than when this is not so. Cases in which they originate in the upper part of the tympanic cavity, especially such as appear through a lost *membrana Shrapnellii*, are very obstinate to treat, it being very difficult to reach their point of attachment. Those polypi from which a moderate amount of bleeding takes place are, as a rule, much sooner eradicated than others: not unfrequently they undergo spontaneous separation from their base, without being followed by a recurrence of the growth. It must be evident that other co-existent morbid conditions of the middle ear will strongly influence the prognosis, if it be remembered that these formations are often accompanied by caries of the temporal bone, and are almost invariably associated with long-standing middle-ear inflammation, from which destructions of tissue may in so many ways be brought about.

Treatment.—This is to be directed towards two objects—the removal of the polypus, and the prevention of its recurrence. In regard to the latter, experience shows that polypi often only thrive upon an inflammatory site, and recur only so long as the inflammatory condition lasts. The chief aim of the treatment will therefore be the abatement of any inflammation present, and if this be accomplished, polypi not infrequently disappear which had previously always recurred after complete removal. Nevertheless, the growth itself cannot always be disregarded. It may perhaps impede the escape of the discharge, and thus provoke a condition fraught

[1] "Histologischer und klinischer Bericht über 100 Fälle von Ohrpolypen." Zeitschrift für Ohrenheilkunde, xii. Bd.
[2] *Virchow's* Archiv, iii. Folge, i. Bd.
[3] Zeitschrift für Ohrenheilkunde, viii. Bd.

with danger. In such a case, therefore, it must be removed at an early period; and this indication is extended by the author even to the malignant neoplasms, although, as previously emphasized, operative interference in connection with these should be avoided as much as possible, since it is well established that when only partly extirpated they grow all the more rapidly. The state of affairs may become still more dangerous by the presence of retention-masses, and then the operation will become yet more pressing. If no such urgent indication exist, it will be unnecessary to hurry on operative measures, particularly with recurrences; as when the inflammatory process recedes, resolution of the polypoid formations readily follows.

The removal of polypi may be accomplished either by operation or by the application of various substances. When practicable, operative treatment is to be preferred to other methods. It is in general less painful, besides interfering much less with the treatment of concomitant morbid processes and with subsequent observation of the structures, than when caustic agents are employed. The consequences also are not so disagreeable, and the duration of the treatment is shortened. The method of operation will vary in accordance with the nature of the growth and its mode of attachment.

Firm pedunculated tumours situated on the lateral wall of the auditory canal are, if the width of the latter allows of it, best removed with a small scalpel, or a pair of probe-pointed scissors with either angular or curved blades. For the same purpose a ring-knife (*Politzer*), or angular forceps, the extremities of which carry a light ring, cutting on the inner surface (*Victor Lange*), may be used. The drawback to such instruments, however, is that several of them must be kept for polypi of different sizes; besides which they are not so easily ground as straight instruments. Smaller polypi may also be removed with sharp spoons, which are made of different shapes (*Oscar Wolf*). With these instruments, the attachment of the polypus may be readily scraped through (*vide* Figs. 102-4).

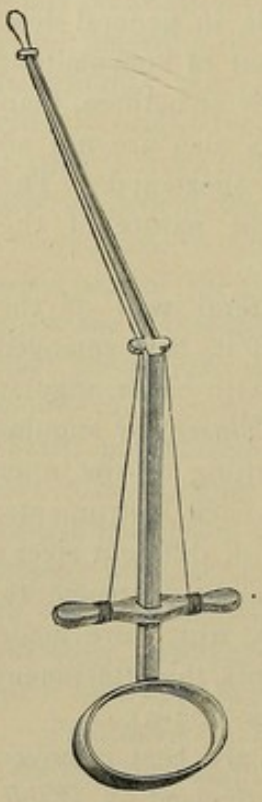
Softer polypi arising from the deeper structures, are best removed with the snare. The oldest instrument of this kind was devised by *Wilde*, and is represented in Fig. 145. It consists of a slim stem of German silver, bent in the middle at an obtuse angle. At one end of this is an oval ring, likewise at an obtuse angle, and large enough to insert the terminal phalanx of the thumb. At the other end, and at the bend of the stem, are small cross-pieces, pierced parallel to its long axis for the wire to pass through. A cross-beam runs along the stem, and on this the ends of the wire are wound. The polypus-snare of *Wilde* has certainly paved the way to considerable advances in the treatment of aural and other polypi, though it possesses inherent defects; the chief being that in using it the hand comes too near the auditory canal, so that it is in the way of

the light; and therefore small, deeply situated polypi cannot be removed, or only with much difficulty. The instrument has likewise the disadvantage that the double bend makes it too bulky. The author invariably uses the polypus-snare which he has contrived (Fig. 102, 1), with which growths no larger than a hemp-seed, and springing from the deeper parts, may, if visible, be taken away as easily as larger ones.

Dr. Blake has modified Wilde's snare so that the wire runs in a tube which is removable from the stem, and the cross-bar carrying the wire is replaced by a ring, by means of which the loop can be tightened up with one finger.

Fig. 145.

Wilde's polypus snare (two-thirds the usual size).



Hartmann also recommends a tube for the wire to run through, as in this way the attachment of the growth is cut off rather than torn through. The author, however, does not think the tube advisable, on account of the difficulty in cleaning it. With few exceptions, too, it is better for the base to be torn through rather than cut, as recurrence is then less likely to take place. Where laceration is to be avoided on account of the proximity of important structures, the galvano-caustic method will upon the whole be preferable.

In using the instrument, a loop is formed by pushing forwards the cross-bar, large enough to receive the growth. The inclination of the loop to the shaft of the stem is then adjusted in accordance with the attachment of the polypus. Thus, when the latter springs from the deeper parts, it will be best to bend the loop to a right angle with the stem; while, if the polyp grows from the wall of the auditory canal, the loop should be left in the same direction as the instrument, as it will in this case generally be possible to pass it round the growth in its introduction. It is always well to have several wires at hand; or, better still, to keep two instruments in readiness, since the wire may easily break, although every care be used.

The operation is carried out in the following manner:—The auditory canal having been properly cleansed—as in all other operations—and the attachment of the polypus having been ascertained as well as possible, the loop of the snare is adjusted as just described. The operator then passes his index finger through the ring of the instrument (Fig. 102, 1, *H*), and introduces it under a good light, in such a way that in its advance the loop passes round the growth. The end of the instrument is now pushed on as near the root of the polypus as possible, the latter being thus encircled by the loop, which is then tightened up round it by drawing on

the ring with the index finger; and by a further constriction, the base of the growth is cut through.

If the existence of a polypus situated on the other side of the drum-membrane be diagnosed, the latter must be incised as a preliminary to its removal.

Moos[1] removed a polypus which grew from the posterior part of the tympanic cavity, and bulged the membrane outwards. By the side of this, another one was present, appearing through a perforation in the upper segment of the membrane. The first mentioned was removed with a Wilde's snare, introduced through an incision made in the posterior segment of the membrane.

Victor Lange proceeded in the same way in a case in which a polypus was supposed to be present in the tympanum. He, however, removed what turned out to be a piece of bone detached from the promontory, and looking like a polypus. *Truehart*[2] also removed a fibrous neoplasm growing from the inner wall of the tympanic cavity after preliminary incision of the membrana tympani.

The polypus having been removed, and any hæmorrhage arrested, a fresh inspection is to be made. The bleeding is rarely profuse: it generally stops by itself very soon; or may be arrested by introducing a plug into the auditory canal. Sometimes one or more fresh polypi, previously invisible, are discovered after the removal of the first; or a part of this is perhaps found to be still left. Under such circumstances, it will be necessary to reintroduce the instrument, either at once, or at another sitting, as may be thought advisable. It is better to remove as much as possible, and not to leave too much to the after-treatment.

Large and dense polypi, especially when growing from a broad base, are best removed with the galvano-cautery. This method is likewise more suitable for small deeply situated polypi or their roots, which are difficult to snare. For the former the author uses the galvano-caustic loop, and for the latter a flat cautery point. Though more convenient in the cases referred to, the author is unable to substantiate the further advantages claimed for the galvano-cautery in regard to the obviation of hæmorrhage, pain, and tendency to recurrence. Electrolysis has recently been employed for the removal of polypi by *Voltolini*. The instrument used consists of two steel or platinum needles, parallel and close to one another, and isolated along their entire length. They are fixed at an angle of 120° into a handle, and are connected with the electrodes of a galvanic battery of one or two elements. As in all polypus operations, cocaine is previously used; the growth is then pierced by the needles, and the current allowed to pass for from half a minute to a minute. According to *Voltolini*, one needle alone is necessary; the second electrode being connected with a

[1] "Ausrottung eines Trommelhöhlenpolypen mit blutiger Trennung des Trommelfelles." *Virchow's* Archiv, xxxvi. Bd.

[2] "Fibroid tumour of the middle ear, neuralgic pains, otorrhœa, and deafness; removal of tumour followed by restoration of function." Med. Record, 1885.

sponge applied to the skin of the face. *Dr. Gomperz* made trial of this method in the author's out-patient practice at his request, and found that polypoid proliferations in the tympanic cavity and projecting into the auditory canal were thereby caused to disappear in a comparatively short time. With granulations on the upper or lower wall of the tympanum he recommends platinum needles to be employed, on account of the facility with which they can be bent in the manner required. The author has come to the conclusion that the procedure is really only a cauterisation, an eschar being produced which must be removed prior to a repetition of the operation. Some of the patients complained of severe pain, despite the application of cocaine, and the process does not appear to possess any particular advantage over that of the galvano-cautery. *Voltolini* eulogises it more especially for the treatment of polypoid proliferations in the tympanum which have perforated Shrapnell's membrane. In such cases, the attachment of a growth near the articulation between the malleus and incus, can be reached better by this than by other methods, and in this respect the author thinks it is to be commended.

The treatment of aural polypi by means of various applications is naturally more tedious than by operation, and by no means necessarily less severe. The use of caustics is especially apt to cause more pain than the measures just described, and is now employed almost exclusively for the destruction of the remains of the attachments of polypi which have been removed by operation. The substance usually applied is nitrate of silver, solid or in strong solution. Other astringents and caustics have been much used, however—*e.g.* sulphate and acetate of zinc, perchloride of iron, acetate of lead, creasote, nitric acid, sulphuric acid, lime-water, and sulphate of copper. *Toynbee* recommended a mixture of quicklime and caustic potash, to which a little sulphate of iron is added to prevent rapid deliquescence, by which the healthy parts would also be attacked. Chromic acid, recommended by *Seely* in 1872, is one of the most efficacious caustics. A crystal is to be taken up on the moistened end of a probe and applied to the growth; the process being repeated after the eschar produced has separated. Its action is more energetic than that of nitrate of silver, but sometimes causes some inflammation of the auditory canal, even when applied most carefully. *Ladreit de Lacharrière*[1] employs for cauterising the bases of polypi, the caustic points (flèches) of *Maissonneuve*, composed of chloride of zinc, flour, and a little morphia. They are hard enough to penetrate the growth, and are said to be certain and painless in their operation.

Politzer recommends perchloride of iron in crystal or in solution. A piece of cotton-wool is to be dipped in the solution and applied to the

[1] Annales des maladies de l'oreille, ii.

growth, or a small crystal is carried to it by means of a probe. The author cannot speak favourably of this treatment. Nor, indeed, can he approve of the "*alcohol treatment*" praised by the same authority. This consists in the introduction of absolute alcohol two or three times a day into the ear, in which it is allowed to remain for ten minutes. *Schwartze* writes: "No benefit has been effected in any case in which I have tried it (alcohol). With its long-continued use for months, it is not impossible that injurious effects might follow from abstraction of water from the tissues and thrombus formation in the vessels." This is in accordance with the author's opinion. Many writers, however, speak of the good effect of alcohol in soft polypoid proliferations,[1] and the author, twenty years since, recommended painting with the tinctures of opium or thuja in such cases, the effect of which is less likely to be injurious than the employment of alcohol baths.

Moos and *Steinbrügge*[2] recommend the application of a 10 to 25 per cent. solution of acetate of lead, to which a few drops of acetic acid are to be added. The clear solution—it should not be cloudy—is instilled into the ear twice a day at least, and a plug of salicylic wool then introduced deeply. In some cases severe pain follows, but soon disappears. The application causes the cellular elements of the neoplasm to shrivel, probably producing also constriction of the vessels and thrombosis; the growth being thrown off in consequence.

The author can from his own experience confirm the statements as to the beneficial effect of lactic acid recommended by *Victor Lange*[3] in cases of polypoid proliferation. A 15 to 20 per cent. solution is to be instilled once or twice daily.

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[1] The translator has frequently seen great benefit derived from this method of treatment both in the wards of *Prof. Politzer* and elsewhere. He has found it very useful in the treatment of cases where no suitable instruments were available (*e.g.*, at sea). At the commencement, the alcohol should be used diluted (with an equal quantity of water), and the strength of the instillation gradually increased. The addition of boric acid (to saturation) is often advantageous in removing inflammatory symptoms. The method is naturally only applicable in the case of small flabby polypi (granulations), not associated with bone disease.—EDS.

[2] "Hundert Fälle von Ohrpolypen." Zeitschrift für Ohrenheilkunde, xii. Bd.

[3] "Einige Bemerkungen über die Anwendung von Milchsäure bei chronischer eiteriger Mittelohrentzündung." Monatsschrift für Ohrenheilkunde, 1887.

III.

DISEASES OF THE INTERNAL EAR.

CHAPTER XIX.

AFFECTIONS OF THE LABYRINTH.

Though until comparatively recent times the doctrine was firmly held that more than half the number of patients with ear affections suffered from "nervous deafness"—or, more definitely, from "primary disease of the labyrinth,"—the conviction is now tolerably general that labyrinthine disease is really of extremely rare occurrence.

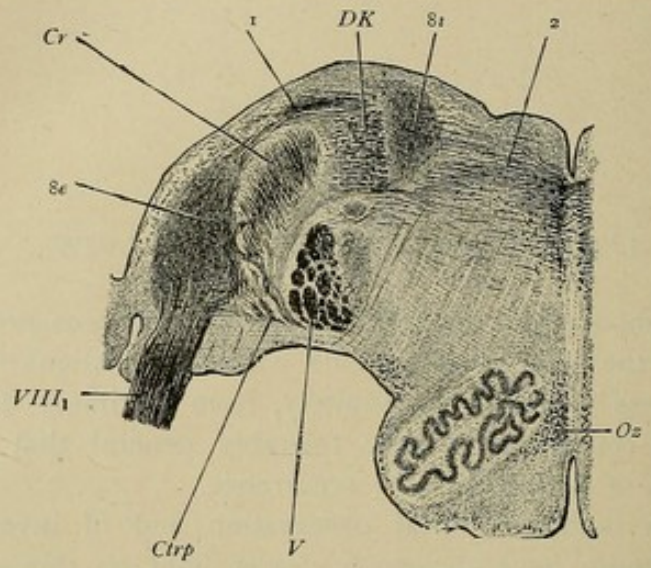
The results both of clinical observation and of investigations in pathological anatomy have thrown a clearer light on this subject. The number of the symptoms which were formerly assumed to depend upon pathological changes in the labyrinth has been considerably lessened in consequence of a better acquaintance with the morbid processes occurring in the external and middle ear, to which regions they are now recognised to belong. The advances made in neurology have equally served to relegate to their true origin in the central nervous system many other subjective aural symptoms previously vaguely characterised as "nervous."

The difficulty experienced in referring the latter phenomena to their actual source, and so determining a diagnosis, lies mainly in the multiplicity of connections of the root of the auditory nerve with the central nervous structures. A glance at the accompanying figures (Figs. 146-50), taken from *Freud's* treatise, will sufficiently indicate that changes in the most diverse parts of the central nervous apparatus may bring about morbid manifestations in connection with the auditory nerve; and that, conversely, affections of the labyrinth may in their turn occasion certain central nervous phenomena in a reflex manner. An accurate elucidation of the subjective symptoms is therefore by no means an easy matter in many cases.

The facts hitherto brought to light in this domain have led to a steady advance in the state of our knowledge concerning the regions above mentioned, and indirectly also in regard to the diagnosis of labyrinthine diseases. It has in the first place been established that, though *secondary changes* in the labyrinth, consequent upon the presence of other forms of ear disease, may be common, *primary labyrinthine derangements*, on the other hand, are very rare indeed. *Kramer* is certainly very near the

Fig. 146.

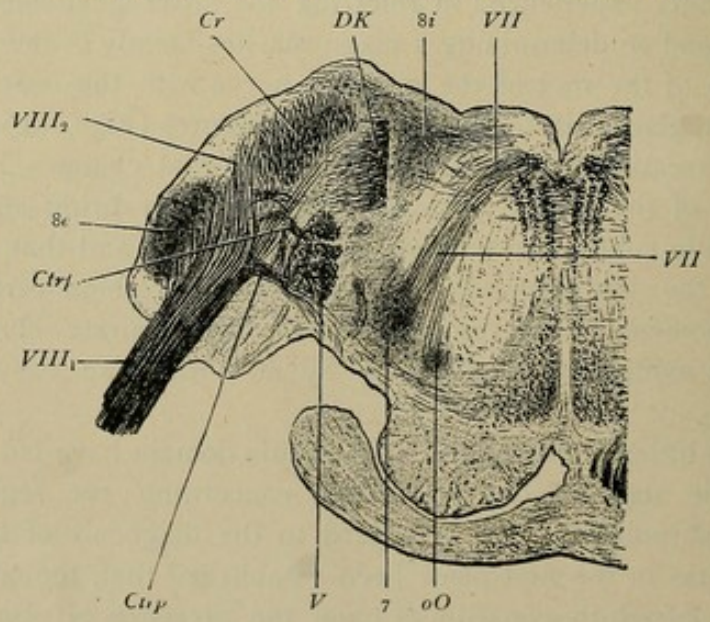
Section through the lowest level of the place of origin of the auditory nerve—from a human fœtus at the sixth month. Treated with Weigert's hæmatoxylin.



$VIII_1$, First portion of the auditory nerve, from the external nucleus of origin, *8e*; *8i*, internal nucleus of origin; *DK*, Deiter's nucleus; *V*, section through nucleus of fifth nerve; *Cr*, restiform body; *Oz*, inter-olivary layer; 1, auditory nerve-filaments round the restiform body; 2, fibres from the internal auditory nucleus to the raphé; *Ctrp*, corpus trapezoides.

Fig. 147.

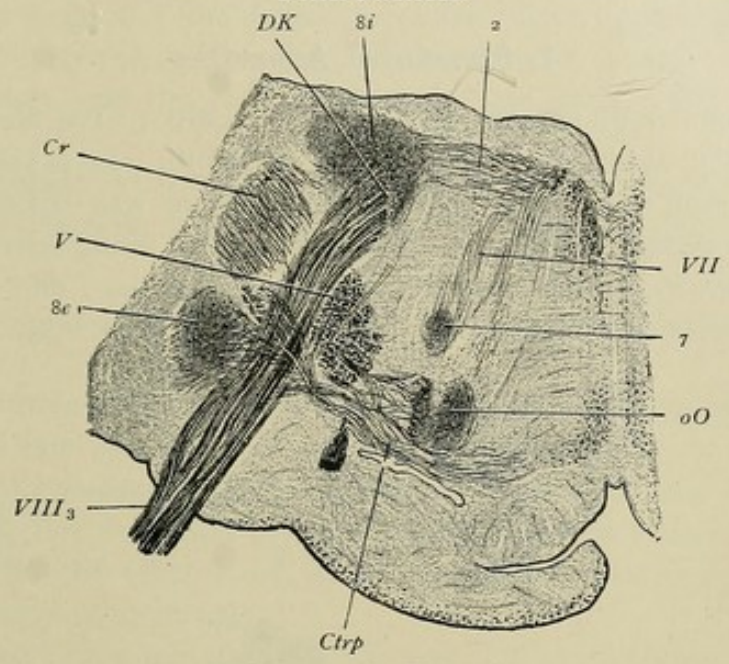
Section at a higher level than the preceding. In this are likewise seen the nucleus of the facial nerve (7), with its connected root-fibres (*VII*).



$VIII_2$, The second portion of auditory nerve, passing round and through the restiform body to the internal nucleus of origin; *oO*, the superior olive. The other letters as in the preceding figure.

Fig. 148.

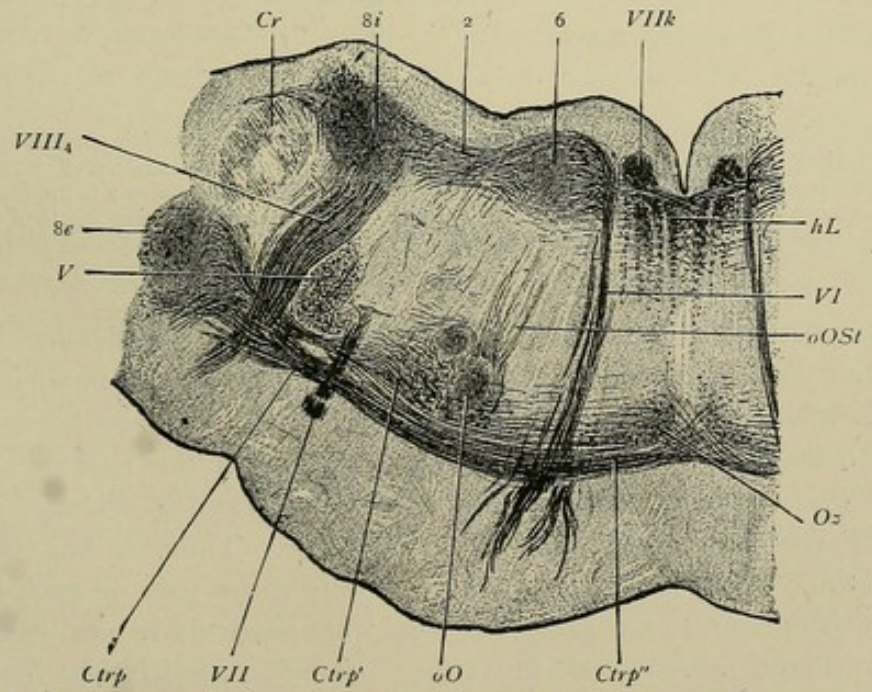
In this is shown the third portion of the auditory nerve ($VIII_3$) in its course to Deiter's nucleus.



Letters as in Fig. 146.

Fig. 149.

Section at the level of the fourth portion of the auditory nerve and the nucleus of the abducens.



VI, Abducens nerve; *hL*, posterior longitudinal fasciculus; *VIIk*, genu of the facial; *Ctrp*, the part of the corpus trapezoides which goes to the superior olive of the same side; *oOSt*, peduncle of the superior olive. The other letters as in Fig. 146.

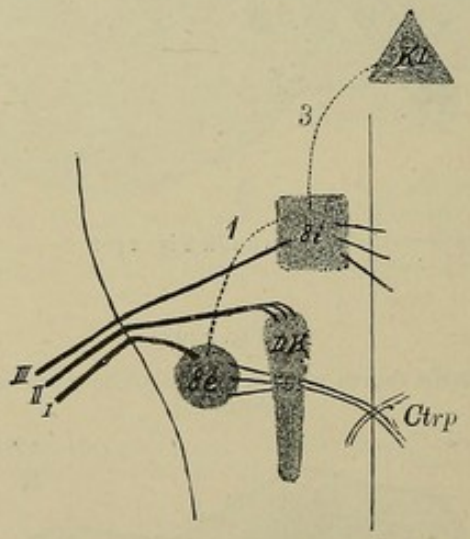
truth in supposing that out of a thousand patients with ear disorders, perhaps four may be affected with primary disease of the labyrinth,—a proportion which must be acknowledged to be relatively insignificant.

1. Structural Anomalies.

Deviations from the normal occur in regard to the size, shape, and number of the constituent parts of the labyrinth. In cases of complete deafness, as well as in others in which the hearing was normal, the entire labyrinth, or certain portions of it only, have been found extremely small; in some instances, on the contrary, of exaggerated size; and sometimes as

Fig. 150.

Schema of the origin of the auditory nerve.



I, First portion, ending in the external nucleus, 8*e*; *II*, third portion, continuous with the fibres of Deiter's nucleus, *DK*; *III*, second and fourth portions of the nerve, terminating in the internal nucleus, 8*i*. Central connections: *Ctrp*, corpus trapezoides; 1, fibres connecting (?) the external with the internal nucleus; 2, fibres from the internal nucleus (8*i*) to the raphé; 3, curved fibres from the internal nucleus to the crossed roof-nucleus (*Kl*) in the cerebellum.

altered in configuration. Such irregularities are of significance, however, only when exhibited by structures which are of functional importance.

Variations in the usual number of the elementary parts of the labyrinth may, on the other hand, seriously affect the hearing capacity; though even here certain structures may be wanting without entailing complete deafness on the corresponding side. Thus, in the case of a woman thirty-five years of age, who had only three toes on each foot, and but three fingers on each hand, and was "not particularly hard of hearing," *Voltolini* found absence of the entire posterior semicircular canal, the inferior being remarkably diminutive, and the cochlea almost a third smaller than normal. Hitherto even partial absence of the structures of

the labyrinth has been observed only in deaf-mutes. *Mordini*,[1] *Röderer*, *Nuhn*,[3] *Hélie*,[4] *Toynbee*,[5] *Michel*,[6] and others have described cases of this kind. In *Michel's* case both the labyrinth and the auditory nerve were completely wanting, and the facial nerve passed through a curved canal in the rudimentary petrous portion of the temporal bone. To the same category belongs also the case described by the author and represented in Fig. 85.

The subjective symptoms will vary with the degree of defect which exists. A precise diagnosis during life cannot be made.

2. Concussion of the Labyrinth (Commotio labyrinthi).

The condition is thus denoted in which certain symptoms occur as the result of external violence—as from a blow, shock, or explosion—which are unaccompanied by perceptible lesion in the ear, and are, on the one hand, not explicable by any known variable of normal acoustic function; or, on the other hand, by the recognised modes of activity of the central nervous apparatus.

Concussion of the labyrinth may or may not be combined with injury of other aural structures, and in the latter case the diagnosis will naturally become all the more difficult. In what the actual nerve condition consists in such cases is no better ascertained than in those of concussion of the brain. Even when complete deafness has ensued it has been well established by post-mortem examination that no recognisable changes in the labyrinth are necessarily present. These derangements most frequently happen from the discharge of firearms, and may be either unilateral or bilateral. In the majority of instances, that ear only is affected which is turned in the direction of the explosion; but occasionally both ears suffer.

The *subjective symptoms* vary. An attack of giddiness not infrequently comes on with the concussion; and some patients fall down, or even become insensible. Pain also is occasionally present, and may last for several hours, even without any demonstrable injury to the structures of the ear. Subjective auditory sensations of the most diverse kind are almost invariably experienced, and these sometimes change during the course of the affection. The hearing capacity may be merely enfeebled, or completely annulled. In occasional instances, hyperæsthesia acustica

[1] Comment. Bononens., t. vii. Anatomia surdinati, p. 422 de labyrinthi auris content.
[2] Descriptio fœtus parasit. in comment. societ. Gotting. t. iv.
[3] Dissertatio de vitiis, quæ surdo-mutitati subesse solent.
[4] Archives générales de médicine, t. xii., p. 485.
[5] L. c.
[6] "Mémoires sur les anomalies congénitales de l'oreille interne," etc. Gazette médicale de Strassbourg, 1863, Nr. 4.

exists for some sounds, and even for speech; or the pitch of certain tones appears altered, being either too high or too low; or again, they may have a disagreeable jangle (Beiklang). The author has often heard patients complain of the latter symptom.

Brunner[1] observed a case in which, after the report of a gun, tones were heard about half a note higher on the left than on the right side. In another case the four notes of the piano, e''''—a'''', could not be heard at all; but the symptom disappeared in ten days. *Blau*[2] treated a patient in whom tingling and dulness of hearing came on from the report of a revolver. "*Sz*" was always heard instead of "*sch*" (*sh*), and every sound-perception had a metallic jangle (Beiklang).

The *objective appearances* will differ according to the nature of any other injuries which may accompany the concussion; and if none such have occurred, no changes are to be recognised.

The *diagnosis* of concussion of the labyrinth is only to be made from the history of the case, and by a process of exclusion; though ophthalmoscopic examination, as pointed out by *Zaufal* and *Knapp*, sometimes furnishes valuable information.

With regard to the history, much circumspection must be exercised in forming an opinion, especially in forensic cases, in which perhaps violence is asserted to have been used. In respect to no organ is simulation easier than with the ear, as the patient's statements cannot be controlled by direct examination. Deception is particularly easy in the case of a supposed unilateral affection of the labyrinth. Under such circumstances, the perceptions of the other ear—the functional activity of which admittedly cannot be eliminated in testing the hearing—suffices to provide the person examined with the means of following the tenour of the examination, even though his eyes be closed; and his statements might in this way readily acquire a colouring of credibility. The more artful and better-informed class of individuals, therefore, simulate an impairment of hearing — unilateral or bilateral — rather than complete deafness (*Chimani*). Even with obvious lesions of the sound-conducting apparatus, the labyrinth may remain intact; and since the condition of the nervous apparatus is of the greatest importance in regard to prognosis, treatment, and a judicial estimate of the nature of the case, all possible means must naturally be employed in testing this, and consideration given to the results of examination for any co-existent affections capable of influencing the state of the acoustic function, as well as to such changes

[1] "Ein interessanter Fall von länger anhaltender Taubheit, verursacht durch einen Flintenknall. Mit epicritischen Bemerkungen." Zeitschrift für Ohrenheilkunde, ix. Bd. Ferner, "Kleine Mittheilungen," Ibidem, x. Bd.

[2] "Beobachtungen von Erkrankungen des Labyrinthes." Archiv für Ohrenheilkunde, xv. Bd.

as may have been present previous to the concussion. The last observation holds not only for the diagnosis of concussion, but likewise for all changes in the sound-perceiving apparatus: that is to say, the diagnosis of an affection of the labyrinth can in general only be arrived at by the exclusion of all other morbid changes in the ear which may, and sometimes do, provoke similar symptoms. It will thus be seen that a precise diagnosis is often a very difficult matter; but an experienced and scientific observer will often be guided correctly in his cultivated conjecture where nothing is visible to the eye.

In the attempt to recognise the presence of labyrinthine disorders, great attention has been directed to the normal function of the organ; and constant endeavours have been made to establish the significance of various deviations from the normal. The results, however, have been but of an approximate value from a diagnostic point of view.

It must nevertheless be insisted upon that testing with the watch alone, or with only one tuning-fork, is insufficient; and that tuning-forks of different pitch, as well as other instruments, must be employed.

In certain labyrinthine derangements, there occurs an impairment in the perception of high or of deep tones; but the author has not met with instances of these anomalies.

According to *Lucæ*,[1] a complete loss of sensibility for the highest musical tones in the four times accented octave, emitted by tuning-forks vibrating strongly before the open auditory canal, is said to betoken an affection of the nervous apparatus. If, with merely diminished hearing capacity for high notes, those of deeper pitch are distinctly audible, this will offer good evidence for the exclusion of an affection of the sound-conducting apparatus, inasmuch as experience shows that, even with a perfectly free auditory canal, deep tones appear muffled in peripheral ear disease.

Erhard's doctrine that defective conduction through the cranial bones is "the pathologico-physiological symptom common to all cases of nervous deafness" is so far true that cranial conduction is generally weakened or annulled when severe labyrinthine mischief exists; but it is no certain indication of such a condition. Disease of the bones may on the one hand impair their conductivity, and on the other hand it is no more possible to test conduction through bone alone than conduction through air alone. How often is the observation made that, after a plug of cerumen is syringed out of the auditory canal, the sound of a watch is audible when placed upon the cranium, whereas it could not be thus heard before the plug was removed, owing to the transmission of the sound-waves through the auditory canal having been prevented by the presence of the cerumen. The loss of cranial conductivity is therefore a symptom pointing with some probability to a derangement of the labyrinth, but it offers no greater

[1] "Kritisches und Neues über Stimmgabeluntersuchungen." Archiv für Ohrenheilkunde, xxiii. Bd.

certitude of this than the existence of cranial conduction does of the integrity of the labyrinthine structures.

The employment of Weber's process is more serviceable. A positive result is sufficient to exclude any marked disorder of the labyrinth; while, if negative, the existence of such an affection may be assumed with some confidence. As regards Rinne's method, the author is unable to ascribe to it any great diagnostic value. With complete deafness it does not of course come into consideration; and when the hearing has merely become impaired, it is to be looked upon in the light only of a control-experiment, which is of some use in estimating the correctness of the patient's statement.

Lucæ[1] holds that no particular diagnostic importance can be attributed to Weber's process, because even with a sound ear an intensification of tone sometimes takes place. He considers Rinne's method, on the other hand, as of decided value, taken along with tests for different high-pitched tones in aërial conduction, and provided always that one is dealing with deafness of high degree.

In cases in which the various tests point to the existence of total loss of hearing, the procedure devised by the author (page 137) should never be omitted, as by this means it may perhaps be shown in certain instances that the deafness is not really absolute.

Concussion may be most readily confounded with actual injury to the labyrinth. A gradual diminution of the hearing capacity after some form of violence, with the appearance and persistence of the symptoms of Menière's disease, tend to indicate the presence of injury with extravasation of blood into the structures of the region. In concussion of the labyrinth, the impairment of hearing comes on more suddenly, and disappears also more readily; so that the diagnosis will be facilitated by watching the course of events.

It will perhaps be most convenient to refer here to the ordinary expedients used in the detection of *simulated deafness*.

Both ears must first of all be accurately examined, in order that from the results a standard may be obtained for judging of the statements made.

The less wary and ill-educated class of simulators may sometimes be exposed by speaking about them in their presence in a sneering or contemptuous manner: they may thereupon become disconcerted, and manifest signs which betray them. *Wilde* suggests that a person pretending to be totally deaf should be asked how long he has been so, when it may readily happen that he answers the question. Simulators have been frequently discovered by calling out to them during sleep or chloroform anæsthesia, or when in a half-drunk condition.

Müller[2] recommends the following method for the conviction of individuals simulating unilateral deafness. An ear-trumpet (or paper tube) is held in each ear, and two persons simultaneously utter two different sentences at the same rate of

[1] "Kritisches und Neues über Stimmgabeluntersuchungen." Archiv für Ohrenheilkunde, xvii. Bd.

[2] Berliner klinische Wochenschrift, 1869.

speaking and equally loudly, one into each ear. If both ears be sound, the individual being examined cannot understand what has been said; while, if one ear be affected, he can distinguish what has been spoken into the other.

Schwartze thinks the tuning-fork may be of service. Persons really deaf always state that they can feel its vibration; but simulators are afraid they will betray themselves by the admission.

Voltolini[1] proposed another means for the detection of pretended deafness in one ear. A large ear-trumpet is placed to the supposed deaf ear, and the other left free. The individual then always says he can hear nothing; although it is certain he must have heard with the ear admitted to be healthy. If a small tube be fixed in this ear he thinks it is quite closed, and so falls more easily into the trap.

Coggin[2] employs in suspected cases of simulated unilateral deafness a binaural stethoscope, one branch of which is completely stopped up with a wooden plug, and fixed in the ear stated to be sound. Some words are now whispered into the stethoscope, which the individual repeats without hesitation. The tube containing the plug is then placed in the ear said to be deaf, and the other one closed by pressure on the tragus. Words now spoken into the stethoscope are stated not to be heard, and the deception thus exposed.

Venturini had drawn attention to the circumstance that persons whose hearing is normal are unable to determine the direction of the sound of a watch if it be moved from before backwards above the head in the plane of the vertex; and if one ear be closed, the sound appears to move over towards the other ear. Upon this is based the expedient of *Weinhaupt*,[3] which is as follows. The eyes of the person to be tested having been closed, he is questioned as to the position of a watch held by an assistant in the direction of the ear said to be deaf, or moved from before backwards in the plane of the vertex. If he answer correctly, he will be convicted of deception.

The method of *Teuber*, which has been described by *Lucæ*,[4] as well as that of *Preusse*,[5] who employs a telephone, are more complicated on account of the specially constructed apparatus required.

In these cases the author has frequently employed with success the hearing test devised by him (*vide* p. 137). The person simulating deafness is mystified by the stopping up of the auditory canal, and always says he hears the tuning-fork worse when placed upon the finger, which is—as is well known—opposed to the fact.

The greatest circumspection is necessary in the statement of a *judicial opinion regarding the condition of the ear*. Without dwelling on the instances of frequent occurrence in which an aural affection which has existed for many years is referred by the patient to some extraneous violence, however slight, to which he has recently been subjected, the author can speak of a case within his own experience, in which a boy, whom he from the first recognised as simulating, succeeded in puzzling different aural surgeons to such an extent that they actually certified the existence of bilateral deafness resulting from illegal violence. It was only after a long preliminary examination before a court of justice that the deceit was exposed

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[1] "Ueber Simulation von Schwerhörigkeit." Monatsschrift für Ohrenheilkunde, etc., xvi. Jahrg.

[2] "Eine neue Prüfungsmethode auf simulirte einseitige Taubheit." Zeitschrift für Ohrenheilkunde, viii. Bd.

[3] "Beitrag zur Eruirung von Simulation einseitiger Schwerhörigkeit und Taubheit." Allgemeine Wiener medicinische Zeitung, 1883.

[4] Berliner klinische Wochenschrift, 1869.

[5] Archiv für Physiologie, 1879.

and the boy punished. Attention should be particularly directed to the following points :—

1. The observer should never omit to inform himself whether the ear was healthy or not before the injury; whether the hearing capacity has deteriorated since; or whether perhaps other pathological changes have made their appearance.

2. It must not be forgotten that interruptions of continuity of the tympanic membrane can only be recognised as of traumatic origin in the recent condition, *before inflammation and suppuration have set in*. No means exist for distinguishing an inflammation of the drum-membrane arising from traumatic causes from one due to other influences.

3. A solution of continuity of the membrana tympani does not in itself imply serious injury. Such lesions, indeed, are sometimes followed by conspicuous improvement in the hearing, on account of pathological changes in the membrane which they may bring about. Nevertheless they may involve the offence of "causing grievous bodily harm"; partly through the length of time needed for the healing of the wound; partly through consequences which entail detriment to the functional integrity of the sense-organ (§§ 152 and 156 of the Austrian State Laws on 'Killing and Wounding'). It will therefore in doubtful cases be advisable to reserve one's judgment for a time concerning the extent of the injury.

4. Much importance has been attached from diagnostic points of view to the non-perception of the sound of the tuning-fork through the cranial bones. It ought, however, to be distinctly understood that this affords no certain evidence in determining the question whether or not the labyrinth has been injured by the violence experienced.

5. When the hearing capacity has been to some extent impaired as the result of an injury, it will be well—especially if only one ear is affected—to adopt the advice of *Prof. E. von Hofmann*,[1] in restricting oneself to a detailed statement of the nature and degree of the derangement, leaving a general estimate of the case to the judicial authorities.

In regard to the question of *life assurance*, a formal professional opinion concerning an aural affection must have reference more particularly to its influence upon the duration of life; to a possible connection with other physical infirmities; and to its effect upon the individual's capacity to earn his livelihood. Further remarks on this subject will be found in the author's chapter on "The Auditory Organ" in *Buchheim's* work.[2]

The *prognosis* in concussion of the labyrinth depends in the first place upon whether it is combined with any other lesions of the auditory or other organs, and in that case upon their nature. It will further be affected by the character of the subjective symptoms which may be present, and their duration. Total deafness on the affected side is a very unfavourable symptom, though even such cases may recover. The author can recall several such instances in his own experience: amongst them one in which total deafness on the left side, accompanied by subjective auditory sensations, came on from a gun going off in front of the patient's ear while out shooting. After more than two years, during which the deafness resisted every kind of treatment, it became distinctly less, and the subjective

[1] Lehrbuch der gerichtlichen Medicin., Wien, 1887, S. 337.
[2] Praktischer Leitfaden für Versicherungsärzte, Wien, 1875

sensations ceased. He has likewise observed a fair number of cases in which deafness arising from labyrinthine concussion diminished, or completely disappeared, in the course of a few days or weeks; though of course in a much larger number, the impairment of hearing persisted or even became worse. *Politzer*[1] reports an instance in which the patient struck his head against a door-post, and fell down insensible. On recovering consciousness some hours later, he had violent tinnitus, headache, and deafness which increased at the end of the fourth week till it became absolute. The deafness continued for ten months; and then, after headache for three days, the patient awoke in the night with a severe attack of vertigo, upon which the hearing became again normal in both ears. Whether in this case there was concussion of the labyrinth, or whether the symptoms were due to a concussion of the central organ, could not be determined.

Long-continued subjective auditory sensations, especially if combined with vertigo and hyperæsthesia acustica, likewise make the prognosis worse. In the belief of the author, a definite opinion can never be given concerning the duration of the affection. Subjective symptoms dependent on a slight concussion of the labyrinth may persist for years; while, on the other hand, the author has observed an amelioration of severe symptoms due to a similar cause in the course of a few days. In any case, the prognosis must be made with much caution.

The *treatment* should be directed towards shielding the ear from injurious influences as much as possible. If the labyrinthine concussion be combined with injury to other aural structures, suitable measures must be adopted in reference to the latter. In other cases, mental and bodily rest ought to be prescribed, and endeavours should be made indirectly to alleviate the subjective symptoms. In strong individuals prone to congestions, local bleeding may be employed if the symptoms be severe; and attempts made to obviate a congestive condition of the head by derivation from the intestinal canal and skin. The use of the air-douche and of electricity should be strictly avoided. The local application of cold, or a general hydropathic treatment may, however, be of service, especially if nervous prostration exist; and for severe subjective sensations, bromide of potassium or of sodium may be administered.

3. Injuries of the Labyrinth.

These involve the labyrinth alone, or are combined with lesions of other structures; and they may be produced either by direct violence to the ear—chiefly from foreign bodies gaining admittance to the auditory canal—or indirectly, through a fall, blow, explosion, etc.

[1] Lehrbuch, S. 842.

In the case of a man who was in hospital for a long time under the author's care, laceration of the drum-membranes, with interruption of continuity and extravasation of blood into both labyrinths, took place on his coming into the open air after working for some hours in a caisson, during the building of a bridge. He was attacked with severe giddiness and vomiting, and became deaf in both ears in a few seconds. The sickness and vertigo soon ceased, and the ruptures of the membranes healed; but the deafness persisted in the same degree in spite of all kinds of treatment during two years.

In cases of injury due to a fall, so-called contre-coup plays an important part. Such labyrinthine lesions are usually accompanied by fissures of the petrous portion of the temporal bone; the latter being in isolated cases found with an uninjured membrana tympani. Mention has already been made of a case of fissure of both petrous bones without lesion of the tympanic membrane (p. 259); and quite recently the author was enabled, through the kindness of *Prof. von Hofmann*, to examine the right temporal bone of a man who had been killed by falling from a great height. The pyramid was separated into two equal parts in the direction of the long axis, and the crown of the incus was dislocated; but the drum-membrane was uninjured, and the external auditory canal contained neither coagulated nor fluid blood.

If a fissure of the temporal bone be combined with rupture of the tympanic membrane, cerebro-spinal fluid usually flows from the external auditory canal. This is, however, not always the case, as the fragments of the bone sometimes remain in such close contact as to prevent the escape of the fluid; or the same result may be due to the presence of blood-coagula between the fissures. The absence of cerebro-spinal fluid therefore does not at all justify the exclusion of fissure of the temporal bone under such circumstances.

Laceration of vessels with extravasation of blood, and interruptions of continuity in the more delicate structures of the labyrinth thereby occasioned, sometimes occur apart from external violence. To this category belong the vascular ruptures which sometimes occur in middle-ear inflammation, as well as similar conditions in the labyrinth demonstrated by *Moos* and *Steinbrügge*[1] in connection with pachymeningitis hæmorrhagica, and also the labyrinthine hæmorrhages which sometimes accompany embolism of the arteria audit. interna.

Blood extravasations into the labyrinth undergo the same metamorphoses as in other parts of the body. From this cause, originate the diverse forms of pigment frequently found in the semicircular canals,

[1] "Ueber die histologischen Veränderungen des Labyrinthes bei der hæmorrhagischen Pachymeningitis (Hæmatoma duræ matris)"—Zeitschrift für Ohrenheilkunde, ix. Bd.; und "Ueber acute Degeneration des Hörnerven im Gefolge einer mit Pyämie complicirten Pachymeningitis hæmorrhagica, sowie über gleichzeitig vorhandene Verstopfung der r. Art. aud. interna"—Zeitschrift für Ohrenheilkunde, xi. Bd.

in the saccule, and in the cochlea. It may be present, it is true, in situations where it produces no obvious symptoms; nevertheless large collections must be regarded as pathological. In certain cases, lesions of continuity with consequent blood extravasation are the cause of inflammation of the labyrinthine structures.

The *subjective symptoms* which follow upon an injury to the labyrinth are approximately the same as in concussion; but the so-called Menière's symptoms, which will be referred to later, occur less frequently in connection with the latter condition than with injury in this region. Derangement of hearing sometimes comes on only gradually, *pari passu* with the extravasation of blood.

The *objective appearances* vary in accordance with the nature of the lesion and with its complications. It is obvious that objective signs in connection with a simple injury of the labyrinth may be completely absent during life.

The *diagnosis* can in many cases only be made by way of exclusion; in others, however, the objective appearances leave no doubt as to the existence of a lesion.

The *prognosis* will be determined mainly by the nature of the injury, and that of possible complications of lesions of other important organs. It is unnecessary to refer to this matter in greater detail.

Treatment.—This must in general be conducted on the same lines as in concussion of the labyrinth. Complete rest is needful under all circumstances; and when obvious injuries of the temporal bone or of other structures are present, attention must be directed to them. For rupture of the drum-membrane; lesions of the soft structures of the auditory canal, with extravasation of blood; or hæmorrhage into the tympanic cavity, with or without laceration of the membrane, the measures must be adopted which were previously described in speaking of the affections of these regions. An endeavour should be made to alleviate indirectly the subjective symptoms as far as possible; and all procedures tending to produce shock to the ear or head—such as syringing, or the use of the air-douche—must be very sparingly employed. The application of electricity, though unfortunately too frequent, is obviously very unsuitable in these cases. With exudations, or extravasation of blood, absorbent remedies may be used both internally and externally.

4. Hyperæmia and Anæmia of the Structures of the Labyrinth.

A more or less severe hyperæmia of the labyrinth is a frequent symptom in connection with inflammation of the neighbouring structures. Such phenomena may, however, depend upon circulatory derangements, without any inflammatory affection of the ear; and in that case may arise

either from disorders of the circulatory system itself, or from morbid conditions of other structures. Tumours in the cervical region, for instance, especially strumous swellings or lymphomata, may occasion congestion of the vessels of the ear generally, and of the labyrinth in particular, by pressure upon the large veins. Again, vaso-motor irregularities within the cranial cavity, depending, according to *Woakes*, upon irritative states of the sympathetic nerve; affections of the spinal cord; and irritation of the nerv. trigeminus (*Baratoux*, *Kirchner*, *Berthold*), sometimes induce labyrinthine hyperæmia.

The same condition sometimes occurs in congestions of the head. The hyperæmia or anæmia of the labyrinth caused by the administration of certain drugs (quinine, salicylate of sodium, veratrin, nitrite of amyl) may likewise be referred to an angio-neurotic origin. Further may be mentioned the hyperæmia which sometimes appears in the course of severe febrile affections—such as typhoid, meningitis, cerebritis, or the acute exanthemata; and which disappears without further disturbance with the termination of the disease.

Anæmia of the labyrinth, on the other hand, may be produced after severe exhaustive diseases; in chlorosis; by certain derangements of the circulation; by embolism of the art. auditiva interna (*Friedreich*); aneurysm of the carotid or of the basilar artery; as well as in all affections in which the afferent vessels are compressed.

Morbid subjective symptoms may be produced both by hyperæmia and by anæmia of the labyrinth. Impairment of hearing occurs very seldom; but subjective auditory sensations are prominent; and occasionally periodical vertigo is also present. The *diagnosis* is generally very easy, as both hyperæmia and anæmia usually represent only secondary derangements; the primary disorder being either some constitutional disease, or an aural affection which can be recognised without difficulty. The *prognosis* will depend upon the nature of the primary trouble; and this likewise affords, as a rule, an indication for the *treatment*.

If upon examination there be found much congestion of the vessels of the tympanic membrane, as well as of those of the mucous membrane of the middle ear; or if the patient should be prone to marked congestion of the head, local bleeding may be employed by applying a few leeches beneath the mastoid process. With concomitant cerebral congestion in plethoric patients, cupping—dry or otherwise—may be performed on the nape of the neck and back. Derivatives also to the skin and intestinal canal are sometimes useful. In such cases, the author is in the habit of prescribing mustard foot baths two or three times a week in the evening before going to bed. Mustard leaves or blisters behind the ear and to the neck are sometimes also very serviceable. Regulation of the diet and of the mode of life are of much importance. The patient should avoid everything likely

to induce congestion of the head, especially long-continued mental work, and occupations which necessitate the head being much bent forwards. The symptoms may be sometimes much alleviated by the application of cold in the form of compresses to the head or round the ear, or by cold lotions and friction. In some instances, however, the subjective auditory sensations are increased by this treatment, when it must of course be relinquished. The cold shower to the head always exaggerates the subjective sensations according to the author's experience. Trial may be made, however, of a small stream directed by means of an irrigator for a few minutes upon the mastoid process, as this is occasionally beneficial.

Methodical rarefaction of the air in the external auditory canal is very serviceable in producing a momentary mitigation of the subjective auditory sensations; but it is very seldom that it brings about any permanent improvement. The measure is still a valuable one for procuring temporary relief from this annoyance.

In certain cases, a better result may be obtained by the use of evaporating lotions—*e.g.* sp. vini gallici 100 parts, sp. vini. rect. 100 parts, æth. sulph. 5 parts; half a teaspoonful of which may be applied on cotton-wool round the ear every hour or two. The author has also seen benefit from veratrin in the form of an ointment (veratrin 1 to 1½ parts, simple ointment 100 parts: a portion of the size of a pea to be rubbed two or three times a day behind the ear). The application of the constant current has been recommended in vaso-motor derangement, but the author cannot speak highly of its effects. Bromide of potassium and sodium are of more service, and should always be tried, especially in cases in which the noises in the head are so bad as to prevent sleep.

In anæmia of the labyrinth, the treatment should be ordered in accordance with the nature of the primary cause of the affection. For general impoverishment of the blood, residence in good air, with nourishing, easily digestible food, and a properly regulated mode of living often suffices for the removal of the symptoms. Advantage may likewise be obtained from the internal administration of iron, and especially from the ferruginous waters of Pyrmont, Franzensbad, Spa, Roncegno, or Levico. The use also of the baths of these places may materially reinforce the treatment.

5. Inflammation of the Structures of the Labyrinth (Otitis intima labyrinthitis).

Inflammation sometimes extends to the labyrinth from the adjoining structures, and this occurs most frequently from substantive diseases of the bone (caries and necrosis). More seldom, a purulent inflammation of the tympanic cavity and mastoid cells extends to the labyrinth; and of least

frequency—although they do occur—are those secondary inflammations of the labyrinth, of which the origin is to be sought in the cranial cavity.

The extension of an inflammatory process in the neighbouring structures to the labyrinth, and still further, may possibly be brought about in many instances by the migration of micro-organisms. *McBride* and *A. Bruce* found in the case of a patient with chronic suppurative inflammation of the middle ear, in which the tympanic membrane and auditory ossicles—even to the foot of the stapes—were destroyed, extreme infiltration with bacteria in sections made in the region of the semicircular canals. Masses of bacteria were observed both on the surface of the bone and between its lamellæ, as well as in the arterial walls and the spaces of the diploë : fewer in the cavities of the ear. The micro-organisms were likewise found in the sheath of the facial nerve, and between its fibrillæ. In the lobe of the cerebellum of the same side was an abscess as large as a walnut, which also contained bacteria.[1]

Little doubt any longer exists of the occurrence of primary inflammation of the labyrinth, to which attention was first directed by *Voltolini*.[2] Certain authors had from the beginning assented to his view, on the basis of their clinical experience ; but only recently has it met with general acceptance (*Roosa*,[3] *Reichel*,[4] *Keller*,[5] *Brunner*,[6] *Gruber*[7]).

Nevertheless, not all the cases referred to by *Voltolini*[8] in his writings are admitted to have been really examples of primary labyrinthitis ; and the author believes from the observations since published on this subject by *Gottstein*,[9] *Moos*,[10] *Lucæ*,[11] and others, that many would have been now differently interpreted even by *Voltolini* himself. The doctrine, however, remains indisputable, that labyrinthitis may make its appearance primarily, and that it is observed most frequently in children.[12]

There exist now, not merely carefully recorded reports, but also pathological facts, which remove all doubt that otitis intima occurs not only

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[1] "The pathology of a case of fatal ear-disease." Journ. of Anat. and Physiol., XIV.

[2] "Die acute Entzündung des häutigen Labyrinthes, gewöhnlich irrthümlich für Meningitis cerebro-spinalis gehalten." Monatsschrift für Ohrenheilkunde, i. Jahrg. "Die acute Entzündung des häutigen Labyrinthes, Otitis intima seu labyrinthica." Monatsschrift für Ohrenheilkunde, v. Jahrg.

[3] "Remarks on the etiology of congenital deaf-mutism, etc." Bulletin of the Academy of Medicine, New York, 1868.

[4] "Otitis acuta intima s. labyrinth., etc." Berliner klinische Wochenschrift, 1870.

[5] "Ein Beitrag zur Casuistik der acquirirten Taubstummheit." Berliner klinische Wochenschrift, 1881.

[6] "Zur Otitis labyrinthica infantum *Voltolini*." Correspondenzblatt für Schweizer Aerzte, 1883.

[7] Lehrbuch der Ohrenheilkunde. I. Aufl., S. 616.

[8] *Voltolini* reports that he observed 157 cases of this kind between 1853 and 1881.

[9] "Ueber den *Ménière*'schen Symptomencomplex." Zeitschrift für Ohrenheilkunde, ix. Bd. ; dann dessen Aufsatz, "Weitere Beiträge zur neuropathischen Form des *Menière*'schen Symptomencomplexes." Archiv für Ohrenheilkunde, xvii. Bd.

[10] "Ueber Meningitis cerebro-spinalis epidemica insbesondere über die nach derselben zurückbleibenden combinirten Gehörs- und Gleichgewichtsstörungen." Heidelberg, 1881.

[11] "Ueber Hæmorrhagie und Hæmorrhagische Entzündung des kindlichen Labyrinthes." *Virchow's* Archiv, lxxxviii. Bd.

[12] "The author does not think it necessary to discuss more closely the controversy on this subject. The reader who desires further acquaintance with it may be referred to the monograph of *Lorenz Eckert*, "Ueber die *Menière*'sche Krankheit." Basel, 1884.

in children, but also in adults. The results are conclusive, because the diagnosis has been confirmed by the post-mortem appearances, as is shown by the following case of *Schwartze's*,[1] which is here transcribed on account of the importance of the subject.

A woman aged thirty-two years, who had become affected with syphilis eleven months previously, and had undergone treatment by inunction and was very weak, complained for some weeks of headache over the right temple, restless sleep, a dull pressure in the ear, and some deafness. Severe pains in the ear, with vertigo and unsteady gait, then made their appearance. In the next few days, vomiting set in, and the noises and pain in the ear increased. The pupils were inactive. No fever was present. The right ear showed hyperæmia of the drum-membrane: hearing distance 15 *cm*. Tuning-fork placed on the vertex was heard towards the right side. There was no pain anywhere upon pressure. Paracentesis was performed, but no pus escaped. Four days later the temperature rose, with vomiting, increased headache, drowsiness, trismus, and slight delirium. The membrana tympani was seen to be slightly hyperæmic, but there was no perforation and no suppuration. Some days subsequently the patient was attacked with deep coma with paralysis of the bladder, and had a small rapid pulse and contracted pupils. Death occurred on the next day without convulsions or paralysis of the extremities. The post-mortem examination revealed infiltration of the pia mater with yellowish-green pus along the course of the large vessels and at the base of the brain. No pus was observed on the nerve trunks at the orifice of the internal auditory meatus. The petrous portion of the temporal bone was healthy externally. The mucous membrane of the right drum-membrane was thickened; the tympanum being normal. *The cochlea, vestibule, and semicircular canals contained sero-purulent fluid. The blood-vessels on the ampullæ were very distended and tortuous. The sacculus vestibuli was of a blood-red colour, and infiltrated with pus. Schwartze* considers that the affection of the labyrinth was not secondary, since the aural preceded the cerebral symptoms.

Cases of primary labyrinthitis have been also described by *Agnew* and *Webster*,[2] *Kipp*,[3] and others. *Agnew* and *Webster* regard the case reported by them as one of plastic exudation into the labyrinth.

Other conditions, however, are found post mortem, which prove that labyrinthitis may be of either primary or secondary origin.

Moos[4] found both labyrinths inflamed in a child three years of age, who had died of scarlatina with diphtheritis. A *small-celled purulent infiltration was present, particularly in the saccule, the semicircular canals, and the lamina spiralis membranacea*. In the case of a man who became deaf in the course of a twelvemonth, and died from pachymeningitis, the same author found in the membranous labyrinth, *pigmentary accumulations, besides hyperplasia with partial fatty and colloid degeneration consequent upon an inflammatory process.*[5]

In a man who had suffered from rheumatism, and became quite deaf with violent tinnitus from administration of salicylate of soda, *McBride*[6] found the whole

[1] "Fall von primärer acuter eiteriger Entzündung des Labyrinthes mit Ausgang in eiterige Meningitis." Archiv für Ohrenheilkunde, xiii. Bd.

[2] "Klinische Beiträge zur Ohrenheilkunde." Zeitschrift für Ohrenheilkunde, xi. Bd.

[3] "Klinische Berichte über Fälle von Erkrankungen der nervösen Gebilde des Gehörorgans." Zeitschrift für Ohrenheilkunde, xiii. Bd.

[4] Archiv für Augen- und Ohrenheilkunde, v. Bd.

[5] Zeitschrift für Ohrenheilkunde, viii. Bd.

[6] "Contributions to the pathology of the internal ear." Journ. of Anat. and Physiol., vol. iv.

perilymphatic space of the semicircular canals filled with a mass of tissue constituted of reticulated bundles of fibrillæ of varying thickness, with interspersed nuclei. The same elements, pointing to a previous inflammation, were also found on the outer side of the semicircular canals.

Very interesting also in this connection are the cases which have been recorded of a *periosteal formation of bone* in the labyrinth, owing its origin to a former inflammation. *Moos* and *Steinbrügge*[1] found in a patient who became deaf in his fourth year while symptoms of encephalitis were present, *newly formed osseous tissue proceeding from the periosteum of the zona ossea of the first coil—both in the direction of the vestibule and of the tympanum, which they explain as the product of a labyrinthitis.* In a boy who died in his thirteenth year, *Politzer*[2] found the *cochlear space and semicircular canals completely filled with newly formed osseous material, and the vestibule contracted.* The substance exhibited the characters of a periosteal bony formation, and originated in an aural affection accompanied by otorrhœa, from which recovery took place in two years and a half, during which time attacks of eclampsia frequently occurred, depriving the child of hearing and speech. *Kundrat, Burckhardt-Merian,*[3] and *Gradenigo*[4] observed perfectly similar conditions. The new formation of bone in *Prof. Kundrat's* case —his preparation of which may be seen in the pathological museum in Vienna—is considered by him to have arisen from a periosteal inflammation, said to have come on after an injury of the skull. *Gradenigo's* case was that of a deaf-mute, in whom nearly the entire labyrinth had become ossified.

In a deaf-mute girl, twelve years of age, who died from typhoid in the general hospital in Vienna, and according to her relatives, heard and spoke very well up to the end of her third year, but then lost both hearing and speech after an illness of some days' duration, the author found the following changes. In the right temporal bone, which was handed to him by the late *Prof. Rokitansky*, the tympanic membrane and the structures of the middle ear were normal, with the exception that the foot of the stapes appeared less movable in consequence of hypertrophy of the mucous membrane in the recess of the fenestra ovalis. The walls of the saccules and semicircular canals were of more than three times their normal thickness, so that they quite filled up the corresponding labyrinthine spaces. No trace of a perilymph could be made out in either the semicircular canals or vestibule. The ligamenta canaliculorum were imbedded in newly formed tissue which brought about a close adhesion of the membranous canals with the osseous wall, rendering their separation from the osseous semicircular canal very difficult. The saccules were also in intimate connection with the walls of the vestibule. The lumen appeared in section very narrowed, and filled with granular masses and numerous cells containing one or more nuclei which exhibited at many parts a peculiar light-yellow colour. Between the cells, pigment was deposited in granules and ramified masses of diverse tints. Much fat was also present in the form of flakes and crystals. A similar condition was found in the saccules. Neither in the walls of the semicircular canals nor in the saccules could their proper structure be recognised, nor was there a trace of the papillæ of the semicircular canals. The cristæ acusticæ were completely transformed into newly formed connective tissue, and nothing resembling an auditory epithelial cell or nerve fibre could be seen. The cochlear cavity still existed, but in the ductus cochlearis only rudiments of the organ of Corti could be distinguished, and at no part was even one of its normal elements visible.

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[1] "Histologische Veränderungen im Labyrinthe in einem Falle von Taubstummheit." Zeitschrift für Ohrenheilkunde, xii. Bd.

[2] Lehrbuch der Ohrenheilkunde, S. 808.

[3] Wiener allgemeine medicinische Zeitung, 1887.

[4] *Ibidem.*

The lamina basilaris also appeared thickened, as though covered by a thin granular layer, and upon its vestibular surface here and there were roundish cells, partly superimposed, partly in the substance of the membrane. Much pigment was present in the lamina spiralis ossea; and in the latter, the fibres of the auditory nerve could be clearly made out. Above and beyond these, towards the lamina spiralis membranacea, only delicate, isolated, radiating fibres were visible, which were mostly soon lost towards the periphery. The fasciculi of the auditory nerve exhibited no conspicuous alteration. The condition described cannot be otherwise explained than as resulting from an inflammatory process; and taken in conjunction with the absence of any such changes in the structures of the sound-conducting apparatus, must be regarded as dependent on a primary inflammation of the labyrinth.

It is comparatively recently only that any accurate acquaintance has been made with the *etiology* of primary labyrinthitis. There is no doubt that it may arise from taking a severe cold, or that it sometimes originates as it were metastatically in connection with various morbid constitutional conditions. It may also be induced by injuries of the organ. It would seem that different varieties of inflammation may occur in the labyrinth as in other regions of the ear. The author believes that on more accurate investigation of the pathological changes, his conjecture—based on clinical observation, and which he naturally submits here with the utmost reserve—will be found to correspond with the facts,—viz. that inflammation of the labyrinth may be either *exudative* or *plastic*: that in the former the products may be *serous*, *sero-sanguineous*, or *purulent*; while the latter brings about *hyperplasia of the structures*. In support of the occurrence of serous exudation, those cases may be cited in which from some known or unknown non-traumatic cause—mostly from a severe cold—an ear hitherto sound becomes either perfectly deaf, or much impaired in hearing capacity, with more or less marked subjective auditory phenomena, while, however, nothing is to be recognised which would justify the symptoms being referred either to an affection of the other aural structures or to some central nervous disorder, and the symptoms themselves completely disappear after some time. It is easily conceivable that a serous exudation might take place merely into the canals of the lamina spiralis ossea, compressing the nerve filaments to such an extent as to cause a temporary abrogation of their function, which might yet be re-established upon disappearance of the exudation.

The author has observed many such cases, and is inclined to explain them in the same way as *Bing* regarded the case described by him. The supposition that the trunk of the auditory nerve, rather than the small branches distributed to the labyrinth, is affected in this way does not, to the author, appear tenable. A compensatory adjustment of the pressure, on the one hand, seems more possible in the internal auditory meatus; while, on the other hand, it can scarcely be imagined that the nerve trunk could suffer compression to such a degree as to completely suspend the

hearing function, without any effect being produced in regard to other nerves. Such a condition might, however, easily exist in respect of the terminal filaments of the acusticus.

The author observed a striking case of this kind together with *Dr. Standthartner*. A lady, while travelling in the winter-time from Germany to Vienna, experienced on the journey a dull sensation in the left ear, which became totally deaf in the course of four-and-twenty hours. On the left, neither the watch nor speech could be distinguished, and a vibrating tuning-fork placed on the crown of the head was always heard on the right side. The pharynx was slightly catarrhal. The external and middle ear appeared quite normal, and no symptom existed which would point to an affection of the central nervous apparatus. The application of the air-douche was without result. The author gave a very doubtful prognosis, but had the satisfaction of finding that the hearing capacity underwent considerable improvement in the course of a fortnight under the employment of iodine ointment and gargle, and in four weeks more had become perfectly normal again. He needs scarcely say that he does not attribute the recovery entirely to the remedies used.

If such an exudation take place very rapidly and copiously, producing laceration of vessels with extravasation of blood and other breaches of continuity (sero-hæmorrhagic exudation), the derangement will be very great, and may be indeed irreparable.

In this category must be included, as the author believes, a disorder of the labyrinth, which he first observed and described as occurring in *syphilis*. In patients thus affected, who hear perfectly well, or are perhaps a little deaf as the result of a slight cold, there sometimes appears after taking cold, or without any demonstrable cause, an affection of the labyrinth which suddenly and permanently abolishes the hearing power, while the concomitant attacks of vertigo disappear after a certain time.

One of the author's patients—the nephew of an Austrian staff-surgeon—happened to succumb to typhus fever, after the aural affection from which he suffered had been present only a short time. On examination, besides considerable hyperæmia of the mucous membrane of the tympanum, there was seen great vascular injection of the soft structures of the labyrinth, which were also much thickened. The labyrinthine fluid was copious, and tinged with blood. Whether the condition was to be interpreted, as the author considers, as the effect of inflammation with hæmorrhagic exudation, must be left to further investigations. This view, however, is strongly supported by clinical experience.

Purulent inflammation may be brought about in the labyrinth traumatically, or through the migration of cocco-bacteria or other septic matters. The incurable deafness appearing in the course of parotitis (mumps), of the acute exanthemata, especially scarlet fever and diphtheria, and perhaps also in many cases of typhoid fever and small-pox, is probably to be referred to such a labyrinthitis.

Moos[1] found that in variola the membranous labyrinth was thickened and of a yellowish colour, with an abundant new connective-tissue formation, infiltrated with pus, between it and the osseous labyrinth. Numerous pus corpuscles were present in the saccules, semicircular canals, and ampullæ; as well as in the zona ossea and in the membrane of the cochlea.

Of great interest in this connection are the conditions observed by *Moos*[2] in the temporal bones of three children who died from simple diphtheria, and in which the middle ear exhibited merely catarrhal changes. They were similar to those found in the labyrinth by *Steinbrügge* in cases of epidemic cerebro-spinal meningitis. The membranous semicircular canals were in many places partially or entirely filled up with a substance consisting of coagulated lymph and a large number of cells with one or more nuclei. The mass exhibited concentric stratification, and more or less advanced development in the directions of connective tissue, bone, and blood-vessels; and was here and there adherent to the periosteum. The latter was partially disintegrated, partially hyperplastic, and the bone was atrophied. The blood-vessels were obviously congested, with rupture and extravasation of blood; producing thus, breaches of continuity in the course of the auditory nerve. The osseous substance appeared to be inflamed, and the medulla disintegrated, with cell infiltration of the Haversian canals. *Chains of micrococci* were everywhere found in the cancelli of the petrous portion of the temporal bone and in the aquæductus vestibuli; while in the endo- and perilymphatic spaces of the semicircular canals they were only occasionally present, and could not be seen at all in the vestibule or cochlea. *Moos* regards these cocci as only accidental in diphtheria, but yet believes them capable of inducing serious affections of the labyrinth. They might gain access to its structures through the blood-vessels, or by way of the subarachnoid space, which, according to *Schwalbe*, *A. Key*, and *Retzius*, is in connection with the deep cervical lymphatics, with the subarachnoid space at the roots of the cranial nerves,—in particular the acusticus,—as well as with the lymphatics of the nasal mucous membrane. Into the endolymphatic space, the micro-organisms might enter from the dura mater, by way of the fine passages demonstrated by *Rüdinger* as present in the fibro-periosteal connective-tissue lining the aquæductus vestibuli, and communicating in this way with it.

The examination by *Moos*[3] of six temporal bones from individuals who had died from typhoid fever, teaches that in this disease the labyrinth on both sides is very frequently affected. The saccule, utricle, ampullæ, and lamina spiralis membranacea were implicated in all cases; the semicircular canals and zona ossea only exceptionally. Histologically the condition consisted in a small-celled and lymphoid cell infiltration.

McBride describes as croupous inflammation of the cochlea, a condition which he found in the case of a patient with a round-celled sarcoma proceeding from the cerebellum and the petrous portion of the temporal bone, and sending a process to the bottom of the external auditory canal. In the scala vestibuli, on Reissner's membrane in certain places, and in the modiolus, was found a yellowish substance composed of delicate straight transparent fibrillæ interwoven with one another in all directions, and enclosing between their meshes, leucocytes with granular contents and occasional vacuoles. In the scala tympani, a different-looking granular material was seen on the periosteum. The latter structure was much thickened in both scalæ, and infiltrated with leucocytes and fibrin. Numerous dilated vessels existed both in the periosteum and the lig. spirale.[4]

[1] Archiv für Augen- und Ohrenheilkunde, v. 221.

[2] "Untersuchungen über Pilzinvasion des Labyrinthes und der Felsenbeinpyramide im Gefolge von einfacher Diphtherie." Zeitschrift für Ohrenheilkunde, xvii. Bd.

[3] Archiv für Augen- und Ohrenheilkunde, v. Bd.

[4] "Contributions to the Pathology of the Internal Ear," Journ. of Anat. and Physiol., vol. iv.

Primary labyrinthitis is almost always bilateral, and is of simultaneous occurrence in both ears. As a secondary affection, it is more common on one side only. It can scarcely be doubted that it occasionally runs a chronic course.

The *subjective symptoms* which attend the onset and course of primary inflammation of the internal ear may be very diverse. Sometimes it commences with very violent febrile symptoms, the temperature reaching to over 104° F.; while in other instances, no fever exists throughout the affection. In the former case, it usually comes on with a rigor; rarely continues beyond the fifth day; and generally ceases by the third or fourth day with more or less abundant sweating. Vomiting occurs at the beginning in the majority of instances. Children generally complain of pain in the head, and usually lose consciousness for a time; on which account the disease may be mistaken for meningitis. At the first, patients occasionally complain of slight pain in the ears, or manifest their discomfort by taking hold of them. The pain very rarely increases in the further course of the disease. At an early stage, the hearing is usually still quite good, but distressing subjective auditory phenomena may be present. The latter symptom being often observed in other febrile disorders, no great importance is apt to be attached to it; and in this way it comes about that the aural affection is always overlooked at the commencement, and is not recognised until it obtrudes itself upon one's notice by the occurrence of total deafness or great impairment of hearing, and this usually happens in two or three days. In cases in which unconsciousness has supervened, the deafness of course only becomes obvious when consciousness returns. In course of time, however, it is observed that the power of co-ordinated movement is deranged; the patient being unable to maintain himself erect without support, and still less able to walk alone. This condition, however, improves from day to day, and mostly passes away in about six weeks; but the loss of hearing in cases attended by acute febrile phenomena either does not disappear at all, or does so only to an insignificant extent. Whether the severe symptoms just mentioned are associated, as the author imagines, with a purulent labyrinthitis, whilst other varieties run their course without fever, are questions which can only be decided by the results of post-mortem examinations. Still, instances do occur in which no fever is present, but which are nevertheless followed by complete abolition of the hearing faculty, and in these it would appear that the deafness may have arisen without any previous objective changes in the labyrinth. Such cases may possibly be referred to extravasation of blood into the structures (morbus Menière); though even in these it is probable that morbid changes precede the onset of the deafness, but pass unnoticed. In certain cases observed by the author in children, giddiness was complained of some days before the appearance of the

severer symptoms, and was probably due to the preceding hyperæmia of the labyrinth.

The *objective appearances* in secondary labyrinthitis will vary considerably in the structures accessible to examination in accordance with the changes connected with the primary disturbance. In primary affections of the labyrinth, objective examination naturally yields very little result. With the exception of a greater injection of the vessels of the malleus, and the depression of the tympanic membrane which is frequently observed, and brought about possibly by the spastic contraction of the tensor tympani muscle occurring in affections of this kind, scarcely a sign is to be found which would indicate the existence of a pathological process in the ear.

Since the symptoms above described occur in conjunction with other labyrinthine affections, as well as in diseases of the central nervous system, the *diagnosis* of labyrinthitis is often a matter of much difficulty. The course of the disease, its complication with other maladies, and the presence or absence of subjective symptoms which cannot be explained solely by the supposed aural affection, always furnish evidence upon which an inference may be based, either with certainty or with probability, as to the presence of an inflammatory process in the labyrinth.

The *prognosis* is not always *absolutely* unfavourable in a unilateral labyrinthitis unassociated with fever, especially in an otherwise healthy individual. The issue cannot be predicted with certainty. The author has, however, never been able to verify any marked improvement in patients in whom the affection made its appearance with fever, nor in such as had a syphilitic history, nor in cases of mumps, nor in cases in which complete deafness became rapidly established. In very rare instances, such patients may regain their hearing power in a slight degree, with or without treatment; but never to such an extent as to permit of conversation, even when conducted in a loud tone; nor such as to allow children who had not spoken before the occurrence of the malady to learn to speak in the usual manner by audition afterwards. On the contrary, children who have been previously able to speak, but not write and read, generally lose this faculty in a short time, and become deaf and dumb.

The *treatment* should have regard, not only to the aural affection, but likewise to any other possible local or general derangement. If there is a suspicion of a primary febrile inflammation of the labyrinth, strictly antiphlogistic measures are to be adopted. In robust children, depletion of the deeper vessels may be aimed at by the application of a few leeches below both mastoid processes, and antipyrin or antifebrin may be administered. With marked congestion of the head, especially if constipation be present, calomel or other purgatives may be given. Should the fever run very high, sponging the body with vinegar and water, and cold compresses to the head will be indicated. By these means one may perhaps succeed in

limiting to some extent the labyrinthine exudation ; and if this has already occurred and total deafness has set in, an attempt may be made to promote absorption by the use of suitable ointments (iodine or mercurial), and by the internal exhibition of similar remedies, as well as by the employment of baths containing iodine : *e.g.* Hall in Upper Austria, Lippik in Slavonia, Ivonicz in Galicia, Kreuznach, Elmen, or Krankenheil. The benefit derived from them is, however, not very considerable. With children who are not fit subjects for iodine, brine baths may be used (Ischl, Gmunden, Aussee, Hallein, Reichenhall, Salzungen). In syphilitic cases, a specific treatment must of course be carried out ; and, speaking generally, attention must be directed to any possible constitutional affection, as well as to other morbid changes which may be met with in the ear or in other organs.

Politzer[1] recommends, especially in syphilitic cases, the subcutaneous injection into the forearm of a 2 per cent. solution of pilocarpin. Two to six drops are injected daily, and gradually increased. If disagreeable consequences arise, such as nausea, fainting, or giddiness, two drops of a $\frac{1}{3}$ per cent. solution of sulphate of atropine should be employed to counteract them. This treatment is said to frequently bring about a surprising improvement in the hearing in syphilis of the labyrinth, as well as in other labyrinthine affections which are not of too long standing. It is, however, useless in hereditary syphilis, in the deafness following epidemic cerebro-spinal meningitis, and in middle-ear catarrh complicated with labyrinthine derangement.

Barr[2] states that he has gained much benefit from pilocarpin injections in a patient who had had syphilis for six months, and in whom the hearing which had been hitherto normal was suddenly lost during an attack of Menière's symptoms. In another case, considerable improvement was obtained in a non-syphilitic patient who had suddenly become very deaf fourteen days previously.

Moos[3] considers pilocarpin efficacious in labyrinthitis associated with scarlatinal diphtheria. Up to the present time, the author has unfortunately no similar results to record.

The efforts of the parents and friends of a child who has become deaf in this way—it having previously heard and spoken—should be strenuously directed towards preventing it from forgetting how to speak. Children who have not yet learnt to read, forget speech extremely quickly ; and it may be best preserved by occupying them a great deal, and causing

[1] "Zur Therapie der Labyrinthaffectionen." Wiener medicinische Blätter., 1885.

[2] "Zwei Fälle von plötzlich eingetretenem hochgradigen Hörverlust beiderseits, in Folge nervöser Ohraffectionen; beträchtliche Besserung durch hypodermatische Pilocarpin-Injection." Monatsschrift für Ohrenheilkunde, xix. Jahrg.

[3] "Ein Fall von doppelseitiger Labyrinthaffection in Folge von Scharlach, günstig beeinflusst durch Pilocarpin-Injectionen." Zeitschrift für Ohrenheilkunde, xiii. Bd.

them to speak as much as possible. It is advisable to show them different objects, and make them name them aloud. Those who can already read, should be encouraged to read aloud, and pronounce the words carefully. Not hearing themselves speak, they easily fall into the habit of pronouncing badly, so as to become later quite unintelligible. The child's attention should therefore always be called to these mistakes, and he should be induced to rectify them. The task is certainly a troublesome one, but is in the end well rewarded by the result.

6. Menière's Disease (Morbus Menière).

In an essay[1] which appeared in 1861, *Menière* adverted to a series of phenomena, until then always connected with affections of the central nervous apparatus, but which he observed in patients in whom such affections could be completely excluded. Upon the basis of the familiar experiment of *Flourens* (p. 116), *Menière* found himself constrained to associate these symptoms with certain changes in the labyrinth, especially in the semicircular canals.

The combination of symptoms referred to is constituted by:—subjective auditory sensations of various kind and duration, a feeling of alarm, uncertain gait, giddiness which may become so severe as to cause the patient to fall down, momentary loss of consciousness, a tendency to nausea, or actual vomiting, and impairment of hearing up to total deafness after one or more seizures.

In the case of a girl who became suddenly deaf after taking cold, and was simultaneously attacked with vertigo, and with vomiting on the slightest movement, death ensued on the fifth day of the disease. On post-mortem examination, the brain and spinal cord were found to be normal. In the semicircular canals, however, was a reddish-coloured exudation—an appearance which not a little supported Menière's view as to the nature of the disease.

He had already expressed the opinion that it is not necessarily always primary changes in the semicircular canals which are responsible for the symptoms in question; but that pathological processes in the middle ear —so far as they are capable of injurious influence upon the labyrinth— may likewise evoke phenomena of this order. Nevertheless he always regarded the semicircular canals as the structures playing the principal part in the disorder. The theory that in these organs only is the origin of the affection to be sought may be the more easily impugned, since *Magendie*[2] and *Cuvier*[3] had both previously shown that the same results

[1] "Mémoire sur les lésions de l'oreille interne donnant lieu à des symptomes de congestion cérébrale apoplectiforme." Gazette médicale de Paris, 1861.

[2] Journ. de phys. expériment., iv.

[3] Rapport fait à l'Academie des Sciences, 1828.

which *Flourens* observed after section of the semicircular canals, may be induced by division of the transverse fibres of the pons Varolii, or of the fibres running from the cerebellum to the corpora quadrigemina, or lastly of those passing from the cerebellum to the spinal cord. In this way it came about that *Hillairet*,[1] a year after the publication of Menière's work, put forward the hypothesis that the peculiar phenomena there described might sometimes originate in pathological changes having their seat in the places of origin of the auditory nerve.

Clinical observation, no less than experiments upon animals, has proved that *Hillairet's* view may be correct; and at the present time all aurists are agreed that Menière's symptoms do not always arise in the labyrinth, though this may be so in the majority of cases.

This is by no means equivalent to saying that the semicircular canals constitute "the organ of equilibrium"; and still less that the maintenance of equilibrium is entrusted to them alone. Notwithstanding the zealous investigations and the accumulated literature on this subject during the last twenty years, the question is still far from being decided. Most physiologists, including *Goltz*,[2] *Mach*,[3] and *Breuer*,[4] as well as a large number of aural surgeons, are inclined to consider the semicircular canals with their ampullæ as the organs which directly bring about the perception of movement in the head, and through this in the whole body. Others are, on the other hand, opposed to this view, and would refer the cause of the uncontrollable movements of the animals, not to lesion of the semicircular canals, but to simultaneous injury to the brain, or to the consequences indirectly incurred by this organ from the operation. Competent observers, indeed (*Tomascewicz*,[5] *Kiesselbach*[6]), look upon the uncontrollable movements of the animal as voluntarily preservative, and movements of flight, which it performs in response to the occurrence of sudden and intense subjective auditory sensations. *Baginsky*,[7] who conducted his experiments under the direction of *Munk*, asserts that the semicircular canals have no part in maintaining the equilibrium; and that the entire labyrinth of a dog may be destroyed without the appearance of a trace of any disturbance of this nature.

On the occasion of a communication made by *Goltz* at the meeting of the Society of German Naturalists and Physicians at Innsbruck in 1869, the author expressed himself on this subject to the effect that according to

[1] "Lésions de l'oreille interne; action réflexe sur le cervelet et les pédoncules." Comptes rendues et mémoires de la Société de Biologie, 1862.

[2] *Pflüger's* Archiv, iii.

[3] Sitzungsbericht der k. k. Akademie der Wissenschaften, 1870.

[4] Wiener medicinische Jahrbücher, 1874 und 1875.

[5] "Beiträge zur Physiologie des Ohrlabyrinthes." Inaug.-Diss., Zürich, 1877.

[6] "Zur Function der halbcirkelförmigen Canäle." Archiv für Ohrenheilkunde, xviii. Bd.

[7] "Ueber die Folgen der Drucksteigerung in der Paukenhöhle und die Function de Bogengänge." Archiv für Physiologie 1881.

his experience he was unable to see in the semicircular canals the exclusive organ of the sense of space; and was induced to believe that they were concerned rather in a participation of the hearing function; whether this may be in an appreciation of the direction of sounds, or possibly in some other relationship to the auditory faculty. As the principal ground for this opinion, he cited cases in which he had observed no trace of vertigo or involuntary movement in the course of affections lasting a considerable time, although it was found after death that the semicircular canals either exhibited changes to a greater or less extent, or were quite destroyed. In deaf-mutes too, in whom, as is well known, these organs are frequently absent or defective, no such disturbances are noticeable. Up to the present time no refutation of these views has appeared. There can moreover be no doubt that in the enormous number of cases of acute inflammation of the middle ear in which a greatly increased labyrinthine pressure can be diagnosed with certainty, the semicircular canals must labour under the same oppression; and yet how rarely are the so-called Menière's symptoms observed in comparison with the great number of such cases. It has been supposed, in opposition to the facts, that derangements of equilibrium cannot originate in the labyrinth. According to the author's opinion, however, they are only evoked by it in virtue of its relations with the central nervous system; and upon slighter or stronger irritation, in accordance as it were with the individual peculiarities of construction of the auditory organ and its adnexæ.

On this hypothesis, therefore, the symptoms in question would not necessarily proceed only from disorders of the semicircular canals, but might also arise in other labyrinthine structures: for example, in the saccule.

The author cannot help thinking that the aqueducts of the labyrinth, in spite of their diminutive size, play a part similar to that conjectured by *Weber-Liel*[1] in regard to the aquæductus cochleæ, under conditions in which phenomena of augmented intra-labyrinthine pressure are present. Although too the experiment of *Högyes*[2] affords evidence that manifestations of this kind are not educed by injections through the foramen occipitale, nor by aspiration of the subarachnoid fluid through a tube introduced into the cranium, the author desires nevertheless to lay stress upon the movements of the fluid in the aqueducts.

Lucæ's observation[3] appears to the author of much importance: viz., that, notwithstanding the slight mobility of the membranes closing the fenestræ, these symptoms may possibly be the more readily produced by

[1] "Notizen über die Frage über die Entstehung des Gehörschwindels, etc." Monatsschrift für Ohrenheilkunde, xvi. Jahrg.

[2] "Ueber die wahren Uhrsachen der Schwindelerscheinungen bei Drucksteigerung im Labyrinthe." *Pflüger's* Archiv, xxvi. Bd.

[3] "Ueber optischen Schwindel bei Druckerhöhung im Ohre." Archiv für Ohrenheilkunde, xvii. Bd.

the waves of fluid which are propagated from the labyrinth through the aquæductus cochleæ towards the cranial cavity, inasmuch as they would impinge upon both auditory nerves, the nervus abducens, and the neighbouring respiratory centre. Still more worthy of consideration are the relations of the *ductus endolymphaticus and its central termination, the recessus Cotugnii.* The author is inclined to believe that a greater significance attaches to this than to the aquæductus cochleæ, and that in the remarkable individual peculiarities of the *recessus Cotugnii,* a foundation may be sought for the severe subjective auditory symptoms with vertigo, etc., which are provoked in many persons upon even a slight increase in the intra-labyrinthine pressure; whilst in others, the latter may become greatly augmented without the evolution of any such phenomena. The most noteworthy fact would appear to be the variability in size of the *recessus*, with a permeable aquæductus vestibuli. If a considerable number of temporal bones of individuals of different ages be examined, it will be found that its width varies so extraordinarily that sometimes it can scarcely be recognised, while in other cases it may be as large as a small hazel-nut. Now it is certain that an exaggerated intra-labyrinthine pressure first of all takes effect upon the perilymph, and is then transmitted through the aquæductus cochleæ to the subarachnoid space, thereby inducing the results under discussion, if the action take place with sufficient rapidity. The pressure may always be moderated to a certain degree, since the direction in which the aquæductus cochleæ opens into the subarachnoid space is not the most effective one. It is, however, quite otherwise with the aquæductus vestibuli; for if the pressure on the saccule become excessive, the endolymph can give way directly through this channel towards the cranial cavity, and if the *recessus Cotugnii* be largely developed, it will become distended to a corresponding extent, and thus exercise a more considerable pressure upon the centre of statical equilibrium, the cerebellum; evoking symptoms of vertigo, etc. If the *recessus Cotugnii* be, on the other hand, but slightly developed, the phenomena in question may then be quite absent. It should likewise not be forgotten that the pressure brought to bear by the perilymph through the aquæductus cochleæ upon the extended area of the subarachnoid space, is proportionately greatly lessened in its effect—a condition which does not exist in respect of the closed *recessus Cotugnii.*

It is well established that such symptoms may originate in different organs. That they arise more readily on irritation of the semicircular canals, does not therefore prove these to be "the organs of sense for the equilibration of the head, and indirectly of the whole body."

James[1] made some experiments in reference to the production of vertigo in

[1] "On the occurrence of vertigo in deaf-mutes." Amer. Journ. of Otol., vol. iv.

deaf-mutes and ordinary individuals, when the head was turned very rapidly in different directions with the eyes closed. Of 519 deaf-mutes, 186 had no vertigo whatever; 134 only in a slight degree; and 199 became giddy in the usual way. Of 200 perfectly healthy persons, on the other hand, vertigo failed to appear in one case only. In the opinion of the author, these results are of little value in determining the function of the semicircular canals; for, in the first place, it is admittedly not proven that these structures were wanting in the deaf-mutes; and, even if it were so, it would at most be shown that individuals without these organs are less subject to vertigo than others normally provided with them. This can in any case scarcely be doubted; but the contention that the semicircular canals alone maintain the equilibrium of the body is not thereby advanced. That deaf-mutes become much more restless when they are under water than other people, is easily explained, since under such circumstances they are deprived of the advantage of a preponderating activity of that sense—viz. sight—which they habitually exercise as compensatory to their infirmity. The same holds good of those persons who have become deaf.

With respect to the phenomena themselves, their intensity varies with different patients. Sometimes they are preceded for a longer or shorter period by premonitory symptoms, such as giddiness or even pain in the head, a feeling of uneasiness, and loss of appetite—particularly when the case is a severe one. Patients in whom the disorder recurs in paroxysms usually become very anxious on the appearance of such prodromata.

The symptoms may arise in all positions of the head. The author has observed several cases in which the first attack occurred during the night, the patient being awakened out of his sleep by the ailment after going to bed quite well. In other instances, the seizure was introduced by a dream having reference to it, in which perhaps he seemed to have fallen down a pit, or in which everything appeared to be going round him; whereupon, on waking up, he was troubled with the subjective auditory sensations, vertigo, etc. The author has repeatedly been told by patients who had previously suffered from slight attacks of vertigo, that in their dream they have seen objects in movement, trees shaken by a storm, stars revolving in a circle, and so forth; when, as they suddenly awoke, violent sensations of vertigo, with vomiting, set in. Many, though lying in bed, always felt as if sinking into the ground, and then rising again. In some persons, a fit of giddiness comes on if they close their eyes, or look in a certain direction, or turn their head. The author has noticed that in most of his patients the paroxysms came on with giddiness, and either without any obvious cause or on some accurately described incident, such as bending the head forwards or backwards. The giddiness continued until they vomited, which generally happened in a few minutes, or less frequently after some hours. One attack only may occur, or it may be repeated after a longer or shorter period. Some patients will complain of feeling more giddy in the dark; others on gazing at shining objects or a bright light,

or on looking at a moving body. In some few instances, the first violent symptoms continue for months, either constantly or with but very short remissions; so that the recumbent position has to be continually maintained to avoid the risk of falling.

It has also seemed to the author that certain individuals at once experienced an attack of vertigo on thinking about their disorder, but were better if they forgot it. The symptoms are in many intensified and accompanied by vomiting when they eat or drink anything, or sometimes on closing the eyes; so that they make strenuous efforts to keep them open, and only fall asleep when quite wearied out.

Moos[1] repeatedly observed visual derangements in this affection—viz. obscuration and limitation of the field of vision, transient hemiopia with a horizontal boundary line and persistent muscæ volitantes, and dilatation of the pupil on both sides.

In some cases, nystagmus was observed during the paroxysm, but disappeared when it passed away. This symptom recalls the doctrine of *Högves*, according to which a certain connection exists between the nerves of the ampullæ and the muscles of the eyes. The symptoms already described may, moreover, be associated with others. In a girl ten years of age, suffering from purulent inflammation of the middle ear, the author observed violent attacks of vertigo, lasting for weeks. During the whole time, convulsive movements were present in the left upper extermity, which only ceased a few days before the vertigo. *Guye* noted an indistinctness in the handwriting of a patient with Menière's symptoms. The writing improved as the symptoms passed away.

Högyes[2] believes that the fits of vertigo which occur with augmented pressure in the tympanic cavity are referable solely to irritation of the vestibular terminations of the auditory nerve. He contends he has demonstrated that a peculiar bilateral reflex connection exists between the muscles of the eye and the ampullary nerves, in conformity with which a reflex stimulus is transmitted by each labyrinth to certain muscles; from the left vestibular nerve to those turning the left eye upwards and outwards, and rotating it inwards; and to those which turn the right eye downwards and inwards, and rotate it outwards: the right vestibular nerve, on the other hand, influencing the muscles which turn the right eye upwards and outwards, and rotate it inwards; as well as those turning the left eye downwards and inwards, and rotating it outwards. On this theory, the membranous ampullæ would have to be regarded, in their relation to the eye-muscles, as the peripheral end-organs of a bilaterally arranged nerve-system by which the movements of the eyeballs are associated or co-ordinated; and as in this way regulating the bilateral movements of the eye which accompany alterations in the position of the head and body, in correspondence with changes of position in the labyrinth. The centre for this nerve arrangement is stated by *Högyes* to be in the mesocephalon and in the medulla

[1] Archiv für Augen- und Ohrenheilkunde, vii. Bd.

[2] "Ueber die wahren Ursachen der Schwindelerscheinungen bei der Drucksteigerung in der Paukenhöhle. Vorläufige Bemerkung zur Physiologie und Pathologie der Bogengänge." *Pflüger's* Archiv für Physiologie, xxvi. Bd.

oblongata, between the highest portion of the auditory nerve and the nucleus of origin of the motor oculi; the centrifugal tract being formed by the oculo-motor fibres to the muscles of the eye, the centripetal by the vestibular branches of the auditory nerves to the ampullæ and the cristæ acusticæ.

Similar phenomena may originate in other parts of the auditory organ. *Pflüger*[1] observed smart sensations of giddiness and numbness in the head in a woman sixty-five years of age, who had an otorrhœa on the left side, with perforation of the membrana tympani, and a polypus attached by a broad base to the posterior-superior wall of the auditory canal. On touching this region with a probe, vertigo came on, and became very severe, accompanied by simultaneous horizontal oscillatory movements in both eyeballs upon tightening up the loop of a Wilde's snare round the growth. The same symptoms recurred with later attempts to remove the polypus, which took its origin partly from the tympanic cavity. *Pflüger* regards them as brought about by the propagation of the irritation to the brain.

For the better comprehension of the symptoms as a whole it will be well to recall the very appropriate utterance of *Exner*, that "in the brain everything is connected with everything else." *Woakes* is of opinion that the attacks not unfrequently follow upon an incidental irritation of the stomach. According to him, by the mediation of the inferior cervical ganglion, which sends vaso-motor fibres to the vertebral artery, and is also connected with the branches of the vagus to the stomach and heart, a correlation is established between the latter organs and the ear. Any considerable gastric disturbance occurring in an individual already the subject of intra-labyrinthine irritation, would on this hypothesis be conveyed to the inferior cervical ganglion; thence to the arteria auditiva interna—the terminal branch of the vertebral—and would find its expression in vertigo, tinnitus, and nausea, caused by the fluctuations of the blood pressure thereby produced in the labyrinth.

If the symptoms described be more closely considered, they prove to be not only such as we have previously become acquainted with in diverse aural diseases, but also as occurring in various affections of the brain and spinal cord. There can therefore be little doubt that but a small number of the cases which have been reported as examples of Menière's disease, had as their foundation the objective changes in the labyrinth to which *Menière* referred in his first communication, and which are generally denoted as *apoplectiform*, on account of the rapidity of their onset, and on the supposition that hæmorrhagic extravasation took place in them. It may be that in certain instances, extreme hyperæmia of the labyrinth, particularly with disease of the blood-vessels, may lead to such extravasations, and bring about the symptoms mentioned; nevertheless such cases must certainly be of very rare occurrence in comparison with the frequency of the phenomena in question. We shall, however, be quite justified in continuing to speak of *Menière's symptoms* as appearing in various kinds of labyrinthine disease, as well as in other affections, both of the organ of hearing and of the central nervous system; and in regarding—like *Guye*[2] and *Brunner*[3]—the sensation of vertigo as the

[1] Deutsche Zeitschrift für pract. Medicin., 1878.
[2] Report of the International Medical Congress in Amsterdam, 1879.
[3] "Zum Morbus Menière." Zeitschrift für Ohrenheilkunde, xvii. Bd.

characteristic symptom of the disorder. The designation *Menière's disease* must either be quite dropped, or it must be limited to those cases in which actual hæmorrhage is supposed to have taken place. The diagnosis of such a condition may in certain cases be made by way of exclusion, if the data referred to in the account of the different derangements of the labyrinth be weighed with proper care.

The duration of Menière's symptoms depends chiefly upon their fundamental cause. In some cases—for example, with incurable bone affections, or brain disease—the manifestations may continue up to the death of the patient. These, however, are exceedingly rare. Generally, the symptoms do not last more than a couple of days, and very seldom longer than from three to four months. Even when arising from disease of the labyrinth, the giddiness and vomiting usually cease in the course of a few days, though the subjective auditory sensations and deafness are apt to persist. In certain instances, the phenomena at first constant, then appear in paroxysms, to diminish in severity at a later period, and finally disappear. Cases have occurred, however, in which the giddiness has remained, with occasional intermission, for years. The prognosis will likewise be affected by the above-mentioned consideration.

In the *treatment* of Menière's symptoms, the nature of their primary cause will first demand attention, and subsidiarily those remedies should be employed which have been shown by experience to procure an alleviation of the troublesome sensations. In regard to the former indication, the means must be adopted which have been already alluded to in the description of the different aural affections. Of the empirical remedies reputed to be of most service, quinine stands first, and is to be given, according to *Charcot*, in quantities of from seven to fifteen grains a day. The giddiness is sometimes diminished by it, but the effect is not usually lasting. If, after it has been taken for three days, no improvement be perceptible, its administration should be suspended, as otherwise a permanent aggravation of the disorder may perhaps ensue. In a vigorous woman who had for several years suffered from chronic middle-ear catarrh, and experienced a severe attack of Menière's symptoms, quinine in large doses (fifteen grains daily) was prescribed by her medical attendant. After it had been taken for three days, acute gluncoma became developed, rendering an iridectomy necessary, which was performed by *Von Arlt*. The Menière's symptoms were not relieved by the quinine. The case shows how much care is needed in the employment of this remedy; especially if the diagnosis of the fundamental cause of the malady be not quite certain.

Brunner calls attention to the contradiction existing between the statements of aural and ophthalmic surgeons concerning the effects of quinine. According to

Kirchner[1] and *Roosa*,[2] large doses produce hyperæmia and extravasation of blood; while ophthalmologists state that it causes marked anæmia of all the retinal vessels. It must, however, be noted that in the experiments made by *Guder* under *Weber-Liel's*[3] supervision, the temperature in the external auditory canal diminished after its employment; and hyperæmia of the canal or of the vessels of the malleus was never observed. Similar results were obtained with salicylate of soda. The mitigation of the auditory vertigo following upon the administration of large doses of quinine would in this way be explained by ischæmia of the labyrinthine vessels.

When Menière's symptoms arise in syphilitic subjects, anti-syphilitic treatment is indicated; preferably by the internal use of "Zittmann's decoction," which generally relieves the vertigo in a very short time. The injection of a solution of iodide of potassium through the Eustachian tube has often rendered good service to the author; and the effect may be aided by the inunction of iodine ointment over the mastoid region. Methodical rarefaction of the air in the external auditory canal is attended with excellent results, especially if the symptoms depend upon morbid processes in the middle ear. The author has also obtained much benefit from the internal use of arnica, which he prescribes alone or with nux vomica; continuing the treatment for some weeks after the disappearance of the symptoms (tinct. arnicæ mont., 10 parts; tinct. nucis vom., 1 part: 6 drops on sugar twice a day, increasing the dose by 1 drop every five days till it reaches 10 drops).

In women at the climacteric period, in whom, according to *Menière fils*,[4] and as the author can confirm, the symptoms in question are easily induced, local bleeding by the application of a few leeches near the mastoid process is serviceable, and may be combined with the employment of derivatives to the skin and intestines. The latter mode of treatment is likewise indicated whenever considerable congestion of the head is perceptible. With long-standing cases, cold frictions may be tried; but the cold douche, as well as all measures causing commotion to the head, should be strictly avoided. *Gowers*[5] recommends colchicum and potash in gouty individuals, and bromide of potassium or ammonium when excessive irritability is present. Massage of the limbs should always be carried out with patients who are compelled to keep their bed for a prolonged period, as the nutrition of the muscles thereby suffers, and when the disorder has passed away the walking power is apt to be much impaired. The application of electricity may readily aggravate the vertigo. It should therefore

[1] "Extravasate im Labyrinthe durch Chinin- und Salicylwirkung." Monatsschrift für Ohrenheilkunde, etc., xvii. Bd.

[2] Amer. Journ. of the Med. Sciences, 1874.

[3] "Zur Frage der Einwirkungsweise von Chinin- und Salicylsäurepräparaten auf das menschliche Gehörorgan." Monatsschrift für Ohrenheilkunde, xvi. Jahrg.

[4] "De l'influence de la ménopause sur les maladies de l'oreille." Annales des maladies de l'oreille, 1885.

[5] The diagnosis and treatment of auditory nerve vertigo." London, 1877.

only be employed tentatively, and with very weak currents, in cases in which the symptoms have persisted for a long time, and all other measures have proved ineffectual.

7. Neoplasms of the Labyrinth.

New growths may arise in this region both primarily and secondarily. Among the first kind are found new connective-tissue formations as threads and membranes, which may bring about irregular adhesions in the vestibule or the semicircular canals. Fibromata, too, of very large size are sometimes developed in the sheath of the auditory nerve.

The occurrence of primary malignant growths in the labyrinth seems to be not yet fully established. Of the neoplasms which, originating in other aural structures or within the cranium, may in their further growth invade the internal ear, are to be enumerated: sarcoma, cholesteatoma, and epithelial carcinoma. The author has had under his observation a considerable number of cases of this kind, of some of which he also possesses preparations. Similar ones are likewise described by *Patterson Cassells*,[1] *E. Fraenkel*,[2] *Stevens*,[3] *Burckhardt-Merian*,[4] *Förster*,[5] *Voltolini*,[6] and others. In the cases of the four last-named authors, the new formation proceeded from the structures of the cranial cavity, and proliferated through the internal auditory canal into the labyrinth.

Among the neoplasms of the internal ear must be included the calcareous deposits found in the periosteum of the internal auditory canal, to which *Böttcher*[7] called attention. They consist of phosphate of lime, and are said to occur in larger bulk in persons of middle age. In a patient who died from pneumonia, and had for several years previously suffered from chronic purulent inflammation of the middle ear, the author observed extensive chalky deposits in the cochlea and semicircular canals, such as have been described by *Virchow* as constituents of the psammomata.

The *subjective symptoms* accompanying new formations in the internal ear may exhibit much variety; and those specially connected with changes in the auditory nerve brought about by the morbid processes in the labyrinth, may be combined with many others depending upon the implication of other organs in the new growth. In some cases, merely slight impairment of hearing may be produced, perhaps with subjective auditory sensations to a certain extent; whilst in others, in which great changes have taken place, not only may most serious symptoms appear from the auditory organ being involved, but also very severe pain and signs of the

[1] Glasgow Medical Journal, vol. xii.
[2] Zeitschrift für Ohrenheilkunde, viii. Bd.
[3] *Ibidem.*
[4] Archiv für Ohrenheilkunde, xii. Bd.
[5] Würzburg med. Zeitschrift, 1862.
[6] *Virchow's* Archiv, xviii. Bd.
[7] *Ib.*, xii. Bd., S. 104.

gravest cerebral mischief may be present. It will be obvious that all these phenomena may be subject to multifarious fluctuations.

Objective signs may be quite wanting if the development of the neoplasm remain limited to the labyrinth, whether it has primarily originated there or encroached upon it in its extension from the cranial cavity. In some far advanced cases of malignant disease in the deeper structures of the ear, glandular swellings may be seen in the mastoid region, which betray the existence of the grave condition within.

It will be evident that in such cases the *diagnosis* of a new formation in the internal ear cannot always be made with certainty. Those may be most easily recognised in which the growth spreads from the labyrinth to the cavity of the cranium; since, besides the symptoms referable to the auditory nerve, others indicating implication of the cerebral structures, taken together with considerations derived from the history of the case, will under such circumstances point to the seat of the disease.

The *prognosis* will depend upon the character and situation of the neoplasm.

Careful regard must be directed in the *treatment*, to the principles set forth in connection with new formations occurring in the middle ear. Where the growth is not exposed, our efforts must be directed towards the alleviation of the symptoms by means of the most judicious remedies.

8. Atrophy of the Auditory Nerve.

Atrophic changes may be observed in the trunk of the auditory nerve in the internal auditory meatus; or one or more of its branches may be thus affected, either in their whole course, or only at their peripheral extremities. Central atrophy depends almost without exception upon cerebral disease, whilst the peripheral is mostly a consequence of disorders of the auditory organ itself. These changes are therefore always brought about secondarily, as the result of long-standing inflammation or other derangements of the sound-conducting apparatus, the atrophy perhaps becoming developed after recovery from its primary cause has taken place.

Moos and *Steinbrügge*[1] reported an interesting condition of atrophy of the auditory nerve. Diminished mobility of the stapes and sclerosis of the mastoid process appeared in a man sixty-three years of age, who became deaf with tinnitus aurium from an ear affection which had come on suddenly two years before, and who died from carcinoma of the brain and stomach. Microscopic examination of the right labyrinth showed an almost normal condition of the root and trunk of the auditory nerve as far as the end of the internal auditory canal, atrophic fibres being only exceptional. The atrophy was characterised by loss of the medullary sheath,

[1] "Ueber Nervenatrophie in der ersten Schneckenwindung. Physiologische und pathologische Bedeutung derselben." Zeitschrift für Ohrenheilkunde, x. Bd.

so that only the axis-cylinders remained, with here and there granule-cells. The ganglion cells of the vestibular nerve were in certain places more attenuated, and seemed clearer than normal, with the transverse anastomoses less numerous (quantitative atrophy). Under stronger powers, wasting of the nerve fibres could be made out. Some of them suddenly ceased, and the rest exhibited varicosities due to swelling of the axis-cylinder with extreme constrictions intervening. In some parts, the nuclei of Schwann's sheath were enlarged, and some of the varicose nerve fibres contained roundish, irregular-shaped bodies of variable clearness at different places. The ganglion cells in Rosenthal's canal were very small, and the contents of the non-nucleated cells were homogeneous. The nuclei were only exceptionally stained by carmine; the cell-contents, where homogeneous, being coloured only slightly or not at all. After remaining in a carmine solution twenty-one hours, the hair-cells were unstained, the inner cells being normal and the outer transformed into a fine granular mass. In the second cochlear convolution the hair-cells appeared normal, the nuclei only being occasionally absent. The cells of the lig. labyrinthi were in part normal, in part non-nucleated with homogeneous contents; the epithelial cells of the semicircular canals, as well as the epithelial layer of the utriculus, were in some parts fatty and showed colloid degeneration. The branches of the arteria audit. int. were atheromatous. On the right side, the patient was said to have been unable to hear *a'*, either by air- or cranial conduction; whilst *c* and *e* were audible by cranial, and *e* by air-conduction.

Amyloid degeneration of the auditory nerve, which has been described by *Förster*,[1] *Voltolini*,[2] *Lucæ*, and others, and seems to be of tolerably frequent occurrence, must also be regarded as a result of atrophy. It is found affecting the trunk of the nerve in its course through the meatus auditorius internus, as well as its larger branches in the semicircular canals and in the lamina spiralis.

It has been already mentioned that the nerve sheath is sometimes observed to be hyperæmic, and involved in new connective-tissue formations and other neoplasms. These constitute the ordinary causes of ectasia of the internal auditory meatus. In the author's collection are temporal bones with dilatations of the internal auditory canal large enough to admit the end of the index finger. That the nerve sheath may become secondarily inflamed, and the nerve itself bathed with pus, or even completely destroyed, has been alluded to in the previous chapters.

[1] Atlas der pathologischen Anatomie, 1856, Taf. xviii., Fig. 5.

[2] "Pathologisch-anatomische Untersuchungen des Gehörorganes." *Virchow's* Archiv xviii. und xxii. Bd., 1860 und 1861.

CHAPTER XX.

OTHER AFFECTIONS WHICH MAY CALL FORTH MORBID PHENOMENA IN CONNECTION WITH THE EAR.

1. Among these must be first mentioned diseases of the intra-cranial structures—i.e. *the brain and its membranes.* On account of the multifarious connections existing between the auditory nerve and the brain, every morbid change taking place in the latter may be followed by symptoms referable to the organ of hearing. These symptoms may arise either through the auditory nerve or the region of the brain in relation with it being implicated in the pathological processes, or from the latter bringing about indirectly a condition of irritation in those structures. Intra-cranial affections which have their seat at some distance from the nuclei of origin and the trunk of the nervus acusticus, sometimes induce very grave aural symptoms.

Hyperæmia and anæmia of the brain; inflammation of the brain substance and of the meninges; abnormalities of the intra-cranial vessels, especially of the basilar artery and the arteria auditiva interna; apoplectic blood-extravasations and their consequences; hydrocephalus; and new formations, whether appearing in a diffuse form or as tumours, are all capable of originating morbid phenomena in respect of the ear. Nevertheless, any of these conditions may exist in the brain without evoking aural symptoms, and even extensive pathological changes have been found post mortem in the floor of the fourth ventricle without anything abnormal having been manifested in connection with the ear during life. Such symptoms occur most frequently as the result of pressure exercised upon the auditory nerve; and since this pressure may be compensated under favourable conditions in the cerebrum or cranium, it is comprehensible how, with the same pathological alterations, auditory phenomena may be either present or absent.

(*a*) *Hyperæmia and anæmia,* if they be not associated with other disorders of the brain and its membranes, usually cause merely slight and transitory aural symptoms. In some cases observed by the author, of cerebral hyperæmia without any existing objective changes in the ear, there was no disturbance of hearing, the patients being only annoyed by

slight tinnitus, and occasionally by vertigo; symptoms which were invariably aggravated by anything increasing the flow of blood to the head, and vice versâ. Bending the head forwards increased the tinnitus, whilst pressure upon the common carotid lessened it; and so forth.

Anæmia of the brain likewise sometimes produces noises in the head and giddiness, without impairment of hearing: indeed, many anæmic patients suffer even from hyperæsthesia acustica.

(*b*) *Meningitis*—particularly *cerebro-spinal meningitis*—not infrequently brings on unilateral or bilateral deafness in young individuals. In adults, in whom this disease occurs less often as an uncomplicated affection, it very seldom leaves behind it any derangements of hearing. When, however, they do arise, their cause is to be sought in inflammatory changes of the corresponding nerves within the cranium, or in an extension of an inflammatory process to the labyrinth from the original seat of disease. The author has, however, seen several cases of extensive purulent meningitis, in which the auditory nerve was surrounded by thick pus as far as its external ending in the internal auditory canal, without the presence of any symptoms connected with the auditory nerve.

Epidemic cerebro-spinal meningitis gives rise more often to disturbances of audition. It is mostly children, too, who become very hard of hearing, or even completely deaf, in one, or more often in both ears, in consequence of this disease. The aural trouble usually appears on the third or fourth day of the illness. If in such cases consciousness be regained, it is rare for them to complain about subjective auditory sensations; whereas during and after convalescence they often exhibit for months a staggering gait, which often disappears at a later period. *Gottstein* called attention to the fact that abortive forms of cerebro-spinal meningitis occur, in which the initial symptoms very soon recede, but the deafness persists.

Heller[1] and *Lucæ*[2] verified extension of the meningeal inflammation to the labyrinth. *Habermann*[3] was even able to demonstrate destruction of the structures of the internal ear with the formation of granulation-tissue, as well as partial destruction of the membrana obturatoria in the oval fenestra.

Steinbrügge,[4] upon the basis of an examination of two cases of cerebro-spinal meningitis, one of an acute and violent type, the other lingering and latent, believes that two forms of destructive process are to be distinguished in the labyrinth—viz. purulent and necrotic; the latter being caused by the direct influence of the specific virus of the disease upon the small blood-vessels of the region, resulting in stasis and thrombosis; whereby in particular, disintegration of the periosteum of the

[1] "Zur anatomischen Begründung der Gehörsstörungen bei Meningitis cerebro-spinalis." Archiv für klinische Medicin., iii., 1867.

[2] "Eiterige Entzündung des inneren Ohres bei Meningitis cerebro-spinalis." Archiv für Ohrenheilkunde, v. Bd.

[3] Zeitschrift für Ohrenheilkunde, vii. Bd.

[4] Bericht über die otiatrische Section der 59. Versammlung deutscher Naturforscher und Aerzte in Berlin, 1886.

semicircular canals and of the structures of the membranous labyrinth which are attached to it, comes about. The necrosis may thus be primary; from which may be explained the early appearance and incurable persistence of the deafness in cerebro-spinal meningitis. The new connective-tissue formation which takes place, is to be regarded as a further stage in the labyrinthine affection, representing probably the process of re-development of the bone.

The investigations of *Moos*[1] in connection with the changes in the ear which arise in pachymeningitis hæmorrhagica, led him to believe that each attack of meningeal hæmorrhage may be likewise accompanied by a similar occurrence in the labyrinth. Hæmorrhage, depending upon diapedesis, might in this way produce complete abolition of the hearing faculty by the atrophy and degeneration which it may bring about in the trunk of the auditory nerve and its terminal branches in the labyrinth. This view of *Moos* is materially supported by the further researches of himself and *Steinbrügge*.[2]

(*c*) The changes in the intra-cranial vessels which are chiefly to be considered in this connection are *embolism* and *aneurysm*. Emboli are sometimes found in the arteria auditiva interna. *Moos*[3] cites a case observed by *Friedrich*, in which during the course of an endocarditis, deafness suddenly set in, which was caused by embolism of this vessel. Such obstructions occasion degenerative changes in the labyrinth, and are accompanied by grave symptoms. Functional disturbances of the auditory organ may also follow abnormal conditions of arteries which have no direct relation to the labyrinth, but which induce secondary changes as a result of their obstruction. In this sense is to be regarded a case reported by *Kaufmann*,[4] in which deafness of the left ear, with softening of the right cerebral hemisphere, occurred from embolism of the art. fossæ Sylvii.

Auditory derangements have been frequently traced to *aneurysm of the basilar artery*, and, according to *Griesinger*, they may appear paroxysmally.[5]

(*d*) Disturbances of hearing may also arise from *apoplectic extravasations* into the brain with their consequences, but only rarely in proportion to the frequency of such affections. Such symptoms are much more often found in connection with:—

(*e*) *Hydrocephalus.*—A marked disposition to affection of the mucous membrane lining the cavities of the nose, pharynx, and middle ear is directly engendered by this disease, and may thus readily bring about impairments of hearing. So-called cerebral deafness, partial or complete, may be occasioned both by hydrocephalus externus and internus; and the

[1] "Ueber die histologischen Veränderungen des Labyrinthes bei der hämorrhagischen Pachymeningitis (Hæmatoma duræ matris)." Zeitschrift für Ohrenheilkunde, ix. Bd.

[2] "Ueber acute Degeneration des Hörnerven im Gefolge einer mit Pyämie complicirten Pachymeningitis hæmorrhagica, sowie über gleichzeitig vorhandene Verstopfung der rechten Art. aud. int." Zeitschrift für Ohrenheilkunde, xi. Bd.

[3] Klinik der Ohrenkrankheiten, 1863.

[4] Berliner klinische Wochenschrift, 1886.

[5] "Beobachtungen über Hirnkrankheiten." Archiv für Ohrenheilkunde, 1862.

author has observed a considerable number of deaf-mutes in whom the deafness depended upon this condition.

(*f*) *Cerebral tumours* more frequently produce disturbances of vision than of audition. Complete deafness very seldom arises from this cause, and when it does occur it is generally unilateral. According to the statistics furnished by *Ladame*,[1] acoustic disorders are apt to be more particularly associated with tumours in the middle cranial fossa (38·5 per cent. of all cases). They were present in 27 per cent. with such conditions in the pons Varolii; in 14 per cent. of those implicating the pituitary region; and in 11 per cent. of those of the middle lobe. They were combined with visual derangements, more especially in the case of tumours at the base of the brain, of the pons Varolii, and of the trunk of the nervus acusticus. Symptoms referable to the auditory nerve are evoked by compression of its trunk or nucleus of origin; by embolic changes in the basilar artery or the art. audit. int.; by extravasation of blood, with its consequences; or by other circulatory derangements in the structures of the labyrinth.

(*g*) *Syphiloma.*—Disturbances of hearing in various degrees, besides subjective auditory sensations and other symptoms, may likewise appear in syphilitic disease of the brain (syphiloma). The author has observed several such cases in which the diagnosis was fully confirmed.

Wernicke and *Friedländer*[2] observed an extremely interesting case, and afterwards the post-mortem appearances, in a woman forty-three years of age, who in her eighteenth year had suffered from epileptic convulsions. About a year before her death, they reappeared in intensity, associated with considerable impairment of hearing; and somewhat later, after an apoplectic seizure, with aphasia and right hemiplegia. After several weeks' treatment, the speech somewhat improved, and she was discharged with paralysis of the right arm. She came back in about four weeks with paresis of the left arm, the paralysis of the right side having passed away. The speech was no better, and there was total deafness on both sides. Death ensued some weeks subsequently with symptoms of leuchæmia. Post-mortem examination showed *gummatous softening in both temporal lobes*, besides other changes of a syphilitic character in various organs. In the left temporal lobe, the whole of the first and second convolutions, together with a section of the adjoining region, as well as the entire corona radiata, were involved in the new formation. In the right temporal lobe, the most superior and the most posterior portions were affected, the latter more superficially; whilst anteriorly, the disease extended to the part of the white substance of the lobe at which the fibres of its corona radiata meet the corresponding fibres of the parietal lobe.

(*h*) *Tuberculosis* of the intra-cranial structures only very rarely leads to auditory derangements.

Other changes certainly occur in the brain, especially those parts in relation

[1] "Die Symptomatologie der Gehirngeschwülste," Würzburg, 1865. Citat aus *Moos'* Aufsatz, "Ueber das combinirte Vorkommen von Störungen im Seh- und Hörorgan." Archiv für Augen- und Ohrenheilkunde, vii. Bd.

[2] "Ein Falle von Taubheit in Folge doppelseitiger Läsion des Schläfenlappens." Fortschritte der Medicin, 1883.

with the nervus acusticus, which we are unable to discover with our present means of examination. Among such must be reckoned all such functional disturbances of the auditory organ, for which an objective cause cannot be assigned, and which are designated simply as "nervous."

The question as to the existence in the brain of a distinctly defined *region of audition*, exclusively destined for the perception of auditory impressions transmitted from the labyrinth, has not yet been fully determined. *Munk*[1] believes such a district to be situated in the cortex of the temporal lobe, below the visual area and above the pes hippocampi. He represents the central sound-perceiving elements of each auditory area to be exclusively connected with the peripheral organs of the acusticus of the opposite side. Dogs in which the region alluded to has been extirpated, appear as deaf as if the labyrinth had been removed; and they soon become dumb also. *Munk* likewise considers it to have been demonstrated that after removal of the posterior half of the auditory region, the animal cannot hear the deeper tones; while the higher tones are not heard if the anterior part be destroyed.

Christiani,[2] on the other hand, observed that, in rabbits in which both cerebral hemispheres and corpora striata had been removed, the sensitiveness of the auditory nerve was notably increased; and *Goltz*[3] repudiates *in toto* the doctrine of the localisation of the sensory faculties in the cortex cerebri in the full measure accepted by recent physiologists and neuro-pathologists. According to him, no area of the cortex exists which is exclusively concerned in hearing, smell, taste, or ordinary sensation. He states that destruction of the anterior sections induces symptoms of deficiency of function, which are to a certain extent distinguishable from such as ensue from destruction of the posterior parts of the cortex, and may perhaps be explained by concurrent injury of the tracts leading to the crus cerebri. If the posterior lobes be destroyed, a more conspicuous dulness of sensibility may as a rule be recognised, but never complete abolition of the sensory faculty. According to this, one may speak of a *sense impairment* or a *cortical auditory impairment*, but not of *absolute cortical deafness* or *absolute psychic deafness*. A dog in which the cortex cerebri has been extensively destroyed becomes intensely stupid, but not deaf. The condition seems something like that when we are absent-minded, in which, too, we do not see or hear acutely.

Whichever view may be the correct one, the facts remain that pathological changes in those regions of the cortex denoted by *Munk* as the auditory areas, may be associated with morbid aural symptoms; and that, on the other hand, cases of lesion of both temporal lobes have occurred without any word-deafness being present (*Brown-Séquard*).

Nevertheless, the "*word deafness*" of *Kussmaul*, or "*sensoric aphasia*" of *Wernicke*, which has also been observed by the author in some cases, and may be perhaps better designated as "*non-comprehension of words*," appears to stand in close relation to such morbid changes in the temporal lobes. By this condition is meant a derangement in which the patient, though hearing words, cannot either understand or repeat them. The defect may extend likewise to all auditory perceptions (tones, noises). Patients affected in this way may hear the slightest whisper, but they attach no meaning to the words. A loud noise, or a word uttered more loudly, often produces painful sensations, so that they request the speaker not to shout; but they can comprehend nothing at all: a condition described by

[1] "Ueber die Hörsphäre der Grosshirnrinde." Monatsbericht der Berliner Akademie der Wissenschaften, 1881.

[2] "Experimentelle Beiträge zur Physiologie des Kaninchenhirns und seiner Nerven." Monatsbericht der Berliner Akademie der Wissenschaften, 1881.

[3] *Pflüger's* Archiv für Physiologie, 1881.

Nothnagel as a loss of the psychological perception of sounds, or psychic deafness (Seelentaubheit). Many varieties in the non-comprehension of words may occur; some individuals still understanding the meaning of certain words, and being able to repeat them; while others may no longer understand a single word, although they can hear quite well. Those cases, again, are interesting in which the meaning of a word is comprehended only after long consideration and considerable effort, somewhat as a fatigued person makes his way slowly along. If these patients be spoken to very slowly, they understand what is said more readily. The condition has some resemblance to that in which a foreign language is spoken quickly to some one who has only an imperfect acquaintance with it.

According to *Stricker*,[1] the sense of hearing alone does not suffice for the comprehension of speech. He holds that impressions upon the acusticus are transmitted to the speech centre, from which is derived the innervation of those muscles by means of which the words heard—or, rather, understood—would be enunciated. Functional incapacity of this central speech-system would annul the faculty of comprehension of spoken words, although the hearing capacity may remain intact. The appreciation of musical motive, according to this investigator, is brought about through innervation of the muscles of the larynx, of the lips, and probably also of the tensor tympani.

The cases of this kind reported in medical literature are tolerably numerous (*Wernicke, B. Fränkel, Broadbent, Bernhardt, Magnan*, and others). *Fränkel's*[2] case is interesting: a tailor went to bed well, but on awaking next morning could neither speak nor write a word, nor even understand what was said or written. His hearing, however, was perfectly good, and he was otherwise well, both mentally and physically. After an interval of three weeks, he commenced to speak again, but with frequent use of wrong words. Subsequently his capacity for writing also returned; but even after two months and a half had elapsed, his comprehension of speech was still imperfect.

2. *Diseases of the spinal cord* sometimes occasion derangements of audition. In tabes dorsalis, especially, impairment of hearing and subjective auditory sensations are not uncommonly observed. *Topinard*[3] recognised auditory disturbances in 10 out of 102 cases. In some instances, *Erb*[4] was enabled to trace the cause to atrophy of the auditory nerve. *Lucæ*,[5] however, proved that in two patients with degeneration of the spinal cord, the deafness was due to middle-ear catarrh, the auditory nerves being free from degenerative change.

3. *Mumps.*—Very grave aural symptoms sometimes occur in the course of idiopathic parotitis. *Toynbee* has referred to these, and ascribed them to a secondary implication of the auditory nerve. More recently, *Buck*[6] has directed the attention of aurists to the subject in his account of two cases

[1] "Ueber Laut- und Tonvorstellungen." Anzeiger der k. k. Gesellschaft der Aerzte in Wien, 1886.

[2] Berliner klinische Wochenschrift, 1881.

[3] Citat aus *Prof. Rosenthal's* Handbuch der Diagnostik und Therapie der Nervenkrankheiten.

[4] *Ziemsen's* Handbuch, S. 142.

[5] "Ueber Schwerhörigkeit bei grauer Degeneration des Rückenmarkes." Verhandlungen der Berliner medicinischen Gesellschaft, i. Bd.

[6] "Sudden and complete loss of hearing in one ear during an attack of mumps." American Journal of Otology, 1881.

of this nature; and at the present time a considerable number of such cases have been reported (*Calmette*,[1] *Seitz*,[2] *Seligsohn*,[3] *Moos*,[4] *Menière*,[5] *Brunner*,[6] *Knapp*,[7] *Moure*,[8] and others). From these it appears that the affection may be unilateral or bilateral; that its onset is accompanied by symptoms similar to those of labyrinthitis; and that it may occur both in children and in adults. The deafness in this disorder is generally absolute and incurable.

A case seen by the author in Vienna, which occurred at a time when no epidemic prevailed, was remarkable from the comparatively insignificant swelling of the parotid glands. The condition was thought therefore, both by the medical attendant and by the parents, to be unimportant, as the child, ten years of age, had been feverish only for a few hours. On the third day of the affection, total deafness appeared in both ears, and persisted, in spite of all remedies employed. The author, like most others, regards the affection as due to a metastatic labyrinthine exudation, similar to the orchitis sometimes associated with parotitis. In one case, *Seligsohn* made out the existence of syphilis—an observation which is noteworthy.

4. *Diabetes.*—As with the eye, so in the ear, morbid symptoms dependent upon changes in various structures occur in association with diabetes. Sometimes pruritus of the external auditory canal is present. In other cases there may be a frequent recurrence of furuncular abscesses, which occasionally lead to extensive destruction of the cutis and areolar tissue. Purulent inflammation of the middle ear arises less often in connection with this disorder (*Raynaud*,[9] *Kirchner*,[10] and others); but even this complication sometimes comes on acutely. *Kirchner*, indeed, observed a case which terminated fatally.

That changes likewise occur in the sound-perceiving apparatus in diabetes, is shown by those cases in which subjective auditory sensations and impairment of hearing are present, although no pathological conditions exist in either the external or middle ear.

Mention has already been made of the changes in the auditory canal occurring in syphilis, typhoid fever, and diphtheria. Reference, however, must again be made

[1] La France Médicale, 1882.
[2] Correspondenzblatt für Schweizer Aerzte, 1882.
[3] "Taubheit nach Mumps." Vortrag in der Berliner medicinischen Gesellschaft, 1883.
[4] "Ein Fall von partieller Labyrinthaffection nach Mumps." Berliner klinische Wochenschrift, 1884.
[5] "Deux cas de surdité unilatérale complète survenue à la suite des oreillons." Revue mens. de Laryngol., 1885.
[6] "Ein Fall von completer einseitiger Taubheit nach Mumps mit epikritischen Bemerkungen." Zeitschrift für Ohrenheilkunde, xi. Bd.
[7] "Ein Fall doppelseitiger Taubheit nach Mumps." Zeitschrift für Ohrenheilkunde, xii. Bd.
[8] Sur un cas de perte complète de l'ouïe à la suite des oreillons.
[9] "De l'otite diabétique." Ann. des Mal. de l'Oreille, du Larynx, etc., 1881.
[10] "Ueber Ohrenkrankheiten bei Diabetes mellitus." Monatsschrift für Ohrenheilkunde, xviii. Jahrg.

to the occasional development, as results of these diseases, of obvious or occult cerebral changes from which morbid subjective symptoms may arise in connection with the auditory organ.

5. *Leukæmia* is sometimes accompanied by diminished hearing power or complete deafness, dependent, as demonstrated by recent researches, upon hæmorrhagic and inflammatory changes in the structures of the middle and internal ear (*Politzer, Gradenigo, Steinbrügge*). *Gradenigo*[1] is probably not far wrong in supposing that these leukæmic changes—which, moreover, are much rarer in the ear than in the eye—are favoured by the existence of old middle-ear disease. Whether such conditions can originate in a perfectly normal ear, has yet to be proved.

In a case described by *Blau*,[2] the affection appeared paroxysmally with Menière's symptoms, and was followed by deafness, which however, diminished later, after subsidence of a purulent perforative inflammation of the middle ear.

The *diagnosis* rests upon the signs of the constitutional disease, and upon the subjective and objective aural symptoms, by which also the *prognosis* must be regulated. Total deafness, caused by extravasation of blood into the labyrinth, would scarcely admit of any improvement.

The *treatment* should have regard to the general affection, and to the avoidance of all irritation, especially of the ear. Absorbent remedies may be employed externally, if their action should be indicated.

9. Neuroses of the Sound-perceiving Apparatus.

These conditions are manifested either in *intensified sensibility to sound*, sometimes even to the extent of pain; or, on the other hand, in a *weakened perceptive faculty*; or again, by the existence of *subjective auditory sensations*. The last-mentioned phenomena are mostly associated with diminished hearing power. Exaggerated auditory sensibility (acute hearing, hyperacusis, oxyecoia) has been chiefly observed by the author in women during an attack of migraine, in which the perceptive function is sometimes so painfully exalted, especially for noises, that a high degree of excitement is produced by the slightest sound. The author observed extremely painful hyperacusis in a boy of thirteen, who had suffered for two days from violent toothache. Upon the least unexpected sound he appeared scared, and complained of a very disagreeable sensation in both ears. This increased sensibility disappeared after extraction of the decayed tooth. The symptom appears generally to occur only in connection with great nervous excitement, and even then only periodically. It is sometimes

[1] "Das Gehörorgan bei der Leukaemie." Archiv für Ohrenheilkunde, xxii. Bd.

[2] "Ueber Erkrankungen des Gehörorganes bei Leukaemie." Monatsschrift für Ohrenheilkunde, 1885.

observed after the use of nerve stimulants—as spirituous drinks or stimulating drugs—as well as in the course of grave diseases. That it occurs also in connection with certain ear affections has already been mentioned when these were discussed.

Local treatment is rarely necessary, as the condition disappears with improvement in the general symptoms. Rest for the auditory nerves is called for during the disorder; and if this should persist for some time, a little cotton-wool upon which a small quantity of laudanum has been dropped may be introduced into the external auditory canal. If of still longer continuance, bromide of potassium may be given.

Much more common than hyperacusis, is *nervous impairment of hearing and nervous deafness.* These conditions may exist either with or without subjective auditory sensations. Unlike over-acuteness of hearing, they are almost invariably continuously present, and are amongst the most difficult aural disorders to cure. Impaired auditory sensibility is observed in convalescence from severe febrile affections—*e.g.* typhoid fever, pneumonia, and recurrent fever; also in individuals debilitated as a result of sexual excesses,[1] or in those whose nervous apparatus has been affected by various forms of intemperance. Respecting the last named, may be more particularly mentioned immoderate smoking, especially of cigarettes, which may induce decided nervous impairment of hearing. Extreme mental disturbance may likewise bring about sudden auditory derangements. Thus, in a young man recently under treatment in the hospital practice of the author, loss of speech and of hearing followed upon an intense excitement. He regained his speech in the course of eight days, but his hearing only after nearly six weeks. Over-fatigue of the auditory nerves, especially from constant monotonous sounds, may also result in a paretic state of the perceptive organs. In this way is probably to be explained the dulness of hearing and deafness, which gradually come on in persons whose occupations subject them to immoderate irritation of the auditory nerves; such as smiths, boiler makers, and millers.[2]

In this place also is to be considered the functional auditory derange-

[1] Compare *Weber-Liel*, "Ueber den Einfluss sexueller Irritation auf affectionen des Gehörorganes." Monatsschrift für Ohrenheilkunde, xvii. Jahrg. *Scanzoni* reports having frequently observed transient deafness after the application of leeches to the vaginal portion of the uterus. ("Gynaecologische Fragmente." Würtzburg Medicinische Zeitung, vol. i.)

[2] *Gottstein* and *Kayser* examined a great number of smiths, with the result that those over fifty years of age showed, without exception, a deficiency in hearing capacity. Scarcely a third of the whole number examined had normal hearing ("Ueber die Gehörveränderung bei Schlossern und Schmiedern": Breslau, ärztliche Zeitschrift, 1881). Judicious measures might, in this respect, obviate many injurious consequences. An arrangement by which periodical intervals of rest were permitted, would act very beneficially in regard to individuals whose occupation entails a continual stimulation of the auditory nerves; and it may still be hoped that the attention of legislators may be fruitfully directed to these matters, though the warnings of *Moos* in connection with the danger to life from possible aural affections in engine-drivers, still remain almost entirely disregarded (*vide* Zeitschrift für Ohrenheilkunde, vol. xi.).

ment sometimes observed in *hysterical subjects*. It usually occurs periodically upon certain external causes, and in various ways. Sometimes the impairment of hearing is manifested merely as regards speech; or again, in connection with definite tones or noises. The disorder is mostly unilateral, and is then usually associated with hyperacusis of the other ear. In certain cases, the transference of the affection to the other side has been brought about by the approximation of a horseshoe magnet: a symptom which is of diagnostic service.

The author has observed numerous instances in which, besides other hysterical symptoms, various unpleasant sensations in the ears have been complained of, together with dulness of hearing and tinnitus, although not the slightest objective change could be recognised. In a patient affected with hysterical hemi-anæsthesia, sensibility was so much diminished over the auricle and integument of the external auditory canal, that the point of a needle was not felt; the hearing distance was also considerably reduced. The patient said he was only temporarily hard of hearing, usually after being extremely agitated, and particularly when he thought much about his condition.[1]

The *subjective auditory sensations* which occur without any demonstrable objective change in the auditory apparatus, and are commonly described as "nervous tinnitus aurium," may be present either alone, or associated with impairment of the hearing in various degrees. As a rule they cause much more annoyance than the deafness, and patients often beg that they may be made completely deaf, if by this means it should be possible to rid them of the noises. Unfortunately this cannot always be accomplished: indeed, there are many persons afflicted with complete nervous deafness, who constantly suffer from the most distressing noises.

Nervous tinnitus is either temporary or continuous. Sometimes the noises appear at first periodically and become constant at a later period; but the reverse also occurs. The nature of the phenomenon is very variable. Not at all uncommonly, patients are annoyed by several noises at the same time. The sound is not always perceived in the ear, but occasionally seems to be present in the head—either throughout it, or only in certain situations. In other cases, a noise is spoken of as in the ear, with another, or more than one, in the head also. Sometimes the patient hears the sound at a distance; and occasionally he has definite noises constantly in the head, and now and again a sharp report as from an

[1] Cases of this nature have been described by *Politzer* (Lehrbuch der Ohrenheilkunde, p. 835); *Rosenthal* (Handbuch der Diagnostik und Therapie der Nervenkrankheiten); *Magnus* (Archiv für Ohrenheilkunde, vol. xx.); *Habermann* (Prager medicinische Wochenschrift, 1880); *Fuldon* (Zeitschrift für Ohrenheilkunde, vol. xv.); *Stepanow* (Monatsschrift für Ohrenheilkunde, xix. Jahrg.), and others.

explosion, in addition to these. The last appears at times so loud as to be associated with reflex motor phenomena. Congestion about the head occurs in many individuals in connection with the above symptoms when these are intermittent; or, if continuous, they are intensified by such congestions (angioneurotic).

The noises may likewise change both in character and position. They seem sometimes to pass from the head into the ear, and thence outwards; or they may move in the contrary direction,—*i.e.* a sound perceived at first at some distance, is heard later on in the ear or in the head. The auditory perceptions are described by patients in the most diverse ways, and in this respect *Von Tröltsch* rightly conjectures that they allow free play to their fancy. They are very ingenious in their descriptions, and frequently invent new terms in attempting to express their sensations. A patient of the author's, who was born and educated in St. Petersburg, likened them to bell-ringing, adding, however, "but not the ringing of the Vienna, but of the St. Petersburg bells." The most disagreeable kind of affection is that in which musical airs or the voices of animals are perceived; such as the barking of dogs, mewing of cats, neighing of horses, or the chirping of crickets. Patients who hear human voices (words, conversation, etc.) are, as is well known, usually either mentally diseased, or become so later.

Türck made the observation that "upon pressure on the forehead and face, or upon the hard palate and tongue," the subjective noises are sometimes lessened.[1] Shortly before this inquirer's decease, the author had the opportunity of discussing the subject with him; and he agreed that in many patients, the phenomenon may be explained by the fact of their forgetting their aural affection altogether, for the moment during which the experiment is being made. The author has, on the other hand, also met with instances in which the noises became augmented upon the slightest irritation of the structures in the region of the fifth nerve,—*e.g.* upon simply touching the cheek.

Moos saw a woman, sixty years of age, who experienced a tingling in her left ear whenever she used a "pince-nez." She was advised to use a glass which she was to hold, upon which the tingling left her.[2]

The statements of *Schwartze* and *Köppe* that the presence of aural diseases, and particularly of subjective auditory sensations, may accelerate the appearance of mental disorders and favour the occurrence of auditory hallucinations, the author can confirm from his own observations, which were made in conjunction with *Schlager* and *Joffe* in the Vienna Lunatic Asylum. The greatest attention should be directed to possible ear affections in patients afflicted with mental disease; and examination of the ear ought never to be neglected, especially with hallucinations of hearing. That reflex psychoses also arise from aural disorders, is established by numerous observations.[3] *Rhys Williams* treated a reflex psychosis, which arose

[1] "Ueber die Einwirkung der Ursprungsstellen des Nerv. trigeminus auf das Centralorgan der Sehnerven in gewissen Fällen von Amblyopie." Vortrag gehalten in der Versammlung der Gesellschaft der Aerzte in Wien, am 16. October, 1843.

[2] "Neuro-pathologische Mittheilungen," Zeitschrift für Ohrenheilkunde, xii. Bd.

[3] Berliner klinische Wochenschrift, 1886, und allgemeine Zeitschrift für Psychiatrie, 1867.

during the course of an otorrhœa with abscess in the mastoid region, and disappeared after recovery from this affection (Lancet, 1877).

As with other neuroses, those of the ear are subject to many variations. These may arise either from internal or from external causes. Everything tending to improve the general health of the patient and cheer his spirits, is also likely to ameliorate the aural symptoms; and vice versâ. We therefore see that bodily indisposition, fatiguing mental or bodily work, mental emotion, sleeplessness, etc., increase for the time both the nervous deafness and the noises in the ears. In many patients, even meteorological conditions have a special influence upon them, and they are much better in bright than in damp, cloudy weather. So, too, with food and drink. A moderate amount of alcohol is often beneficial, while in other cases it greatly aggravates the disorder. The tinnitus may often be mitigated by holding the head in a certain position. In most instances, the subjective auditory sensations become diminished in intensity by external noises, though in others this is not the case; indeed, a noise is in some individuals capable of inducing these phenomena, or of causing an already existent tinnitus to become still more distressing.

Special reference must be made to the *reflex neuroses* which may be excited by the ordinary sensory nerves of the ear, as well as by the auditory nerve. Allusion has already been made to the first kind, especially in connection with acute suppurative inflammation of the middle ear. For an extremely interesting observation of this nature the author is indebted to *Prof. Northnagel.*

A man of business, twenty-three years of age, from Witebsk in Russia, who had previously enjoyed good health, was frightened during a fire so violently that he fainted, and for three months subsequently suffered from severe headache. During this period, not a day is said to have passed without his having from six to eight "fainting fits," and he was obliged to keep his bed constantly. Later on, he had daily attacks of "spasms in the stomach, in the region of the heart, and in the neck, which lasted only for a few minutes." These cramps, according to the patient's statement, were at first brought on by the slightest pressure upon the right side of the abdomen; but after a few weeks they could not be produced in this way, though they appeared upon the least touch on the right ear. A few weeks later, the previous condition returned; the attacks being again excited by pressure upon the hypogastrium. This state of things still continues. For the last eight days, tinnitus has been present on the right side; and it was on this account that he sought advice.

When the author touched the right auricle for the purpose of examination, the patient fell down, his eyeballs rolled upwards, and trismus and very severe opisthotonos occurred, by which he was several times jerked upwards from his bed. After about four minutes the attack ended; he got up, and said he felt somewhat languid; but he could walk without effort, and answer questions. He stated that during the paroxysm he could hear everything, but could not speak.

Some days afterwards (June 25th) his ears were examined under chloroform. On the right side was a chronic purulent inflammation of the middle ear, with destruction of the tympanic membrane with the exception of a band-like remnant about 2 *mm.*

broad, which was attached to the margin of the auditory canal; the malleus being also preserved. The left drum-membrane was moderately thickened, and a cicatrix as large as a hemp-seed existed on the posterior segment. He was not aware when the aural affection began. A horseshoe magnet was brought into contact with the auricle, upon which a violent paroxysm came on (June 26th). On June 27th, he could be examined and catheterised without anæsthesia, and the tinnitus had somewhat abated. On the right side, the watch was heard on contact with the auricle, as well as by cranial conduction: on the left side, the hearing was normal. On July 1st, he complained of slight pain in the right ear, and a little purulent exudation was observed in the depths of the canal. Next day a violent spasmodic seizure, lasting more than five minutes, occurred upon contact of the right auricle with the magnet. On the 3rd and 9th of July, the ear could be examined without the occurrence of a paroxysm. The noises in the ear were still present to a slight extent, as also a little otorrhœa.

During the ensuing weeks the patient attended at intervals, and stated that he now never had an attack on touching the ear, but that it happened if pressure was made over the right hypogastric region. He returned home, and nothing more was heard of him. The author regards the case as one of hysterical reflex eclampsia.

Högyes[1] made some observations upon hystero-epileptic subjects, from which it appeared that as a result of prolonged tones, reflex muscular spasms arise in them, which finally merge into a hypnotic state. The louder the tone, the more muscles became affected; and the higher tones occasioned a more rapid and intense spasm. With rhythmic tones, the hands and feet were moved rhythmically, both in hypnotised patients and those in an ordinary condition. If the sound was perceived only by one ear, then reflex contractions on one side only followed. When the tuning-fork was caused to vibrate before the ear, both eyes were turned towards the source of sound—upwards if it was above, and downwards if below. From the deaf side, reflex movements were more readily evoked than from that on which the hearing was normal. It would thus seem probable that the nerve tracts for the perception of tone, are distinct from those for the acoustic reflexes, though the functions are to a certain degree independent.

Such patients cannot turn their eyeballs away from the sounding tuning-fork, however much they may desire to do so. The tuning-fork may in these cases be looked upon as a will-dynamometer. *Högyes* refers all acoustic reflexes to a propagation of the stimulus to the nuclei of origin of the motor nerves and the spinal motor ganglia.

Clonic spasms sometimes occur in the internal muscles of the ear and the muscles of the Eustachian tube, and may inter alia produce intermittent or constant subjective auditory sensations, which are mostly also perceptible objectively. These muscular contractions likewise are expressions of reflex neuroses, excited by morbid changes in the ear or in other organs. It should, however, be remarked that such subjective aural phenomena may also originate in a bad habit of the patient. Children especially, sometimes during play, make certain sounds in the throat by rapid successive contractions of the muscles of the soft palate. An adult patient once told the author that he did the same thing to get rid of a disagreeable tickling in this region. When such a habit

[1] "Neuere Beiträge zur Physiologie und Pathologie der Acusticus-Reflexe." Orvosi hetilap, 1885, Ref. Monatsschrift für Ohrenheilkunde.

is practised for a long while, involuntary contractions may supervene, which occasion the noises in question. Only quite recently, the author saw a law student, kindly referred to him by *Dr. Prossinagg* of Laibach, who was much troubled about these noises in his left ear, which were accompanied by visible contractions of the soft palate. The hearing was perfectly normal, and no objective changes could be recognised. The author put it to him, whether he did not perhaps himself produce the noises, and that he could possibly suppress them. He was in fact able to do so, and in the course of a few weeks had cured himself of the habit, and was free from tinnitus. The diagnosis of such cases is not difficult, as the muscular contractions may be controlled by an effort—a result which cannot be attained with the clonic spasms.

Since the nature of the pathological changes which are the fundamental cause of the nervous phenomena are unknown, a certain *prognosis* is generally out of the question. Some hope of successful treatment may be entertained if the symptoms may conceivably be referred to some remediable constitutional affection, or if they be induced by external conditions which it is possible to remove.

An indication in regard to the prognosis is often furnished by the nature of the symptoms. Thus, experience shows that nervous deafness which is subject to fluctuations, especially if the hearing return temporarily in nearly normal degree, can be in general more easily cured than if it exist always to the same extent, or steadily increase. The same remark is true in regard to the subjective auditory sensations. Intermittent tinnitus is usually easier to relieve than that which is constant. Undefined sounds, too, are more amenable to treatment than such as approach in character definite tones or the voices of animals; and noises in the ear are less difficult of alleviation than those which seem to be located in the head. If, again, the source of the noises always appear to be the same, they as a rule yield to treatment less readily than such as seem to change their place of origin; and those most capable of amelioration are such as appear to proceed from a distance.

With respect to *treatment*, the general state of health must first be considered, and the requisite measures taken for the removal of any existing disturbance. The diet and mode of life of the patient should be properly regulated; and all excesses avoided, whether of a physical or mental nature. In appropriate cases, the internal use of natural waters, a hydropathic course, and residence in certain health resorts, particularly those of high altitudes, may prove very beneficial.

For the relief of the auditory symptoms, the remedies at our command are chiefly empirical. We are ignorant of the exact indications for their particular employment, and therefore a simple account will be given of such as have proved efficacious in different instances.

In the first rank may be placed the various ethereal preparations and chloroform. They are employed both externally, and through the Eustachian tube with the aid of the catheter. From five to ten drops of the following combinations may be applied to the auditory canal on cotton-wool in the evening, or more often during the day: æth. sulph., 2·0 to 4·0; glyc., 10·0; or æth. acet., 2·0 to 4·0; tinct. valerian, 10·0; or chloroform, 2·0 to 4·0; glyc., 10·0; or the ethereal vapour may be blown into the tympanum through the catheter by means of the air-ball, into which a few drops of sulphuric or acetic ether have been previously introduced. By this treatment the hearing is sometimes improved, and in other cases the noises in the ear may be lessened. If no effect follow after, say, ten applications, their employment may be relinquished as useless.

The inhalation of two or three drops of nitrite of amyl is said by *Michael* and *Urbantschitsch* to be beneficial in tinnitus; but this has not been substantiated. It usually produces severe vertigo, and sometimes even syncope, without any good result, and its repetition is generally objected to by the patient.

Nerve sedatives, such as opium, morphia, hyoscyamus, cocaine, and chloral hydrate, are also used for the relief of noises in the ear. They may be taken internally, applied externally to the auditory canal or to the neighbourhood of the ear in the form of ointments, or employed hypodermically. Chloral hydrate may be administered, or injected in solution through the Eustachian tube (*Lucæ*).[1] Cocaine may be injected subcutaneously, or given internally (cocaine 0·02 to 0·05, sacch. alb. 1·00; a powder to be taken in the evening). The hypodermic injection of morphia may be employed, especially when the symptoms are worse at night and prevent sleep. A favourite remedy is oil of hyoscyamus with tincture of opium (ol. hyoscyami 10·0, tinct. opii 1·0; ten drops, on cotton-wool, to be placed in the ear two or three times a day). Bromide of potassium or sodium in one to three gramme doses are among the drugs most used and most efficacious for the relief of nervous tinnitus. The author prefers them to be taken at bedtime. He has not found hydrobromic acid to be of service.

Other remedies recommended for these derangements are the various balsamic substances. Camphor especially was much used in former times, and is even now esteemed by the public a panacea in aural affections. It may be employed in the form of an ointment—*e.g.* camphor 0·10, ol. menth. pip. 1·0, ung. simpl. 10·0; a portion the size of a pea to be rubbed around the ear morning and evening; or it may be

[1] "Ueber locale Anwendung des Chloralhydrates beim sogenannten trockenen chronischen Mittelohrcatarrh." Berlin. klinische Wochenschrift, 1872.

dissolved in oil, and five to ten drops introduced into the auditory canal on cotton-wool (ol. amygd. 10·0, camph. 0·1); or again, a small piece may be wrapped in cotton-wool, and this placed in the ear. In nervous, very debilitated patients its internal use is occasionally beneficial (0·05 to 0·10 gramme pro dosi).

Valerian, arnica, and nux vomica likewise enjoy a certain reputation. The author has found the internal administration of arnica advantageous in many cases, and has in particular often observed that troublesome nervous tinnitus has been relieved or even completely removed by its use. Five to fifteen drops of the tincture may be taken on sugar several times daily. Strychnine has been specially recommended by *Kramer* for noises in the ears. It is most effectual when employed hypodermically. The author commences by injecting two drops of a 1 per cent. solution; increasing this to eight drops, and repeating the treatment every other day. It should, however, be remembered that the effect of strychnine is cumulative, and care must therefore be exercised in increasing the dose. Many patients are affected with severe vertigo even after the first injection; and though this soon passes away, it indicates the necessity for caution.

Ferruginous preparations may be given with advantage in anæmic, and especially in chlorotic individuals. They may be prescribed either in solution or as powders—*e.g.* the lactate, phosphate, or carbonate of iron; dialysed iron with carbonate of soda and sugar; or a few drops of a mixture of equal parts of tinct. ferri and tinct. aurantii. In scrofulous or syphilitic cases, the syrup of the iodide of iron is useful. A teaspoonful of a mixture of equal parts of this and of syrupus aurantii may be taken twice or three times a day (*Von Sigmund*).

Preparations of iodine have also been employed in affections of the labyrinth, either internally, or externally to the region of the ear. Their effect is frequently beneficial in these cases, especially when exudation has taken place. They may be combined with other remedies—*e.g.* with camphor. The author often employs the following ointment:—Ammonii seu potassii iodati, 2·00; camphor, 0·10 to 0·30; ol. menth. pip., 1·00; ung. simpl., 10·00: a piece of this the size of a pea to be rubbed over the mastoid region for five minutes morning and evening. The iodides of potassium, sodium, or ammonium may be given internally; the last was warmly advocated by *Hinton*. The iodine-ethers are also used by some by way of the Eustachian tube. The best result is in many instances to be obtained from a regular course of the natural iodated waters and baths.

Baths of the indifferent warm springs, and even of common warm water, will often alleviate the symptoms; while in some cases, on the other hand, this treatment aggravates the condition. When circumstances do not otherwise contra-indicate it, a methodical cold water cure may be

carried out; though as a general rule, little benefit is derived from it in regard to the aural trouble.

In labyrinthine disorders induced by frequent congestions of the head, the fundamental cause of the ailment should be investigated. Saline waters, or remedies which promote digestion or act directly upon the biliary secretion, sometimes render good service in cases of derangement of the abdominal organs. Aloes has in particular acquired a certain reputation in aural affections.

If the tinnitus be very loud, and associated with giddiness in robust plethoric subjects in whom circulatory disturbances are present, local or general bleeding, or dry cupping to the neck, may be adopted. Vesicants are likewise recommended, to be followed up with hypodermic injection of quinine or opiates. Methodical rarefaction of the air in the external auditory canal has an excellent effect; and, according to *Weil*, inflation of the canal is useful for the relief of severe attacks. The latter procedures may be carried out by the patient himself with the aid of the simple apparatus designed by the author for atmospheric rarefaction—a point which is of much advantage.

We now come to the application of electricity, which may be made in the form either of the induced or the constant current. The latter is used much more frequently than the former, which is employed almost exclusively for cases in which pathological changes are present in the muscles (tensor tympani and stapedius). The apparatus used by the author[1] consists of twenty Siemens-Halske elements, with rheostat, commutator, and electrodes of various forms; but, since the introduction of the simple and ingenious graphite rheostat of *Gärtner*, he uses this for opening and closing the current. According to *Erb*, the rheostat is superfluous, but not the commutator. The electrodes may be applied in various ways. The author mostly follows the practice of *Duchenne* in introducing a wire-like electrode, isolated almost to the extremity, into the auditory canal which has been filled with tepid water; the other electrode is applied in the vicinity of the ear (mastoid region or zygoma). In very sensitive individuals, especially if the auditory canal and tympanic membrane be hyperæmic, one electrode may be applied over the mastoid region, and the other near the zygoma, or one before the ear of one side, and the other behind that of the opposite side. When it is desired to act upon the internal muscles of the ear, a long wire electrode may be passed through an elastic catheter into the mouth of the Eustachian tube, and the other inserted into the auditory canal, in which some water has been placed.

Erb[2] employs as an electrode a square plate, the side of which is

[1] It is made by the firm of *Meyer* and *Wolf* in Vienna, ix. Bez., van Swietengasse.

[2] "Zur galvanischen Behandlung von Augen- und Ohrenleiden." Archiv für Augen- und Ohrenheilkunde, ii. Bd.

4 *cm.* in length, and fixes it just in front of the ear; the other electrode being somewhat larger and applied to the neck. They should be moistened with water before being used. *Erb* believes that, in nearly all healthy individuals, a current of smaller strength is sufficient to stimulate the auditory nerves when employed in the manner described.

With respect to the latter point, the statements of physiologists and aurists differ widely. While some are of opinion that the acoustic nerve cannot be stimulated at all by the galvanic current, others hold that auditory sensations may be excited even by very weak currents. Both sides rest their views upon their own careful observations, and are perfectly justified in so doing. Experience teaches, in fact, that an extremely slight current may in many persons produce a reaction in the auditory nerve; whilst in others, even strong currents (*e.g.* 20 elements) are unable to bring this about; and in such cases, pain, vertigo, and nausea, are often caused without the faintest acoustic perception.

The author's experience is completely in accordance with *Benedikt's* statement,[1] that the electric current can evoke auditory sensations much more readily in ears in which morbid changes exist, than in such as are in a healthy state.

In regard to the manner in which acoustic phenomena are induced by the galvanic current, many views are extant. *Schulz*[2] thinks that the peripheral extremities of the sensory nerves are in a state of electrotonus at the place of application of the electrode, and that this condition is propagated up the nerves to their central terminations, from which it is transmitted to the sensorial centre, to be there translated into consciousness. *Benedikt* believes that auditory perceptions in the acusticus are invoked by the reflex activity of the sympathetic; and he consequently bases his treatment upon galvanisation of the latter nerve. *Erb*, however, considers this hypothesis of *Benedikt* to be unsubstantiated.

Brenner[3] has constructed a special theory of electro-otiatrics upon the basis of his own observations. He claims for the constant current, not only much therapeutical importance, but also a distinct diagnostic value. According to him, a current-strength of from 6 to 9 Wollaston's elements, with the electrodes arranged as recommended by *Duchenne*, is always capable of exciting an acoustic sensation in individuals with normal hearing. Thus, when the kathode (K) is in the auditory canal, a loud sound (S′) is perceived upon closing the current (C); and, as the latter continues to pass (D), the sound gradually fades away (S s s). When the circuit is opened (O), no fresh sensation of sound occurs (—). If, however, the anode (A) be placed in the ear, no sound whatever is heard when the

[1] Wiener medicinische Presse, 1873.
[2] Wiener medicinische Wochenschrift, 1868.
[3] Untersuchungen und Beobachtungen auf dem Gebiete der Electrotherapie." Leipzig, 1868.

current is closed, nor while it is passing; but when it is opened a weak sound becomes audible (s).

Conformably with the above, *Brenner* has drawn out a "normal formula," as follows:—

KC. S′	Kathode closure.	Loud sound.
KD. S s s	Kathode duration.	Sound dying away.
KO. —	Kathode opening.	No sound.
AC. —	Anode closure.	No sound.
AD. —	Anode duration.	No sound.
AO. s.	Anode opening.	Weak sound.

Brenner supposes that a deviation from the formula indicates some morbid condition, which is to be regarded as a *depreciated* or an *exaggerated sensibility* of the auditory nerve, according as a stronger or a weaker current be needed for the establishment of the proper reaction. He considers that, so far as the results of testing with the constant current exhibit variations from the above formula, they furnish data for the diagnosis; and he also believes that by the methodical application of the current, any irregularities which exist may be remedied.

Brenner distinguishes between primary, secondary, and tertiary excitability. The primary he calls, that corresponding to the number of electromotor elements necessary to call forth the functional activity of the nerve. The secondary is that shown when the number of elements is reduced to the point at which the nerve just continues still to respond to the stimulus; and the tertiary excitability is manifested on a further reduction of the number to that at which the nerve yet remains capable of reaction on reversal of the current.

The doctrine of *Brenner* is now accepted by very few; it having been completely refuted by *Schwartze*[1] soon after it was enunciated. He proved that the so-called "normal formula" does not always hold for healthy ears; and that, on the other hand, the reactions in the case of a person totally deaf, who was examined by this method, were nevertheless in accordance with it.

Many cases of nervous deafness without any changes in the external or middle ear are attributable, according to *Althaus*,[2] to asthenia of the auditory centre; and to this circumstance is to be ascribed the recovery or improvement of a number of such cases on galvanisation of the temporal lobe. Hallucinations frequently depend upon hyperæsthesia of the same region, unaccompanied by any structural change. He relates the following case: A married man, thirty-eight years of age, had suffered for several years from epileptic convulsions, for which he consulted him in February 1879. The patient's memory had become bad, but his intellect and other faculties were unimpaired. One morning he experienced hallucinations of hearing, without knowing whence they originated. He constantly heard

[1] "Ueber die sogenannte 'Electro-Otiatrik' *Brenner's*." Archiv für Ohrenheilkunde, i. Bd.
[2] "Ueber Asthenie des Gehirns." Centralblatt für Nervenheilkunde, 1882.

voices behind him making all kinds of objurgatory remarks, particularly concerning his pecuniary position. The constant current, applied for five minutes on the side of the head, caused the symptoms to disappear, and they did not return.

As regards the employment of electricity, the author, from his own experience, entirely agrees with *Schwartze* in reference to *Brenner's* statements about "electro-diagnosis." Neither, unfortunately, can he say much as to the effects of electricity in aural diseases from a therapeutical point of view. The induced current appears most serviceable in cases in which there is a paretic condition of the internal muscles (*Weber-Liel*). Perhaps, too, the electrolytic action of the galvanic current may have an influence, as *Schwartze* has suggested, upon plastic processes in the middle ear; though the results hitherto obtained are not of a very favourable kind.[1]

With respect to particular symptoms, it is certainly true that galvanism is frequently capable of temporarily relieving or removing the subjective auditory sensations. It is nevertheless well ascertained that a permanent cure of these is an extremely rare occurrence, and that in the majority of instances the noises return after a few hours, sometimes in a much more intense degree.

In such cases, or in those in which other morbid symptoms are increased by the application of electricity, its further employment should be undertaken with much circumspection, as thereby the condition may be considerably aggravated. Electricity may tend to improve the hearing power when general nervous affections are present which are benefited by this mode of treatment. The author has, however, not been able to convince himself of its efficacy in primary disease of the auditory nerve. If he were to draw a conclusion from his own experience of its action, he should in general agree with *Bettelheim*,[2] who says that, though it may be proper to employ it in cases of nervous aural affections after long-continued treatment conducted on ordinary principles has proved fruitless, yet it would not be good practice to do so before everything else had been tried.

Finally are to be mentioned, the *auditory contrivances or ear-trumpets*, which are intended to be used by persons whose hearing is impaired, with the object of ameliorating their condition. The improvement is brought about by them, either by a more suitable form and position in regard to

[1] *Bonnafont* connected one electrode with a wire introduced into the Eustachian tube, and the other with an acupuncture needle which was pushed through the tympanic membrane on to the promontory, and was kept in position by means of cotton-wool in the external auditory canal. He met with but slight success, however, from this method. "Reflexions sur le degré de confiance qu'on doit accorder à l'électricité dans le traitement de surdité en général, etc." Gazette de Paris, 1861.

[2] "Ueber die Wirkung des electrischen Stromes auf das Gehörorgan." Wiener medicinische Presse, 1868.

function which they produce in the sound-conducting apparatus; or in virtue of their shape and the material of which they are made facilitating the collection and conduction of a larger number of sound-waves than would otherwise be transmitted. The former kind are generally of advantage only with a low degree of imperfect audition; whilst the latter are often of service even in cases of pronounced deafness.

The hair may often be easily arranged so as to improve the position of the auricle, as indicated in the description of abnormalities of this structure. Thus, it may be brought behind the ear in such a way as to press this forwards to a variable distance from the side of the head. If this cannot be done, an apparatus in the form of two metal slips connected at their ends with a spring may be employed, which clasps and pushes forwards the attachment of the auricle.

In cases of narrowing of the meatus due to collapse of its walls, especially in old people in whom the angle of the lower jaw has become widened, small tubes of silver or gold are useful (*Abrahams*). They are made about 1 *cm.* long, with the inner extremity rounded off, and the outer ending in a small cup-shaped expansion, painted so as to resemble the integument. The cup has a concave margin which is to be directed forwards to receive the tragus. These little tubes with a piece of cotton-wool twisted round them are placed in the auditory canal, in which they remain fixed by themselves. Though sometimes of advantage in the cases referred to, the number of patients who derive benefit from them is very small, compared with those from whom money is extracted on their account by the practices of quacks. They may even be prejudicial, where a definite indication for their employment is absent, as they narrow the lumen of the canal, and so obstruct the entrance of sound-waves. The author can say nothing more favourable, either of recent modifications of these tubes, or of the apparatus of *Politzer*, which is said to transmit the vibrations of the auricular cartilage by means of a drainage-tube from 4 to 5 *cm.* long. The outer end of this tube is provided with a gutta-percha disc, to be fixed in the deepest part of the auricle in front of the meatus; whilst the inner extremity is brought into contact with the tympanic membrane. The contrivance cannot be recommended, if only on account of the pain caused by its touching the drum-head.

Besides those just described, many other instruments are in use, differing from them in size, shape, and the materials of which they are made: *e.g.* vulcanite, horn, or metal,—as a rule brass. The form is not without importance, as experience shows that with some patients, an ear-trumpet of a certain shape may perhaps be more serviceable than others constructed more in accordance with the laws of acoustics. The fundamental principle in all, is that one end is expanded for the reception of the sound-waves, while the other is suitably curved for insertion into

the auditory meatus. If an instrument for use with both ears be desired, the narrow end is so made that it may be turned round in the tube, and thus adapted for either side. The central portion varies in width and length, corresponding to the intensity of resonance required. Metal instruments are usually shaped like a trumpet, post-horn, or hollow cone. The so-called elastic ear-trumpets serve their purpose very well. They consist of a variously long elastic tube of spirally-coiled wire, which is surrounded by an external casing of indiarubber material. At one extremity of this tube is a resonance-cup, and at the other is the piece for insertion into the auditory canal. The patient can carry such an apparatus about with him round his neck, and easily bring it into use when requisite.

Metal tubes conduct sound better, but they have the disadvantage of producing loud accessory sounds, which greatly annoy the patient. This imperfection is less prominent in those made of vulcanite or horn; and the elastic tubes can be so constructed that no accessory sounds occur at all; for which reason they are to be preferred.

During the last ten years, many forms of apparatus for assisting the hearing have been devised, without coming essentially nearer to the ideal of an invisible instrument. The most noteworthy improvements almost exclusively concern their more convenient manipulation, but by none of them has an important advance been attained in increasing the hearing power at a distance. *Leiter's* ear-trumpet is handy: the main part, of vulcanite, can be carried in the coat sleeve or waistcoat pocket; and when required for use, one needs only to place the insertion-piece in the ear. Ear-trumpets have also been adapted to walking-sticks, umbrellas, fans, etc.; and the author long ago proposed that they should be attached to neckties, head-dresses, etc.

Others have endeavoured to take advantage of sound-conduction through the cranial bones. In this way originated *Rhodes'* "Audiophone," consisting of a flexible vulcanite plate, 25 to 30 *cm.* long, and 20 to 25 *cm.* wide, and furnished with a handle by which it is held when used. The free margin of the plate is intended to be placed on the incisor teeth, or on the zygoma. In *Turnbull's* modification, the plate is constructed of separate parts, connected by hinges, and by this means a variable curvature may be given to the instrument. The "Dentaphone" is another apparatus based on the same principle. In this, the vibrations communicated to the plate, are said to be conveyed to the labyrinth through the medium of a spring held between the teeth.

The "Fonifero" of *Paladino* is intended for the conduction of the sound-vibrations from the larynx of a person speaking, directly to the teeth or auditory canal of the listener. It consists of a rod, $\frac{1}{2}$ to $\frac{2}{3}$ *m.* in length, one extremity of which carries a semicircular piece to be adapted to

the larynx of the speaker, and the other end is provided with a moderately curved piece for application to the teeth or ear of the deaf individual.

The various apparatus already described have for their aim, not merely the improvement of the hearing-power, but are also in a certain sense curative in their action. If in regard to the latter, an influence so important as that asserted by *Toynbee* and others cannot be justly attributed, it must nevertheless not be forgotten that both the auditory nerve and the internal muscles of the ear, suffer gradually from want of exercise. These structures are found in an atrophic condition, when they are no longer sensitive to ordinary sounds. In chronic ear affections, the ear-trumpet should therefore be used at a sufficiently early stage to prevent enfeeblement of the function of the acoustic nerve as a result of disuse. In this matter, however, we have unfortunately often to contend with much vanity and prejudice, in order to induce patients to follow a rational course.

On the other hand, it should be remembered that the sensibility of the nerve is liable to be deadened by too strong stimulation, in which case it responds less readily to a slight exciting cause—a circumstance which must be taken into consideration in the choice of an ear-trumpet. The author would in this connection submit the following principles:—

1. The employment of an ear-trumpet ought not to be too long postponed. In chronic aural affections, the use of an instrument should not be delayed until the hearing of the patient becomes lost, or inadequate for social intercourse; but it should be adopted as soon as possible.

2. The choice of an instrument ought to be made in a similar way to that of eye-glasses—*i.e.* it must be properly adapted to the particular case.

3. Those kinds are to be preferred which produce fewest accessory sounds.

4. An apparatus should not at once be selected by which sounds are heard best; but rather such as suffices for ordinary intercourse, even though it necessitates some effort of attention.

5. Regard should be had, as far as possible, to the convenience and inclination of the patient; and in this respect, instruments are preferable which retain themselves in place, without requiring to be held by the patient; as well as such as are least conspicuous.

Sometimes an elastic ear-trumpet will suffice for ordinary intercourse, while a more powerful instrument will be needed to enable the person to take part in a general conversation. In such a case, therefore, more than one apparatus should be kept at hand.

Certain phenomena which have been recently the subject of much discussion, and which deserve mention here, are the *secondary sense-perceptions*; whereby upon a simple sensory stimulus, sensations are produced in two different sense-

organs. An individual, for example, manifesting this peculiarity, not only perceives a tone in the usual way, but may likewise experience a sensation of colour; the same colour-sensation being always excited by the same tone. According to *Baratoux*,[1] this phenomenon was first observed by *Dr. Sachs* of Erlangen, in himself, in 1812; and his sister is said to have had the same peculiarity. They were both albinos, and *Sachs* describes the condition in his "Historia naturalis duorum lucaethiopium auctoris ipsius et sororis ejus," 1812, p. 82. Among later accounts, that of *Lussana* is particularly interesting. He was acquainted with two brothers who manifested the same idiosyncrasy. *Nussbaumer* directed the attention of the profession in Vienna to the subject in an essay which appeared in 1873.[2] He himself, as well as one of his brothers, exhibited this condition; while his other brothers and sisters were free from it. On hearing the same tone, they always experienced a sensation of colour, but the colour in each case was different. Upon the rattling of a carriage, *Nussbaumer* perceived a grey colour, but other noises did not evoke any optical phenomenon. When they heard accordions played, they saw different colours, according to the various tones. *Nussbaumer* was able to rid himself of the secondary sensation by diverting his attention to some other matter. Among later communications,[3] that of *Bleuler* and *Lehmann* is especially noteworthy. The results of their investigations, set forth in a detailed report,[4] show that out of 596 persons examined, 76—*i.e.* 12·8 per cent.—exhibited secondary sense-perception (45 males and 31 females). The sensations of light and of colour (photopsia and chromatopsia) which follow upon sound stimuli, they designate "schallphotismen"; while the sensations of sound produced by impressions of light and colour, they call "lichtphonismen." According to these authors, light and colour sensations may also be evoked by gustatory and olfactory stimuli (geschmacks- and geruchs-photismen); and presentations of colour and form may result from impressions of pain, heat, and taste. The secondary sensations are simultaneous with the primary; or in some rare cases, appear after a short interval. In those who manifest this peculiarity, the effect of a given impression varies. For example, a noise may in one person induce a secondary sensation; whereas in other individuals, none results, though these may be susceptible to other primary stimuli. *Bleuler* himself heard noises as a result of visual impressions.

Steinbrügge saw in Madeira an ecclesiastical neophyte, sixteen years of age, who, besides being the subject of secondary optical sensations, saw also with each prayer, a line ascending in the room in a different direction. *Steinbrügge* believes that some of these cases are examples of double sensations in which an exaggerated cerebral irritability plays a chief part, but that the greater number are instances of association of ideas. *Baratoux* and *Urbantschitsch*,[5] on the other hand, are of opinion that the phenomenon is to be referred to a physiological correlation of the organs of sense. Further investigations are needed for the elucidation of this subject.

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[1] "De l'audition colorée." Publications du Progrès Médical.

[2] "Ueber subjective Farbenempfindungen, die durch objective Gehörsempfindungen erzeugt werden."—Wiener medicinische Wochenschrift.

[3] Compare *Baratoux's* previously mentioned work; as well as *Steinbrügge*, "Ueber secundäre Sinnesempfindungen." Wiesbaden, 1887.

[4] "Zwangsmässige Lichtempfindungen durch Schall und verwandte Erscheinungen auf dem Gebiete der anderem Sinnesempfindungen," 1881.

[5] Compare Sitzungsbericht der Wiener k. k. Gesellschaft der Aerzte vom 22 October, 1887.

CHAPTER XXI.

DEAF-MUTISM.

A CHILD acquires the power of speech by a process of imitating that which it hears, and therefore in dependence upon the integrity of the sense of hearing. A deaf child, or one whose hearing is impaired, cannot learn to speak in the natural way—that is to say, an imperfection in the faculty of speech is associated with an imperfection in the hearing function. The pathological condition which entails the deafness need not necessarily be congenital. Experience shows that during the first years of life, children whose hearing becomes lost in consequence of disease, very soon forget how to speak, and become both deaf and dumb, although they have already spoken. Upon this fact is founded the distinction between *congenital* and *acquired deaf-mutism*, and statistics prove that the acquired is of more frequent occurrence than the congenital condition.

With regard to the age at which a child who is able to speak loses this faculty as a result of becoming deaf, it can only be stated generally that this is usually the case up to the age of six years; but that in certain instances the power of speech may be retained, though the hearing becomes impaired at the fourth or fifth year. The result depends chiefly upon the mental development and upon judicious surroundings. A child forgets speech because it merely imitates mechanically the words it has learnt to utter, without any accurate comprehension of their meaning. If its mind be more developed, it will forget less readily, and its memory may be stimulated by lively social intercourse. More especially may its conceptions of words be preserved or suggested, by a timely method of instruction by demonstration. Children who can already read and write do not easily forget how to speak, while those who are older but more backward, rapidly lose the faculty of speech if they should become deaf; as happened, for example, in the case of a boy twelve years of age, referred to on page 418. Sometimes a few words can be pronounced, though usually in an imperfect manner: four or five indistinctly enunciated words, to which, however, the same signification is always attached, constituting their entire vocabulary.

When the hearing is much impaired, the child cannot hear the words used in ordinary conversation, and consequently cannot repeat them,

although it may not be completely deaf. With reference thereto, deaf-mutes are classified as :—

(*a*) Such as still retain their hearing power to a certain extent ; and

(*b*) Those who are totally deaf.

Those in whom the auditory faculty is not absolutely destroyed, exhibit various degrees of such impairment. Some can hear only the loudest noises—*e.g.* the report of a cannon. Some perceive weaker tones and noises,—perhaps that of a bell ringing. Others, again, are able to hear certain definite sounds, such as one or more of the vowels or consonants, or even certain syllables. Finally, there are those who can repeat words of more than one syllable more or less distinctly when pronounced behind their back, although their hearing capacity is inadequate for learning to speak in the usual way.

Since the incapacity for speech is but a natural consequence of the deafness, it follows that all morbid changes in the organ of hearing or of the central nervous system which may bring about deafness, may also lead to deaf-mutism. Such changes may be sometimes referred to intra-uterine aural affections from which recovery has taken place; but they mainly occur during the first years of life.

Scarlet fever with diphtheritic inflammation stands first among the diseases which destroy the hearing in early childhood. Other acute exanthemata, inflammation of the intra-cranial structures, and more particularly epidemic cerebro-spinal meningitis, hydrocephalus, and cretinism, are sometimes associated with deaf-mutism. Labyrinthitis, typhoid fever, and mumps may also cause deafness in infancy, and therefore deaf-mutism.

The belief that close consanguinity of parents frequently leads to deaf-mutism in the offspring, is generally well-founded.[1] An hereditary predisposition to this infirmity cannot be denied, if it be considered how frequently it recurs in families in which it has once appeared. It is also extremely interesting to observe how its occurrence sometimes follows a certain rule. Thus there are some families in which all the male offspring are deaf, while all the females are unaffected—and vice versâ. The author is acquainted with a married couple of whom the five sons are all deaf and

[1] According to the reports of *J. Deutsch*, the statistics of the Vienna Jewish School for the Deaf and Dumb, are in favour of this hypothesis. *John Roosa* also states that a district in America, where such marriages are common, furnishes a large contingent of deaf-mutes to these institutions ("Remarks on the etiology of congenital deaf-mutism," Bulletin of the Academy of Medicine, New York, 1868). Amongst the negroes of Iowa, with whom marriages between near relations are of constant occurrence, the number of deaf-mutes is, according to *Lacassagne*, 91 times greater than among the white population ("Des unions consanguines, de leurs influence et des rapports de la consanguinité avec la surdi-mudité congénitale." Ann. des mal. de l'oreille, 1876. *Hartmann* again, states that in Germany, 12·9 per cent. of congenital deaf-mutes are the offspring of unions between blood-relations; while, on the other hand, only 3 per cent. of the cases of acquired deaf-mutism spring from such alliances.

dumb, but the four daughters hear and speak perfectly well.[1] Sometimes the imperfection skips one generation, to reappear in the next.

Hartmann calculates that, in round numbers, out of 246 millions of the inhabitants of the earth, about 191,000 are deaf-mutes—*i.e.* on an average, about 7·7 in every 10,000. In Europe, the lowest proportion exists in the Netherlands—viz., 3·35 in 10,000. In Belgium it is 4·39; in England, 5·7; in Denmark, 6·20; France, 6·26; Spain, 6·96; Italy, 7·34; Norway, 9·22; Austria, 9·66; Germany, 9·66; Sweden, 10·23; Hungary, 13·43; and in Switzerland, 24·52. In other parts of the world, Australia stands lowest, with 1·83 in 10,000; then come the United States, with 4·20; the West Indies, 7·62; Canada, 8·05; Africa, 16·01; while in the Argentine Republic it is 38·07.

In Germany the maximum is shown in Sachsen-Meiningen (13·1), and the minimum in Lippe-Detmold (5·0).

The number of cases often varies considerably in different parts of the same country. In the district of Zell am See, for example, and in St. Veit and Wolfsberg in Kärnten, the proportion of deaf-mutes reaches as high as 50 in 10,000.

If the condition is to be referred to some pathological change in the ear or in the central nervous system, additional symptoms may naturally be present. It is, however, very remarkable that deaf-mutes who still retain a certain degree of hearing power, and manifest such morbid changes in their ears as are commonly associated with subjective auditory sensations, are so seldom troubled with tinnitus. When, however, noises in the ears do occur in deaf and dumb individuals, they are very apt to take on the character of hallucinations, and then generally constitute the earliest symptom of a subsequent mental derangement.

From what has been said in regard to the etiology of deaf-mutism, it follows that questions both as to *prognosis* and *treatment* may come into consideration. In this relation, the actual objective conditions present must determine any treatment which may be feasible, in accordance with the principles previously set forth. Even if the results attained be but very rarely satisfactory, such measures as may appear advisable should not be omitted in appropriate instances. The least improvement in the hearing is of the first importance, since experience shows that if this advantage be gained, a deaf-mute child taught to speak by an artificial method (lip-reading), will do so much better and much more distinctly than if nothing at all could be heard. A greater distinctness of speech affords a great relief in social intercourse, both to the deaf-mute and those with whom he is in communication.

[1] Compare *Wilde*, "The census of Ireland for the year 1861," part iii., vol. i.; and *Moos*, Archiv für Ohrenheilkunde, Bd. i. In 211 families, numbering 320 persons, whose direct or collateral antecedents were deaf and dumb, there were 187 deaf-mutes in whom the infirmity had been transmitted from the paternal, and 183 in whom it descended from the maternal side. 135 were married (76 males and 59 females), and of these couples there were 129 in which the husband alone, or the wife alone, was deaf and dumb—viz. the husband in 73, and the wife in 56 cases. Of 91 of these individuals, 213 children were born, of whom only 3 were deaf-mutes. In three instances in which both man and wife were deaf and dumb, there were 12 children, amongst whom not one was either deaf or a deaf-mute.

It must again be repeated that the persons to whose care a deaf child is entrusted, should direct timely and assiduous attention to its infirmity. If the child be merely hard of hearing, it should always be spoken to loudly enough to be heard. Many would not have become deaf, if their friends had regarded their condition sufficiently early, and instead of making things easier for themselves by using signs, had persevered with speech, and had always named, instead of simply indicating, the things about which they were talking.

Unmistakable progress has been made during the last forty years in the education of deaf-mutes, in the almost universal supplanting of the employment of signs and gestures by the method of teaching speech by lip-reading.[1] The modern method is to be preferred, because it places the deaf-mute in a position to be understood by all persons whose faculties are perfect, and not merely by those alone who are acquainted with the language of signs. The respiratory organs besides, are invigorated by being exercised in speaking. In connection with this matter, the author fosters the desire, that in deaf and dumb asylums those who possess some slight hearing capacity should be separated from the remainder in whom this is entirely absent. By this means much advantage would accrue to the former, in regard both to improvement of the hearing power and clearness of speech. By intercourse, on the other hand, with those who can hear nothing at all, they become readily habituated to the unpleasant guttural tone which is peculiar to the latter and renders them frequently unintelligible. Furthermore, it is much to be wished that the method of outdoor instruction experimentally and successfully tried in London in 1874, may also find imitation elsewhere. The limitation of the social intercourse of deaf-mutes with the outer world is much too great by their confinement in special asylums, and is detrimental to their mental development. The efforts of charitable persons would be exercised in a manner equally beneficial and grateful, by the establishment of houses near deaf and dumb schools, where children thus afflicted could find shelter and maintenance, while their education meanwhile was cared for in the neighbouring institution.

[1] Further details concerning the instruction of the deaf and dumb may be found in an able paper by *Dr. Elsner*, "Ueber Taubstumme und ihre Erziehung," in the Archiv für Ohrenheilkunde, vol. v. Likewise in an essay by *Coldefy*, "De l'education des Sourds-Muets," in the Annales des Maladies de l'Oreille, etc., 1879; and in *Hartmann's* work on deaf-mutism and the instruction of the deaf and dumb.

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