BEZOLD AND SIEBENMANN'S

TEXT-BOOK OF OTOLOGY

TRANSLATED BY

J. HOLINGER, M.D.

M B.

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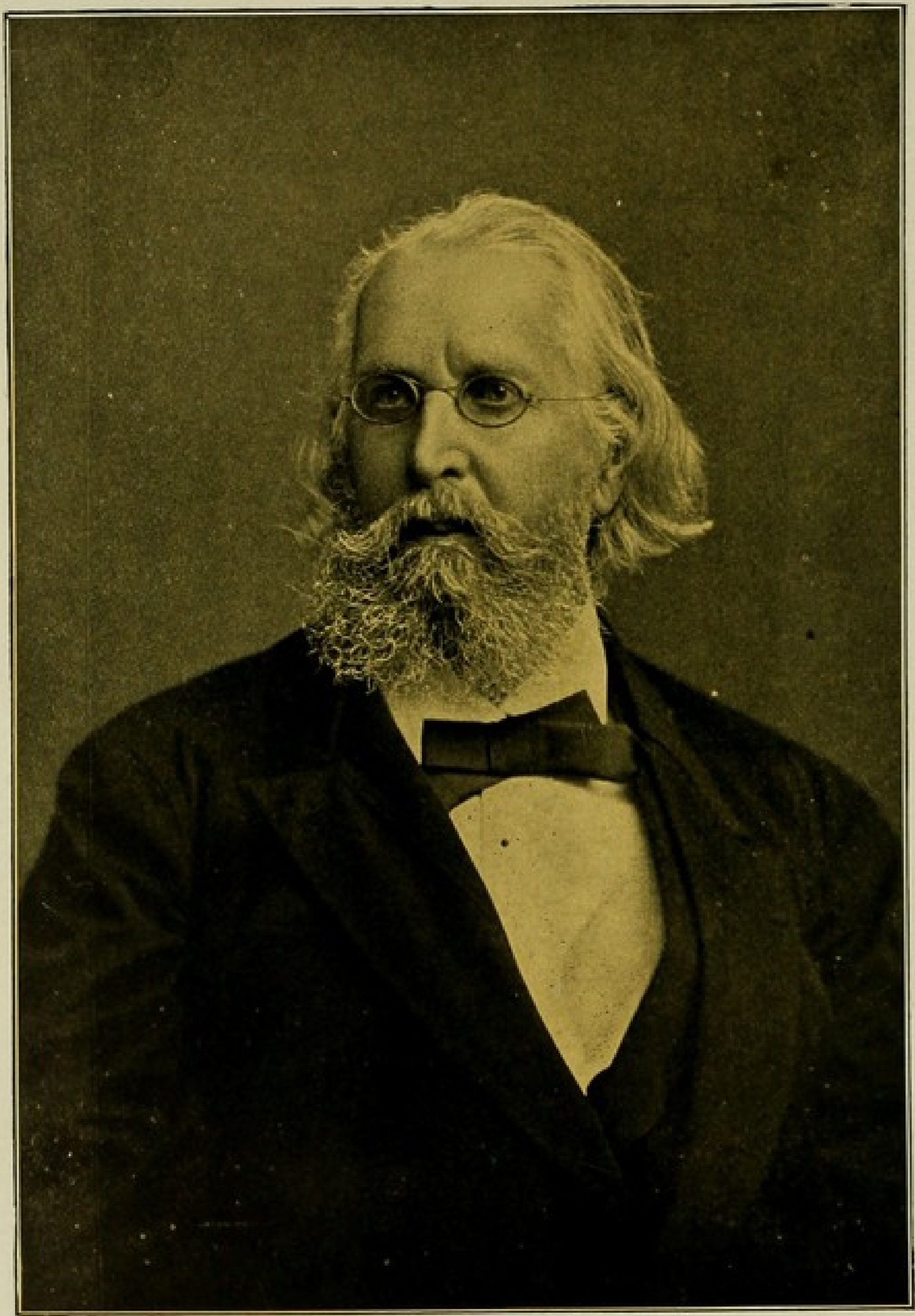

Horace A. Ross
Major, M.D.
Boston, November, 1910,

TEXT-BOOK

OF

OTOLOGY

FOR

PHYSICIANS AND STUDENTS

In 32 Lectures

BY

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Preface of the Author (Abridged)

Having taught otology for twenty-five years, I decided to condense in a text-book all that has developed in the course of years and is worth being retained. This decision was in response to the wish of my disciples, many of whom are now professors of otology. The book is written for physicians and students. Its teachings differ in many respects from the ideas which prevail at present. Distinct advances will be found even outside of the direct clinical domain, in physiology and topography.

Physiology gained from a careful study of the changes of the sound-conducting and sound-perceiving apparatus and from the analysis of the influence of those changes upon the function of the organ of hearing. The clinical importance justifies the amount of space devoted to it.

The *topography* of the ear and its surroundings is accurately described because it indicates the avenues frequented by the numerous diseases of the organ of hearing.

Only those operations have been accurately described which the general practitioner may be called upon to perform. A description of the technic of the major operations, such as the opening of all the spaces of the middle ear, the operations on the sinus and bulbus, of otitic abscesses of the brain, etc., is worthless to the student if it is not supplemented by years of training in some special clinic.

The complications of diseases of the ear which require those operations have been, however, carefully discussed, as it is the general practitioner who has to recognize the danger signals.

The therapy which I advocate is stripped of all unnecessary ballast. To many it may appear simple, to the general practitioner this simplicity may mark its greatest advantage.

On account of illness the lectures XXVIII to XXXI were written by my former disciple, Prof. Siebenmann, who did a great deal of original research work on their subject, the diseases of the inner ear.

The author limited himself to present what he recognized as of the greatest importance after years of careful discrimination and refrained from reproducing a large number of contradicting theories and methods.

In order to obtain clearer views on many questions of my specialty, I have worked on anatomical, clinical, statistical and physiological problems uninterruptedly since my student days and have therefore to refer repeatedly to these investigations. Wherever matters are given that may be new to the men of our specialty I have entered into details and have referred to the literature.

Other branches of science have profited by view points gained through the researches in the distant regions of our specialty. Of those sciences I might mention general medicine, physiology, our knowledge of the means of self-protection of the organism and the education of deaf-mutes.

Preface of the Translator

The need of a translation of Bezold's "Text-Book of Otology" became apparent among otologists, whenever the discussion led to the subject of diagnosis of invisible diseases of the ears. This diagnosis was based on the characteristic changes of function. The great importance of this means of diagnosis becomes evident in our office and clinic every day, and ere long the otologist who is not thoroughly familiar with it will be in the same position as the surgeon who does not examine the function of a joint, of a stomach, of a bladder, etc., which he is called upon to treat. The negative proof for the accuracy of this diagnosis may be seen in the fact that no case as yet has been published where the pathologic diagnosis contradicted the functional diagnosis in the living. A positive proof was published last spring by Prof. Siebenmann, who demonstrated a labyrinth showing characteristic pathologic changes which had been predicted years previous by Prof. Bezold when only the changes of function in similar cases, but not their pathology was known.

The general practitioner with scholarly proclivities will be interested also in the statistics of the various diseases of the ears, and in the chapters on pathology of the labyrinth, on deaf-mutism and on education of deaf-mutes.

The book has been printed by W. B. Conkey & Co., who have in our opinion produced a first-class book in all respects. The entire expense of the publication has been undertaken by the translator.

If I have succeeded in presenting the subject matter of "Bezold's Lehrbuch der Ohrenheilkunde" in a clear and concise manner and acceptable form I will have accomplished my object.

In connection with this work I have received the aid from Dr. T. M. Hardie of Chicago, Dr. O. B. Monosmith of Lorain, Ohio, and Dr. D. T. Vail of Cincinnati, Ohio, and wish to thank these gentlemen most cordially for their kind services.

Chicago, November, 1907. J. Holinger, M. D.

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INTRODUCTORY LECTURE.

Gentlemen:—Only within the last forty years has the special branch of medicine that now concerns us been thoroughly investigated and justly appreciated as to its manifold and great importance to general medicine.

We are able to exactly determine the time from which the scientific development and the more general valuation of otology date. At the very time when the mighty and glorious structure constructed by *v. Gräfe* in the modest field of ophthalmology was still dazzling the eyes of all, a manual on otology appeared which, inspired by the results of his notable achievement and animated by a like spirit, became also a pioneer in a parallel field of medicine. This manual was first published in 1862 by *v. Tröltsch* and it ran through seven editions up to 1881. It revealed lofty stand-points, from which new aims and new roads spread in all directions in the domain of otology. In fact, there is hardly a part of our branch which *v. Tröltsch* did not enrich with new and fruitful views. To the stimulating impulse of this real Book of Instruction, we are indebted first of all for the fact that otologists have since then investigated their cases from the stand-point of anatomy as well as of physiology, and further that our then little appreciated branch of medicine has become the established and scientific department of otology.

Von Tröltsch's text book was often called the codex of otology and it is well for any one who writes a text book to follow its trend of thought and its arrangements as much as possible. That is what we propose to do. His ingenious work did not become superfluous through the great number of text books which appeared since, nor will it through this present one, to any one who wants to be informed about the scientific development of our branch.

Otology is important to the general practitioner firstly, because diseases of the ear occur frequently. Secondly, because suppurations of the different spaces of the ear are so common and may so easily invade the very important surrounding organs. This explains the comparatively high mortality from complications of diseases of the ear. The practitioner does not sufficiently appreciate these facts.

All physicians who, as I did, treat diseases of the eye as well as those of the ear, find out that very soon the number of ear patients exceeds that of eye patients. This may be taken as another illustration of the frequency of diseases of the ear.

Many diseases of the ear are independent of other affections. A large number however are consequences of some general infectious disease. Suppurations of the middle ear for example are integral phenomena of scarlet fever and measles, as was shown by a large series of post-mortem examinations after these children's diseases. The statistics of otologists show furthermore that a large number of permanent destructions of this organ as well as a considerable number of deaths, in later years must be lead back to an early localisation of some general diseases in the ear.

Functional disturbances of this organ are very frequent in old age, but even in children and young adults the estimation of *v. Tröltsch* may hold good, that on an average one out of every three persons does not hear normally well at least in one ear.

The fact that *O. Körner's* book on otitic diseases of the brain,[1] the meninges and its blood vessels has appeared in its third edition in a comparatively short time may be taken as another evidence for the recognition of the danger to the organism from suppuration of the middle ear.

My statistics appeared in 1895 regarding 20,468 ear patients, who were treated from 1872 to 1892.[2] It shows that 31.8 per cent of all ear patients, or nearly one third were treated for suppurations of the middle ear or its residues, like perforations or scars of the drum-head.

Körner gives the following figures of death due to suppuration from the middle ear:

In Guy's Hospital out of 9000 post mortems 57 deaths were due to suppurations of the ears according to *Pitt. Gruber* in the Wiener Allg. Krankenhaus counted 232 deaths due to ear diseases, among 40073 post mortems, and *Paulson* found that 48 deaths were due to ear diseases in 14,580 post mortems in the Communal Hospital in Kopenhagen.

Diseases of the ear were therefore the cause of death in one case out of every 158 according to *Pitt*, of every 232 according to Gruber and every 303 according to *Paulson* of all other diseases combined.

Barker gives similar figures as *Pitt* of three other London Hospitals.

These figures are certainly not too high but rather too low, because the pathologist does not examine every ear if his attention is not drawn to it, as in cases which were not treated for ear diseases, or which were brought to the hospital in an unconscious or dying condition. Acute suppurations of the middle ear are most difficult to determine at the post-mortem, since they may lead to death without causing perforation of the drum membrane and the redness has faded. Or a suppuration may have healed and the perforation closed at the time when an endocranial complication killed the patient. The connection of the cause of death with the ear may remain undiscovered not alone in cases of meningitis

[1]) Bergmann, Wiesbaden 1902.

[2]) "Ueberschau über den gegenwärtigen Stand der Ohrenheilkunde." Bergmann, Wiesbaden; 1895.

and abscess of the brain which were never clinically observed, but also in thrombophlebitis and pyaemia when a decomposed thrombus was washed away, or when it is located in the bulb of the jugular vein, which region is examined only rarely and inadequately. The origin in the ear may furthermore be overlooked in the fatal abscesses of gravitation below the deep fascia of the neck, in which no perforation of the drum-membrane occurred or when for any other reason no competent examination of the ear was made.

The mortality from ear diseases of 33017 *patients who were treated for their ears* amounts to 0.3 per cent according to *Bürkner* who compiled the numbers of many authors.

The author saw 30,336 ear patients from 1881 to 1901 and had 0.2 per cent deaths due to ear diseases.

Of 820 patients with suppuration from the ears who were seen in the hospital and in the free clinic 2½ per cent died according to *Barker.*

The severe cases which terminate fatally are chiefly met with in hospitals and therefore we get a more accurate idea if we take also into consideration those patients who are seen in private practice. The above mentioned number of 30336 ear patients, consists of private, free clinic, and hospital patients. There were 7273 acute and chronic suppurations of which 0.8 per cent were fatal.

Accurate statistics of *Körner, Pitt, Gruber* and *Paulson* demonstrate how often each one of the different complications of suppuration of the middle ear was fatal.

If we add up the number of all four authors we find,

Sinusphlebitis.	Abscess of the Brain.	Uncomplicated Meningitis.
164 cases.	123 cases.	136 cases.
or 38.8 per cent	29.1 per cent	32.1 per cent

It will be of special interest to find out what part of all the diseases of the sinus, of abscesses of the brain and of meningitis are of otitic origin.

Pitt found 56 abscesses of the brain in his 9000 post-mortems. *One third* of them originated in the ears. *Treitel* gives the same proportion in 6000 consecutive post-mortems of the *royal "Charïté"* in Berlin.

Pitt found in the same 9000 post-mortems 44 cases of sinus phlebitis and thrombosis as causes of death, 22 of which were due to diseases of the ear.

One third of all fatal cases of brain abscesses and *half* of all fatal cases of sinusphlebitis and thrombosis are caused by infections of the temporal bone according to these figures. Yet *Pitt* counted also the simple marantic thrombosis. If the latter be excluded *nearly two thirds* of all the cases of sinusplebitis are of otitic origin.

Lepto-meningitis is such a frequent general disease as compared with the two other complications of diseases of the ear, that the fatal cases due to the ear represent only a small fraction of the mortality from meningitis.

Males succumb to the above complications about twice as often as females; they also suffer much oftener from suppurations of the middle ear than females do.

The otitic diseases of the brain are distributed very irregularly through *the different periods of life.*

The 246 cases that *Körner* collected were divided as follows:—

Age	Cases	Per cent
0—10 years	44	17.88
11—20 "	73	29.66
21—30 "	70	27.45
31—40 "	30	12.19
over 40 "	29	11.81

Körner basing his calculation of the number of people and their mortality upon the Prussian statistics of 1885 calculates from this that in every 100 deaths at the age of,

0—10 years	0.22 per cent
10—20 "	5.15 "
20—30 "	3.85 "
30—40 "	1.44 "
above 40 "	0.27 "

are due to diseases of the ears.

4 TO 5 PER CENT OF ALL DEATHS *which occur during the healthiest* and *strongest years of life, that is from 10 to 30 years are due to suppurations of the ears according to those statistics of Körner.*

It is therefore evident that the practicing physician ought to be versed in the main principles of otology. Firstly, because diseases of the ears are not at all rare, and if neglected or incompetently treated may frequently cause death. Secondly, because the frightful misfortune of partial or complete loss of hearing viz. impossibility of learning to speak, lack of development of the intellect in early childhood, and complete social isolation later on in life, can often be averted.

The time which at present is given to the study of otology, is entirely out of proportion to the practical importance and to the vast extent which this branch has acquired within the last decades.

It offers furthermore a great many difficulties which are caused by the anatomy and physiology of the organ.

So many anatomical details are crowded together in the narrow space of the temporal bone that every student dreads to be examined about them. But whoever wants to work here practically has to know also the topographical anatomy of those parts as well as of the neighboring organs, the meninges, the brain and the large blood vessels. The matter becomes even more complicated from the extreme *variability* of the architecture of the organ of hearing and its surroundings, especially the arrangement and size of the pneumatic cells of the temporal bone and the course and position of the main sinus.

Our therapeutic actions are mostly of a surgical nature as in most of the well developed specialties. But the danger of an incompetent operator who does not know the variations is much greater here than in any other region.

The *inspection of the drum-membrane* which is one of our most important means of examination is done through a narrow tube with one eye only. We have no perspective view. We see the most important changes of the drum-membrane only in extreme perspective fore-shortening. It requires therefore years of practice to gain an accurate judgment and use the many points gained by the examination, which is equally true of the many delicate operations that have to be performed in this way.

Hearing tests are just as highly developed and therefore equally as complicated as the functional tests of the eye.

We are now able to analyze with the continuous series of tuning-forks the very elements of the organ of hearing. We can diagnose changes and localize loss of functions in the *inner ear* just as accurately as we can search the fundus of the eye with the ophthalmoscope.

The continuous series of sounds led us to the deaf-mute institutions and made a systematic examination of deaf-mutes possible. We recognized that many deaf-mutes have a considerable amount of hearing left which they may be taught to make use of for hearing or speaking. For this purpose a new method of education was discovered. A new and very rich field for work was opened to the ear surgeons in those institutions.

Gentlemen: You see how much is required of otologists. The time allotted the future practicing physician for the study of otology is so short that it only suffices to give him a superficial idea of what might be accomplished by careful study.

To make an accurate diagnosis is most important in general practice. The house-physician has to determine the time when, in the course of the local disease, an invasion of the general organism is threatened and operative interference has to take place.

The treatment of the most frequent local disease is now very simple. It can be studied and even tried as to its merits during the time given for the purpose.

The deeper the conscientious physician who wants to devote himself to otology, enters into the study of this branch the keener will he feel the necessity of practical work as an assistant for several years in some special clinic and the careful study of anatomy, in collections as well as from specimens prepared by his own hand. This feeling will be even stronger than in other branches of medical science.

LECTURE II.

Division of the Organ of Hearing and Topography of the Temporal Bone.

Gentlemen:—The anatomy of the temporal bone is very difficult, so much more so since the parts change form and mutual position from childhood to old age. Moreover there are great individual variations. The topographical anatomy will therefore be a main point of our general considerations.

We will start with a general survey of the organ of hearing.

As to the *physiological function* we recognize *a sound conducting* and a *sound perceiving* apparatus.

The sound conducting apparatus consists of the concha and the external canal which act as receivers of sound. Secondly of the real sound conducting apparatus, the drum-head and the chain of ossicles including the foot plate of the stirrup with the ligamentum annulare.

The sound perceiving apparatus consists firstly of the labyrinth which contains the terminal distributions of the acoustic nerve. Secondly the acoustic nerve with its nuclei in the medulla oblongata, the acoustic tracts in the brain and the acoustic centers of the cortex of the first and second convolution of the temporal lobe on both sides.

As you know from physiology, the labyrinth contains besides the cochlea, which, according to our present views has exclusively the function of hearing, another organ which serves to maintain the equilibrium. It has its terminal apparatus in the vestibulum and the semicircular canals. It has its own nerve fibers which are separated from the others throughout.

The part of the organ of hearing which is included in the temporal bone, consists of *three systems* of bone cavities which are separated from each other partly by membranous partitions. They are called *the external ear*, the *middle* and the *inner ear*. Each part having its own diseases. we speak about *diseases of the external ear, of the middle and of inner ear.*

The different parts of the *external ear* are the concha, the external auditory canal and the drum-head which forms the bottom of the glove-finger of cutis of the external meatus. It takes part in its diseases.

The drum-cavity is the main cavity of the *middle ear.* It has the shape of a low cylinder or a flat box directly inside of the drum-head. The top and bottom of it are the large external and inner wall (compare fig. 1 and 2). The external wall is the drum-head, which is funnel shaped.

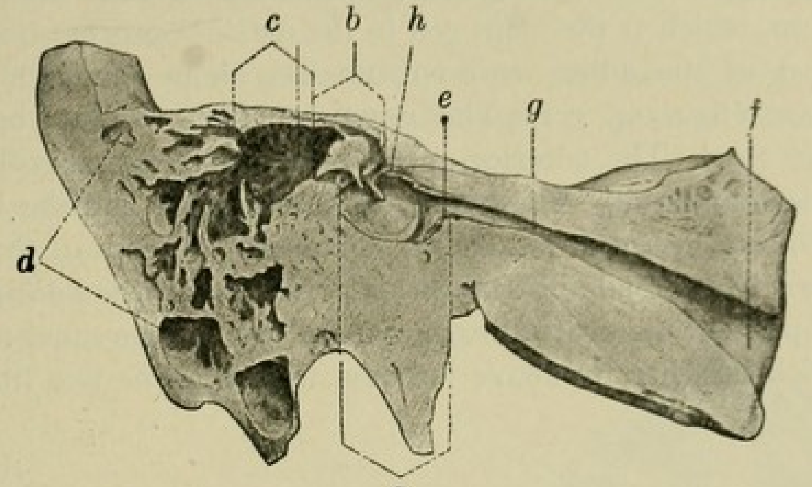


Fig. 1.

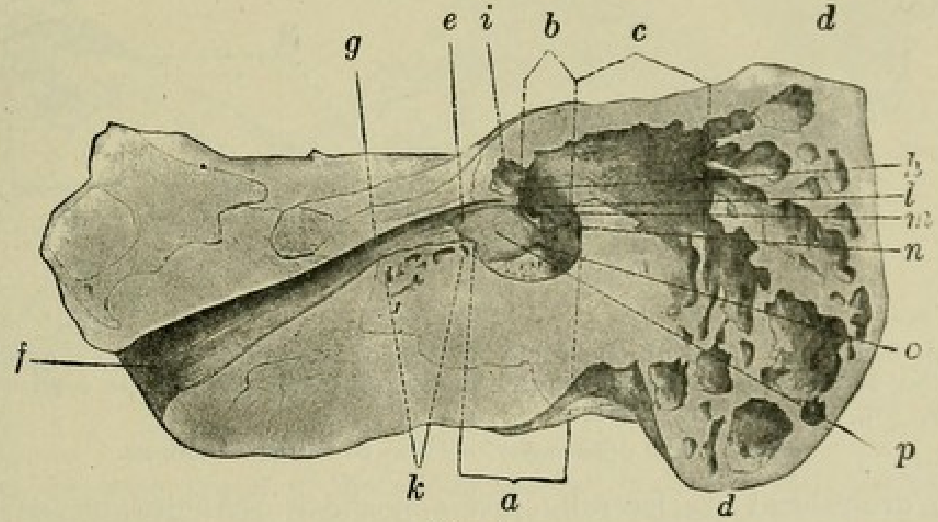


Fig. 2.

Figs. 1 and 2. Vertical cut in the axis of the tube and through the other main spaces of the middle ear. Fig. 1 showing the outer surface of the cut, presenting the inner surface of the drum-membrane. Fig. 2 showing the inner surface of the cut containing the promontory in the drum-cavity (according to *Siebenmann*).

a drum-cavity, *b* aditus ad antrum (containing in Fig. 1 the bodies of the hammer and incus), *c* antrum, *d* cells of the mastoid process, *e* ostium tympanicum of the tube, *f* ostium pharyngeum of the tube, *g* isthmus of the tube, *h* tendon of the tensor tympani muscle (in Fig. 2 it is cut), *i* pneumatic cells of the aditus ad antrum, *k* pneumatic cells in the floor of the tube, *l* prominence containing the facial nerve, *m* stapes in the niche of the oval window, *n* tendon of the stapedius muscle.

The interior wall is the promontory which separates it from the labyrinth. Both the drum-head and the promontory protrude into the middle ear and therefore come very close together in the middle of the cavity. The circumference is a low, trabeculated bony wall with many little holes. This wall is absent in two places. The first gap is the ostium tympanicum of the Eustachian tube, which begins at the upper part of the anterior circumference, and runs in a straight line from the rear, upward and outward, forward, downward, and inward to the lateral wall of the naso-pharynx, where its opening is called the ostium pharyngeum of the tube. The second gap is much larger. It is on the rear part of the upper circumference and leads through the aditus ad antrum into the antrum mastoideum, which is the main cell in the mastoid process.

A cast of the aditus and antrum has about the form of a three sided prism (fig. 3-4, c.). The upper surface is the bony tegmen tympani et antri. The anterior part of this prism contains the bodies of the hammer and anvil. The handle of the hammer and the long process of the anvil are in the drum-cavity. The short process of the anvil rests with its point in the edge of the prism. We begin the aditus ad antrum from that piece of the protruding horizontal part of the canal for the facial nerve which lies directly above the oval window. The two liminal stands

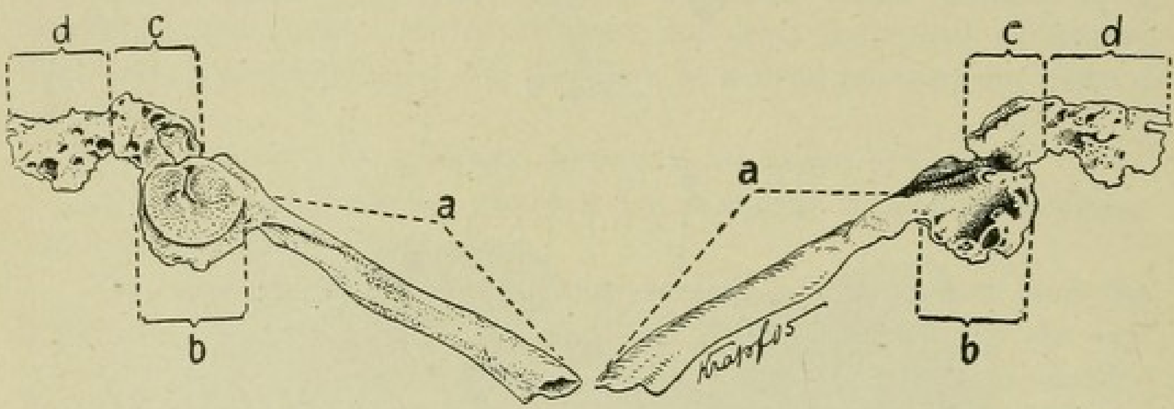


Fig. 3. Fig. 4.

Figs. 3 and 4. Cast of the main spaces of the middle-ear. Corrosion specimen, the soft tissues were not previously removed. Fig. 3 as seen from the outside, Fig. 4 from the inside.

a the tube, *b* drum-cavity, *c* aditus ad antrum, *d* antrum.

of the drum-head are laterally just opposite it. An isthmus is formed there by the protrusion of the Fallopian canal which is so much narrower on account of the ossicles. Natural limits are thus fixed between the low cylinder of the drum-cavity and the prismatic space of the aditus (comp. fig. 4.). The greater number of authors add the anterior part of the aditus, as we just described it, to the drum-cavity and call it the upper part of the drum-cavity, or the cupola, the recessus epitympanicus or the attic. They have to describe besides an aditus ad antrum. The description which was just given seems to be considerably more simple and more accurate as to forms. It is all the more justifiable in that the diseases above the isthmus are different from those of the drum-cavity and require a different treatment.

The antrum mastoideum is the enlargement of the aditus in the rear. It has the form and size of a bean the hilus of which is turned down. This cavity in the new born has nearly the same size as in adults and may be found as a cavity almost constantly at our frequent operations, years of serious suppurations of the bone notwithstanding.

Fig. 5 representing a cast of the main cavities shows that the drum-cavity, the aditus and the antrum lie approximately in the continuation of the axis of the tube. The external meatus forms with it a very obtuse angle downward and outward.

This is the main tract of cavities of the middle-ear which is constantly present. A system of *pneumatic cells* is in connection with it. These cells vary extremely in size and number.

The main group of these cells start from the mastoid antrum. Like the branches of a tree they have generally a radial direction. They are narrow near the antrum and become wider towards the periphery. They

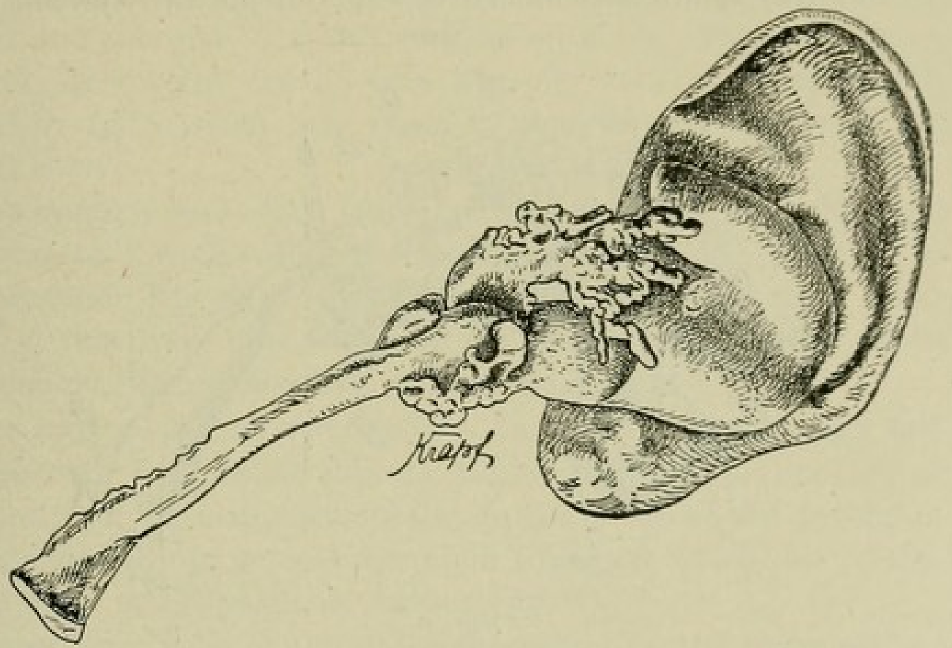


Fig. 5.

Cast of the main spaces of the middle ear in connection with the external canal and the auricle. The first intermediary cells emanating from the antrum are also seen. Corrosion specimen, the soft tissues and skin were not previously removed.

terminate in large ball shaped cavities which are on an average larger the further they are away from the antrum. The first ones are *intermediary cells,* the last *terminal cells.* Fig. 6 gives you an idea of the arrangement of this system of cells.

A second, much smaller system of cells starts from the floor of the drum-cavity and the bony tube. It is often absent and is homologous to the bulla ossea of mammals. The author never found a communication of these cells with the large ones starting from the antrum.

The cells starting from the antrum are almost exclusively responsible for the propagation of suppurations of the middle-ear, which lead to serious complications.

We shall therefore give a more complete description of them:

The new born babe has neither a mastoid process nor cells. At the age of one year we find little off-shoots from the circumference of the antrum and at six years we find almost completely developed systems of cells.

The number, size and distribution of the mastoid cells of the adult vary with each individual.

The cut of a cast of the soft parts (fig. 6) gives you only a very inadequate idea of the real extent of the cells over the temporal bone, because the greater number of peripheral cells do not fill up with the substance, or because they break off later on in the course of the preparation.

We get a very good idea of all the cavities, if we place a well macerated temporal bone into boiling corrosion mass, which drives out all the air. In this way faultless casts can be made of the two systems of cells

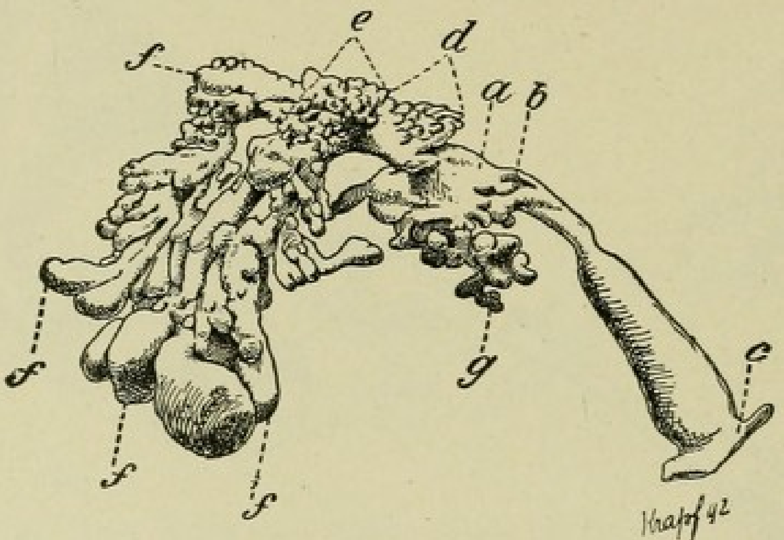


Fig. 6.

Cast of the spaces of the middle ear seen from within. The soft tissues were not previously removed.

a drum-cavity, *b* ostium tympanicum of the tube, *c* ostium pharyngeum of the tube, *d* aditus ad antrum, *e* antrum mastoideum, *f* cells of the mastoid process, *g* cells on the floor of the drum-cavity.

as well as of the labyrinth, the aquaeducts, the porus acusticus int., the facial nerve, the canal of the chorda tympani, the carotid artery, the sigmoid sinus and the bulb of the jugular vein. The cells which emanate from the antrum are lined with a very thin mucous membrane and therefore their form is the same whether the mucous membrane is in or not.

From such a cast of the temporal bone we are able to form a general idea of the *topography* of the cells and their neighborhood (fig. 7-8).

We ought to study not only one, but a number of such specimens in order to become acquainted with all possible ways by which suppurative processes of the middle ear may reach surrounding organs. I have shown a series of cuts in my "Corrosion Anatomy of the Ear." (Munich Theoder Riedel, 1882 Literar, artist institution) which show how the number, size and distribution of the cells vary, as do also the size and form of the adjoining organs, especially the sinus and the bulb of the jugular vein, which become infected most often.

In examining a collection of such casts you will find that wherever the cells are well developed, they show an almost perfect image of the forms of the temporal bone, though a trifle diminished in size. The cells penetrate everywhere, with the exception of the squamous part and the anterior wall of the meatus. You will recognize the mastoid processus with the incisura mastoidea. The cells may spread even medially of the latter, along the base of the temporal bone to the bulb of the jugular vein which they often partly overlap. Starting from the base of the mastoid process they surround the whole external canal with the exception of its anterior wall and fill the entire root of the zygomatic process as far as the crista temporalis. Towards the interior they extend into the pyramid and surround the labyrinth on all sides. Flat cells may partly surround the carotid canal. The sigmoid sinus is often directly surrounded by cells, which may reach to the rear far beyond it, into the occipital bone.

The *thinnest part* which may even have dehiscencies is the upper wall of the flat cells enclosed in the tegmen tympani and antri. The cells which surround the sigmoid sinus are often also transparent toward the sulcus. A third very thin portion of the wall is at the bottom of the temporal bone on either side of the incisura mastoidea.

The *largest cells,* as stated before, lie in the periphery. We find them in the point of the mastoid process, behind the sinus and on top of it, in the vicinity of the crista temporalis, in the point of the pyramid. One or more especially large cells are often found on either side of the incisura mastoidea and towards the bulbus (fig. 8).

These large cells in the different regions of the temporal bone are especially important in the propagation of the suppurative processes. In locating the three thinnest portions of the cellular walls we have ascertained the spots where suppurations of the middle ear most frequently perforate, inwardly and outwardly.

Fig. 7-8 show casts of temporal bones with perfectly developed systems of cells.

Fig. 9 on the other hand shows a cast of a temporal bone of an adult in which, with the exception of the antrum all the cells are wanting.

The latter specimen is especially instructive in studying the *relative position* of the outer meatus and the sigmoid sinus. In order to open the antrum mastoideum at an operation we have to pass between the two. You perceive the cast of the antrum lying in the depth between the meatus and sinus. The cast of the facial canal runs perpendicularly downward on the inside of the antrum. Thus in this specimen you have a perfect survey, which shows how to avoid injuring the sinus or the facial nerve in opening the antrum.

In order to attain an exact conception of the great variety of the cellular formations in the temporal bone you must remember that between the extremes of perfect formation on one hand and the absolute absence

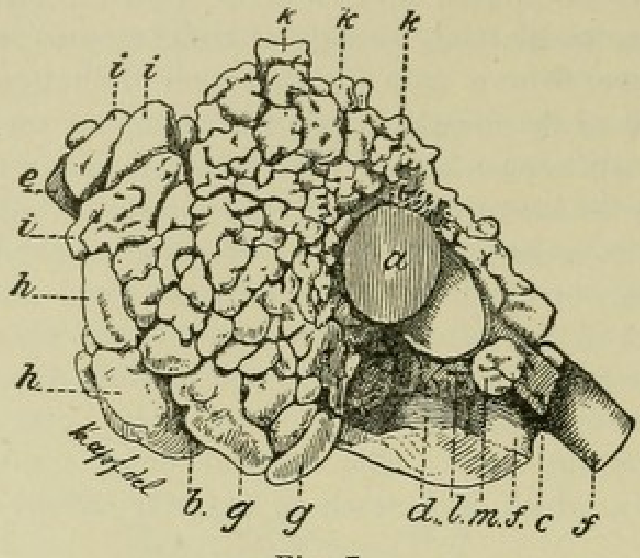


Fig. 7.

Cast of the cavities of the temporal bone, seen from outside, obtained by corrosion, all soft tissues being previously removed.

a external meatus, *b* fossa digastrica (incisura mastoidea), *c* bony part of the tube, *d* bulbus of the internal jugular vein, *e* sulcus sigmoideus, *f* canal of the carotid artery, *g* terminal cells in the point of the mastoid process, *h* terminal cells medial of the incisura mastoidea, *i* terminal cells on top of the sigmoid sinus, *k* terminal cells below the crista temporalis, *l* cells on the floor of the drum cavity, *m* a cell in the floor of the tube.

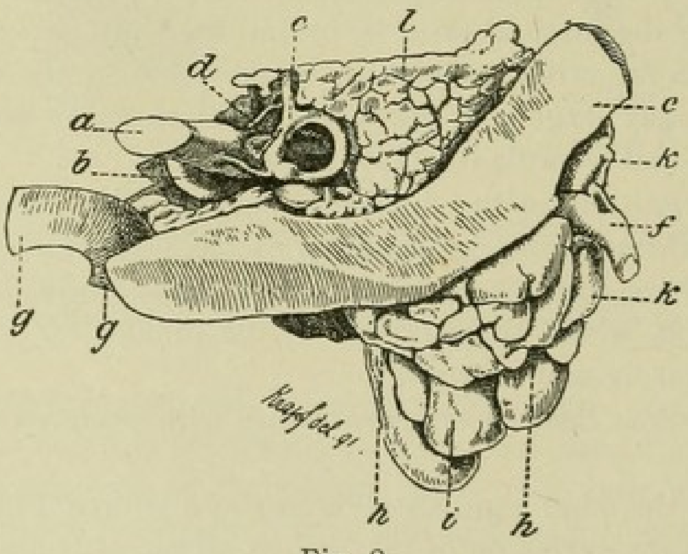


Fig. 8.

Cast of the temporal bone seen from inside.

a porus acusticus internus, *b* cochlea, *c* semicircular canals, *d* ductus subarcuatus, *e* sinus sigmoideus, *f* emissarium mastoideum (vein) *g* canal of the carotid artery, *h* fossa digastrica, *i* terminal cells of the mastoid process, *k* cells surrounding the emissar mast, *l* cells surrounding the labyrinth.

of pneumatic cells on the other, we find all degrees imaginable, if we will but examine a great number of casts.

I must take it for granted that the shape of the three *ossicles of the ear* is known to you, also their connection with each other and the tensor tympani and stapedius muscles, as well as that of the foot-plate of the stirrup with the oval window.

A few points must be mentioned as to topography. Examining a macerated temporal through the external canal you will find that the *oval window* is usually partly covered by the posterior upper part of the bony frame of the drum-head. A different view presents itself, when the ossicles are preserved. You then see the lower part of the long process of the anvil extending upward and backward in a vertical direction. Close to its end the anterior part of the tendon of the stapedius muscle runs horizontally backwards. You see furthermore the profile of the entrance of the niche of the *round window* in the posterior lower quadrant. It forms the posterior edge of the smooth promontory. A direct injury to the membrane of the round window, which is hidden in the depth of the niche, is therefore impossible.

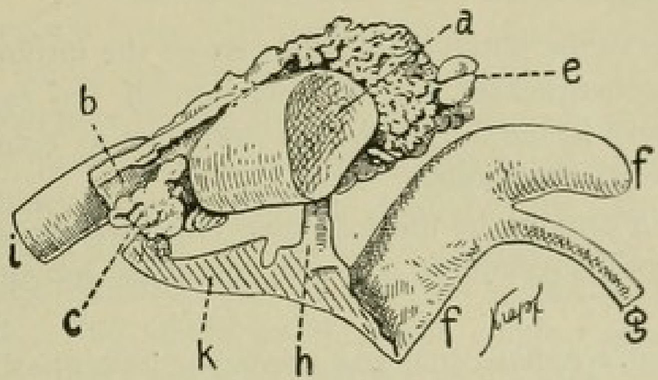


Fig. 9.

Cast of an adult with very rudimentary development of the cells. The soft tissues were previously removed.

a external canal, *b* tube, *c* pneumatic cells in the floor of the tube, *e* rudimentary cells in connection with the antrum, *f* sulcus sigmoideus, *g* emissarium mastoideum, *h* canalis Fallopiae (facial nerve), *i* canal of the carotid artery, *k* bridge of corrosion mass.

A knowledge of the general form of the labyrinth and its contents must be taken for granted.

Looking at the median wall of the middle ear you see the prominence of the horizontal semicircular canal in the aditus running directly above and parallel to the elevation of the canal for the facial nerve which has here a horizontal direction. The basal whorl of the cochlea runs horizontally forward from the round window within the promontory. The cupola of the cochlea rests against the tympanic end of the osseous Eustachian tube.

The membranous labyrinth is entirely enclosed in the bony labyrinth. It contains the *endolymphatic space,* which has no communication with the outside. It is surrounded by the *perilymphatic space,* which is much larger and also enclosed in the bony labyrinth. The scala tympani and the scala vestibuli in the cochlea are parts of the perilymphatic space. The endolymphatic space is enclosed in the ductus spiralis which has three sides and contains the organ of Corti. The continuation of the perilymphatic space in the vestibulum is the cysterna perilymphatica (*Steinbrügge*) which is rather wide and lies between the foot-plate of the stirrup and two small sacs in the vestibulum. The form of the membraneous labyrinth is simply a somewhat smaller reproduction of the bony labyrinth, to the inner walls of which it is everywhere attached.

Both the perilymphatic and the endolymphatic spaces communicate with the cranial cavity. The aquaeductus cochleae leads directly into the subarachnoidal space from the base of the scala tympani through an opening in the floor of the temporal bone. The aquaeductus vestibuli, which starts from the sacculus and utriculus, communicates with a large flat bag through a slit-like opening in the posterior surface of the pyramid of the temporal bone. This bag extends across the sigmoid sinus and is between two layers of the dura, which is split for that purpose. This saccus endolymphaticus is connected with the system of lymph-vessels of the dura.

We can observe the pathological increase of the intraocular pressure and its serious consequences for the function of the eye. A similar increase of pressure in the labyrinth was described as a cause of disease of the end organs of the acoustic nerve.

I succeeded in proving by the following experiments on fresh temporal bones that both aquaeducts are very patulous for the labyrinthine fluid:

The upper semicircular canal was opened at its highest point. In the opening a capillary tube which contained some colored fluid was hermetically inserted, so that its fluid was a continuation of the labyrinthine fluid. The fluid in the glass tube acts as a manometer, and rises several centimeters if we press with our finger against the saccus endolymphaticus on the posterior surface of the pyramid of the temporal bone. The same thing occurs if we press the finger tightly against the opening of the aquaeductus cochleae at the floor of the temporal bone. In several cases I saw the colored fluid which in this way was inserted into the upper semicircular canal drop out of the aquaeductus cochleae. Finally we succeed in causing the fluid to rise in the manometer tube, when we press our finger hard upon the porus acusticus internus. This is explained by the transmission of pressure through the rich supply of blood vessels of the lamina cribrosa.

It is evident that on all sides there is a free communication of the labyrinth with the interior of the skull. It is therefore *impossible that a local increase of pressure in the labyrinth* can occur and last long enough to cause all those diseases which were attributed to it.

The free communication between the spaces of the labyrinth and the skull will attract our interest for another reason, which we shall enter into more minutely in the special part. We will recognize *the great* *danger which threatens the whole organism when the pus of an inflammation of the middle ear perforates into the labyrinth.*

I explained the experiments with the manometer of the labyrinth for another purpose. They enable us to study as *Politzer and v. Helmholtz* did before me the movement of the sound conducting apparatus of the windows of the labyrinth. We see the fluid in the manometer rise and fall when we compress or rarify the air in the *external auditory meatus.* This is due to the inward and outward movement of the foot plate of the stirrup. The rise and fall of the fluid in the manometer is five times as large if we compress and aspirate the air of the middle ear through the Eustachian tube than through the external meatus, because the movement is transmitted through the flabby membrane of the round window. Starting from these observations we will learn to understand the physiological function of the sound conducting apparatus.

After this little deviation from our subject let us return to the topography of the ear. You know that the facial nerve runs mostly on the inside of the temporal bone. Its path leads backward directly above the cochlea laterally along the whole osseous labyrinth. Its canal forms a horizontal protuberance on the inner wall of the aditus ad antrum, just above the oval window. The thin wall of this canal is often perforated. About three millimeters to the rear and medial of the sulcus of the drumhead, the horizontal course of the nerve changes into a vertical one, downward through the main part of the pars mastoidea to the foramen stylo-mastoideum. The whole course gives ample explanation for the frequent injuries to this nerve in destructive diseases of the bone, both of the middle and inner ear.

Pus from suppuration of the middle ear may travel along the canal and invade the skull cavity through the porus acusticus internus.

The *internal carotid artery* also is in close proximity to the anterior wall of the drum-cavity and to the bony wall of the tube. A number of cases are described in literature where a fatal hemorrhage from the ear and tube was caused by necrosis or injury of the temporal bone.

The close proximity of the spaces of the middle ear and the transverse sinus and jugular bulb are finally of great practical importance. The "S" shaped vertical part of the sinus descends along the inner surface of the pars mastoidea. The posterior end of the antrum is often divided from it by a thin bony partition only. (Fig. 16 c.) Pneumatic cells of different dimensions may be found all along the sinus and jugular bulb. The main point is the *extreme variability in size and position of this largest sinus,* through which passes the greater part of the venous blood from the interior of the skull. The right sinus and its bulbus is usually larger than the left one. The arch of the sinus may be advanced so far forward and outward that its groove seems to have dug out the whole base of the pyramid from the rear. The bony wall between the groove and the external meatus as well as the outside of the pars mas-

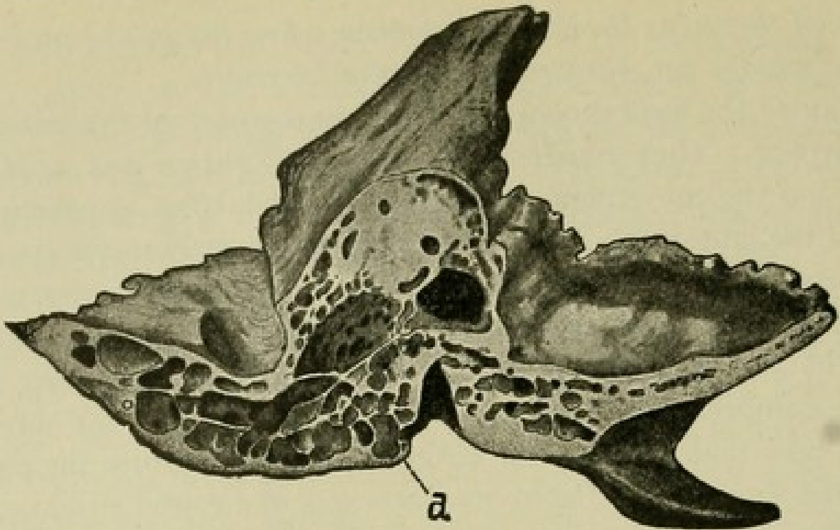


Fig. 10.

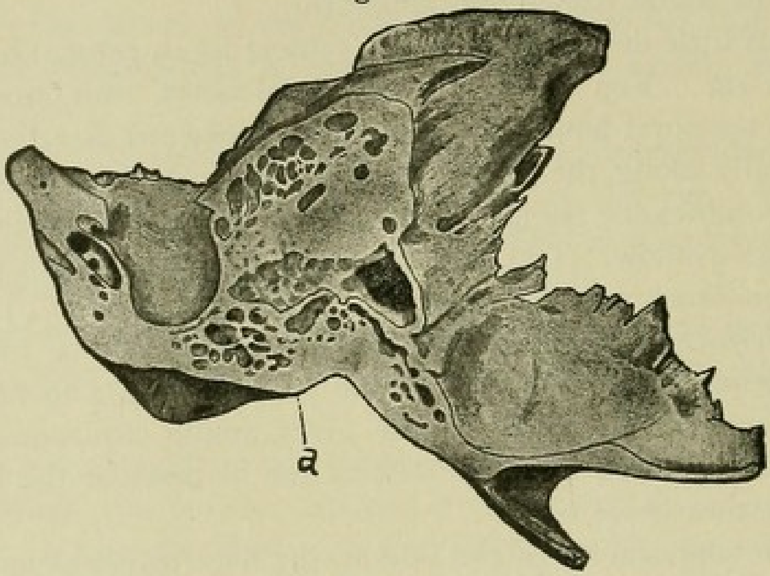


Fig. 11.

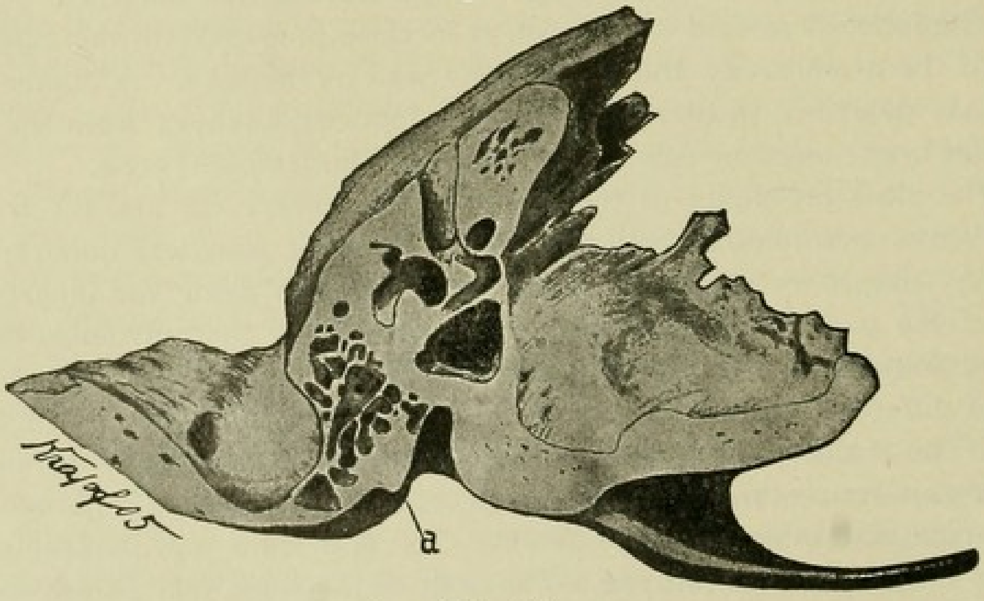


Fig. 12.

Figs. 10 to 12 are horizontal cuts of the temporal bone through the spina supra meatum (*a*) showing different development of the sigmoid sinus. Fig. 10 shows a moderately well, Fig. 11 a well, Fig. 12 a very well developed groove for the sigmoid sinus.

toidea in such cases may be very thin and transparent. The bony wall between the jugular bulb and the floor of the drum-cavity may either contain pneumatic cells or may be extremely thin. It may even be wanting altogether to a large extent, so that the bulb protrudes into the drum-cavity, and in making a paracentesis of the drum-head it was repeatedly cut open. In some rare cases the bulbus forms the floor of the bony meatus and may take the place of the bone of the innermost part of the canal.

You will see the great difference in size and position of the sinus by the three horizontal cuts through the spina suprameatum of the temporal bone. In very rare cases the anterior wall of the drum-cavity is wanting, in which cases the internal carotid artery is exposed.

You have to be thoroughly acquainted with all these variations of form if you want to accurately judge of the frequent involvement of the sinus in suppurations of the middle ear. Operations on these parts very often become necessary and great damage may be done.

You will easily recognize that there is hardly another part of the body which calls for higher qualifications on the part of the operator as to anatomical knowledge than the temporal bone.

LECTURE III.

Methods of Examination of the Ear.

Gentlemen:—Otology was considered up to our days by the majority of physicians as one of the most unsatisfactory branches of medicine.

Our therapeutical results in such a limited area depend first upon the question: in how far can we control it with our methods of examination? and next, in how far can we enter into it surgically?

Considering the organ of hearing from this point of view, we find that there are *three avenues* by which we can reach those spaces for examination and operation.

Under normal conditions we are able to examine the walls of the outer canal and the outside of the drumhead up to its periphery with a perforated reflector. The reflector was introduced by *v. Troeltsch*. The color and form of the drum-membrane are extremely changeable, on account of its partial transparency and easy mobility. From changes of the drum-head we are able to draw conclusions as to changes in the middle ear often to its most remote parts even up to the pharyngeal end of the eustachian tube.

We can see into the drum-cavity if there is a perforation in the drum-head. With the reflector as our guide we can perform a number of operations either through an already existing hole in the drum-membrane or after we have excised a part of it; they are, removal of polyps, tenotomies, extraction of ossicles, and so forth.

Destructions of bone at the upper pole of the drum-membrane which may extend far into the bony meatus are comparatively frequent occurrences. They allow us to inspect and treat large parts of the aditus and antrum.

The second avenue by which to reach the middle ear is through the eustachian tube. Its pharyngeal opening is hidden in the naso-pharynx, but we can reach it through the eustachian catheter.

Many different methods of treatment through this avenue were tried and partially abandoned, as for example the direct introduction of vapors and fluids into the middle ear, the use of bougies, massage, galvanolysis, etc., etc.

Inflation by means of compressed air through the catheter and tube is by far the most important method of treatment. We are able in this way to open the tube artificially when it is not patulous, to fill the different parts of the middle ear with air, and to remove secretions at least to some extent. At the same time we succeed in bringing the sound conducting apparatus back to its normal position and mobility.

Politzer in 1863 introduced the air douche without the catheter, and thereby connected his name forever with the development of otology. He put us in a position to open up the tube in those cases, in which the use of the catheter is impossible, as for example in children, who have a great tendency towards inflammations of the middle ear and therefore need the air douche so often. By *Politzer's* method alone the greater number of ear diseases of childhood became curable and a large number of diseases which later on might have been deleterious could be prevented.

The third avenue by which we may reach the diseased spaces of the middle ear is by operation.

Schwartze and his assistant *Eysell* published a paper in the Archiv F. O. in 1873 concerning the operation of the mastoid process. Bad experiences at the end of the 18th century had created a general dread of this operation amongst surgeons and otologists which lasted for many decades. At that time it was done without sufficient anatomical knowledge, with inaccurate indications and poor technic, reasons enough for the fact that it was often fatal. *Schwartze* pointed out all these shortcomings and, by means of his bold surgical procedure did away with all prejudice against opening the middle ear.

Since we learned to open the middle ear, we have found out how often suppurations occur in distant locations. By and by we even followed up and successfully operated the serious complications which are caused by progression of the suppuration in the vicinity of the ear, for instance in the meninges, sigmoid sinus and brain, which so often endanger life. It is impossible to estimate the number of cases which only a few decades ago were incurable and which now are cured within a few weeks or months by operative procedures. Complications which may endanger life are now nearly excluded if treatment follows the well-established rules, and operation, when necessary, is not postponed too long. Even in very neglected cases where thrombophlebitis with septicopyemia or abscess of the brain has already set in, an operation may be successful. Finally there is no question but that death from diseases of the ears will be reduced to a minimum when the present too great operative enthusiasm, which is explained easily enough, is reduced to its proper limits.

These few remarks may suffice to show you that otology, as concerns its lasting results, is really one of the most fertile branches of medicine.

You heard that there are three avenues by which the ear may be reached for examination and treatment. For practical reasons I want to talk to you first about the second one, that of the eustachian tube, because I want you to have a chance to use the catheter as often as possible while we are together. This little manipulation requires a good deal of practice. We often find out only after years of experience that we might have succeeded almost without causing any pain in cases which in the beginning offered insurmountable difficulties.

The best way to introduce the catheter is as a rule through the lower nasal meatus (fig. 13). The ostium of the tube lies in the prolongation of the lower turbinal, a little more than 1 centimeter from its rear end in the side wall of the naso-pharynx. Its upper and rear limit is the protruding cartilage, which gives it the shape of a Roman tube. The anterior and lateral parts of the circumference are membranous. A groove, called Rosenmüller's fossa runs around the rear and upper parts, i. e., around the cartilage. The vault of the naso-pharynx is lined with glandular tissue which is similar to the tonsils. This tissue is often developed to such an extent, especially in children, that it forms a regular tonsil with a middle and two side folds (compare fig. 55). The tissue of this naso-pharyngeal tonsil often extends somewhat over the rear wall of the naso-pharynx and into Rosenmüller's fossa.

This naso-pharyngeal tonsil becomes hypertrophic in children at least as often as the faucial tonsils. It then becomes a cause for disease of the middle ear either through occlusion of the tube or through progress of its inflammations along the tube.

The floor of the naso-pharynx is the soft palate which acts like a trap door. It is closed only during the act of swallowing and phonation, when it rises into the naso-pharynx like a cupola. At the same time the openings of the tubes together with all the soft tissues of the rear wall, protrude so that the catheter during the act of swallowing is often held so tightly that it cannot be moved.

The eustachian tube, the anatomy of which we have to study on account of its importance for physiology and pathogenesis of the ear, is a nearly straight tube about 36 millimeters long (compare fig. 3 to 5, pages 8, 9). Not quite one-third of its length nearest the drum-cavity has bony walls, and its cross section is triangular. The remainder is cartilaginous and slit-shaped. It becomes wider towards the naso-pharynx, and its opening is about nine millimeters in length. The upper part of the cartilaginous tube is the narrowest, called the *isthmus*. Here the slit is only three millimeters high on an average. The median and lateral wall of the tube touch, so that in trying to fill it for casts the cartilaginous tube fills only exceptionally. In cuts of frozen specimens also, this part of the tube is found closed. Successful casts therefore present the tube while it is opened.

The tube at the isthmus often shows a slight curve, and its axis is somewhat twisted. These are the reasons why it is often impossible to insert a bougie through the normal tube without interference, as I became convinced from experiments on the cadaver. We are therefore not justified in drawing the conclusion that there is a stricture of the isthmus in the living, from the fact that we do not succeed in inserting a bougie. In fact in all my very numerous post mortems I never found a stricture there.

The cartilaginous tube in children is shorter, in proportion to the bony tube, than in adults. The membranous part of the lateral wall is more developed and the isthmus is wider. All these points cause the tube to open more easily in children. The pharyngeal end in children does not protrude so much as in adults nor is it so much wider than the rest of

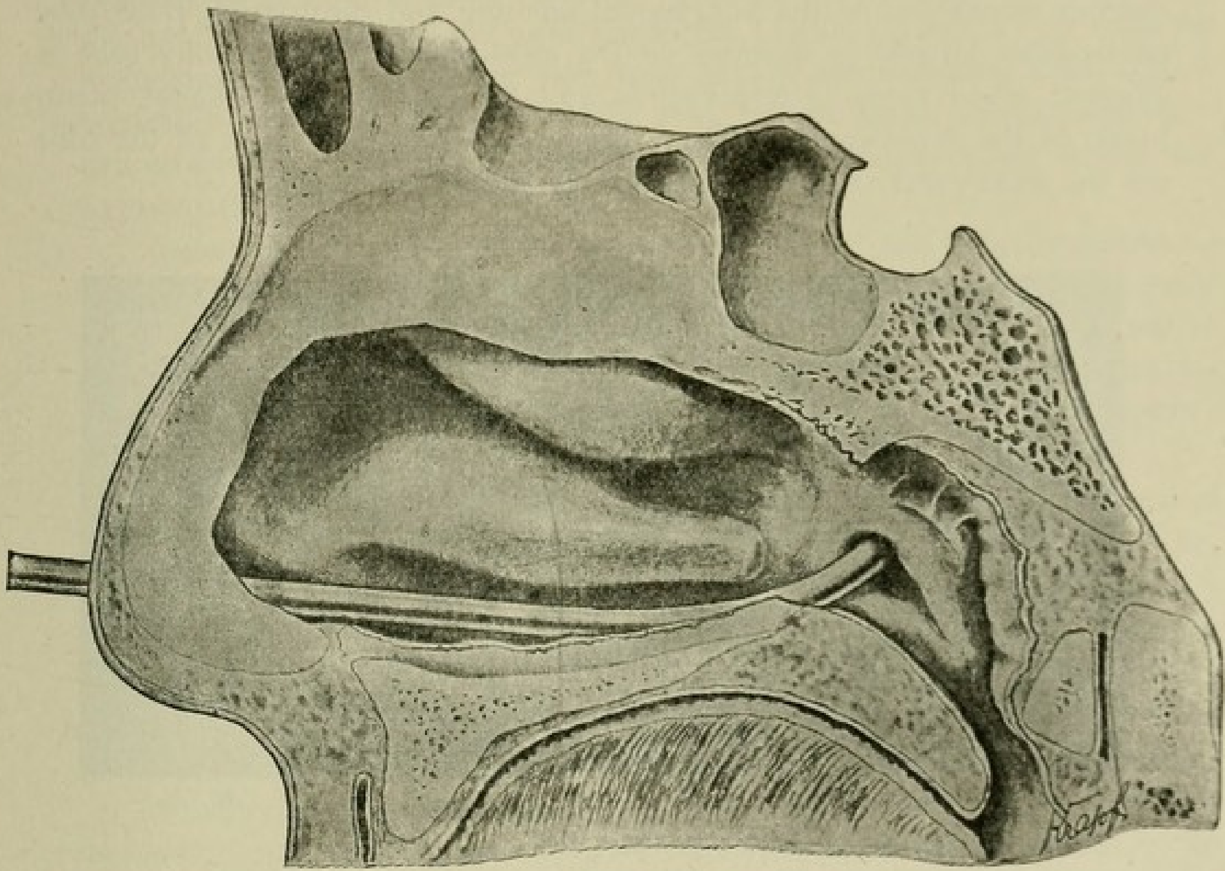


Fig. 13.

Sagittal cut through the skull, the septum of the nose is removed and a catheter is inserted into the tube.

the tube as is the case in adults. It is a simple slit. Consequently occlusion of the tubes occurs much more easily in children than in adults, if the mucous membrane of the entrance and its neighborhood is swollen. The ostium of the tube in children is on a level with the bony palate and only later rises up to the level of the turbinal.

The mucous membrane of the tubes is a direct continuation of that of the naso-pharynx. It is lined with a layer of high ciliated epithelium. The constant movement of the cilia is justly considered a protection against the advance of infection in the tube.

A layer of adenoid tissue is immediately below the epithelium of the cartilaginous tube. It is a continuation of *Waldyer's* adenoid ring. It has crypts and follicles which are especially well developed in children and a frequent cause for occlusion of the tube. The submucous tissue contains a great many mucous glands of the alveolar variety. The openings of these glands are especially numerous about the ostium of the tube. The adenoid tissue and the mucous glands decrease towards the isthmus. In the bony part of the tube there is no adenoid tissue and only few mucous glands (*Siebenmann*). There the ciliated epithelium is lower in type and the mucous membrane merges into the periosteum of the drum-cavity and the rest of the middle ear. Experience shows that the mucous membrane of the pharyngeal opening and the cartilaginous tube participates largely in diseases of the naso-pharynx. The bony tube is affected when there is hyperaemia and swelling of the mucous membrane of the drum-cavity. The isthmus and the middle part of the tube are the most rarely and least affected by pathologic changes.

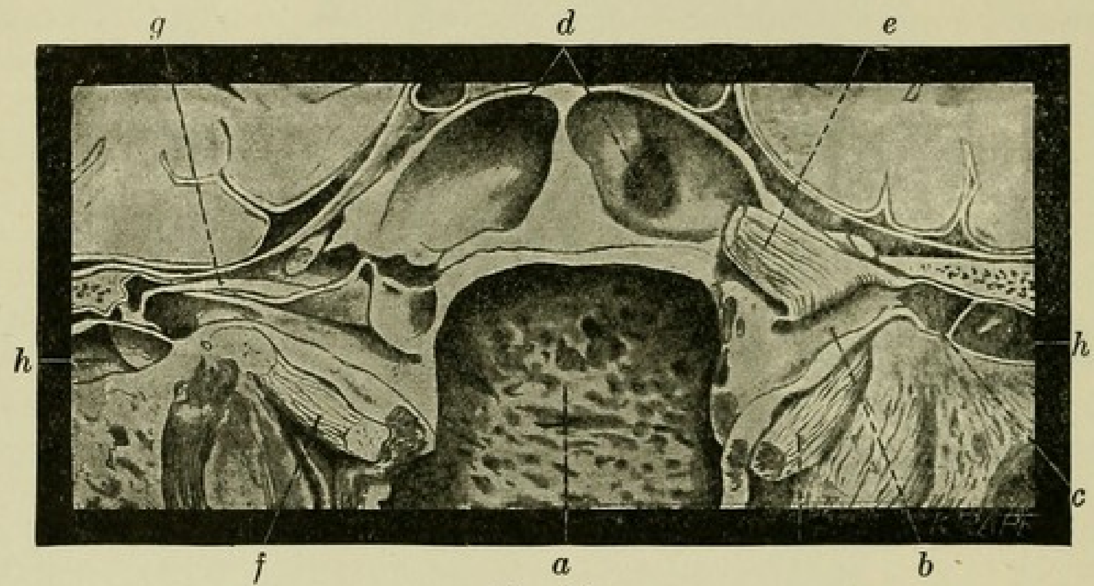


Fig. 14.

Perpendicular cut through both tubes (according to Rüdinger).

a posterior wall of the naso-pharynx, *b* cartilaginous tube, *c* ostium tympanicum of the tube, *d* sphenoidal sinuses, *e* *M* tensor veli, *f* *M* levator veli, *g* *M* tensor tympani, *h* meatus auditorius externus.

The tube is closed as a rule. *It opens actively* in swallowing and yawning by means of two muscles which have their insertion in the soft palate.

The first one, the Musc. spheno-salpingo staphylinus, or musc. tensor veli arises partly from the spina angularis and the pterygoid process of the sphenoid bone. A large part of its fibres arise from the exterior and lower surface of the cartilage of the tube, the cross section of which has here the shape of a hook, and also from membranous parts of the wall of the tube which fills the gap of the cartilage. (Compare fig. 14 and fig. 55).

The muscle starts fanshaped downward from the outside wall of the tube in an acute angle with the tube and forms a tendon which turns around the hamulus of the pterygoid bone. Further on, the fibers spread again and form a tendinous plate with those from the opposite side which is attached to the hard palate. Some of the fibers of the tendon are attached to the hamulus where they find an immovable point, which is much steadier when the soft palate is stretched out by the glosso- and pharyngo-palate muscles, as in swallowing. The fanshaped upper part of the muscle pulls at the lateral hook of the tube and acts therefore as an abductor of the membranous lateral wall of the tube. (*Rüdinger.*)

The second muscle which helps to open the tube is the petrosalpingo-staphylinus or levator of the palate. It starts from the lower surface of the temporal bone near the entrance to the carotid canal. From there its cylindrical belly runs along the floor of the cartilaginous tube. It is separated from the abductor of the tube by the fascia salpingo-pharyngea which runs downward from the tube. Its fanshaped end is inserted in the soft palate.

Sometimes we are able to see the opening of the tube by means of anterior rhinoscopy, as when the lower turbinal is deficient. The belly of the contracting levator muscle can be seen rising from the floor in front of the entrance of the tube. It appears as though it might compress the lumen, but its pressure on the slit in the direction of its axis, together with the action of abductor results in a round opening.

The protrusion of the opening of the tube into the naso-pharynx in swallowing is the effect of the salpingo pharyngeus muscle, called retrahens tubae, which is a continuation of the palato pharyngeus muscle.

We can convince ourselves by means of an auscultation tube that the tube opens in swallowing. A current of air which is directed into the tube can be heard much louder during the act of swallowing. It can be heard during that moment only if there is a partial occlusion of the tube.

Furthermore a sounding tuning fork held in front of the nose can be heard again during the act of swallowing after it has ceased to be heard otherwise.

Many people are able to open their tubes at will, and keep them open for some time. All nasal consonants like M. and N. and also the nasal vowels which are pronounced by the experimenter during this action, sound very strongly, and disagreeably. Everybody can notice the same increase of sound in yawning. It is called autophonia.

This shows that the occlusion of the tube in repose is necessary for protection against entrance of infection and foreign bodies as well as for the normal function of the sound conducting apparatus. There is a pathologic condition where the tube is wider than normal and is continually open. We hear from such patients how disagreeably the continuous autophonia feels.

We shall learn in the chapter about etiology of diseases of the tubes of what importance a temporary opening of the tube is for the ventilation of all the spaces of the middle ear.

The insertion of the catheter through the lower nasal meatus would be a very easy procedure under normal conditions. A symmetrical form of both sides of the nose is however not the rule, but rather the exception. Generally one side of the nose, in most cases the left side, is narrower than the other. This narrowness is caused by some irregularity of the septum, which may be located either in the bony septum or in the cartilage or in both. The vomer may have edges or ridges. The cartilaginous part of the septum may be so deformed as to be visible in either nostril like a tumor. The most frequent deformity is, where the vomer and the quadrangular cartilage together form a long ridge which protrudes into either side.

The cartilage and often the bone too, is thickened so that the ridge protrudes into one, and often both sides. Some times these ridges and deviations of the septum come far to the front. Near the entrance of the nose they come close to the floor of the nose, so that even thė expert is unable to insert a catheter. Rarely an abnormally low inferior turbinal and still more rarely irregularities of the floor of the nose block the way. A few more pathological changes that may interfere are polyps, large diffuse hypertrophies, stalactite shaped crusts in ozaena, etc. The removal of these different obstructions will always be an important part of our therapy.

LECTURE IV.

Examination through the Tube.

Gentlemen: Before entering into a description of the technic of the insertion of the catheter I have to mention a few accidents which may occur thereby. An extensive swelling of the cheek and side of the neck may suddenly appear while forcing air into the catheter, if the same was awkwardly or forcibly inserted, or if a whale-bone or celluloid probe was previously passed through it. The patient then usually grasps the hand of the operator or pulls out the catheter. An examination of the nasopharynx shows that the rear and side wall and the soft palate are bloated. You feel the crepitus of the escaping air bubbles when you touch the cheek or neck. *A subcutaneous and submucous emphysema was caused* by the inflation through the catheter. This can hardly be explained otherwise than that the catheter or the probe bored a new road into the submucous tissue. We shall see later in talking about the technic of catheterisation how easily such an injury may occur.

That is probably also the explanation of two deaths during catheterisation which were reported in the beginning of the past century by *Turnbull* of London. The patient had been entrusted to charge an air tank which was used for forcing the air through the catheter. The emphysema, on account of high pressure, probably spread over the entrance of the larynx and caused death from suffocation. We now use a single or double bulb for the compression of air, which will hardly produce high enough pressure to cause an emphysema of that extent.

The first attempt of students at introduction of the catheter must be personally guided by the director in every clinic. I have not seen a case of emphysema in many years since that rule was accepted. Should such an accident occur, a dressing which compresses the parts for the next few days will cure the emphysema. It may however become necessary to make a few small incisions with a pair of scissors to relieve the swelling of the soft palate.

There is much greater danger of carrying infections *from one patient to another by means of the catheter*. A number of cases of primary syphilitic affections in the naso-pharynx caused by insufficiently cleaned catheters are recorded in the otological literature. The secondary affections in all those cases were particularly serious. The same minute cleanliness and asepsis must be observed in otological as in other surgical instruments. The catheter must be boiled in a solution of wash soda or 5% carbolic acid after a careful mechanical cleaning. It ought to be kept where no new infection can reach it.

We use silver catheters of three different curvatures of the beak. The aperture may be equally wide in all, about 2.5 millimeters. A hard rubber catheter which can be bent into different shapes after it has lain in boiling water, may be used when such is required.

There are different methods *in the technic of inserting* a catheter. It is expedient to learn *one* of them well and only recur to the others when this one does not succeed.

Von Troeltsch used mostly *Kramer's method* which we also adopted in our clinic. The lower nasal meatus is used as a passage. The distance from the point of the nose to the opening of the tube is not the same in all individuals and can therefore not be measured with the catheter. It varies within several centimeters according to the age and the different forms of the skull, viz. dolicho and brachycephalic, ortho and prognatic. We must therefore find another measure. It is found in the distance between the opening of the tube and the rear wall of the naso-pharynx. The average is 15 millimeters (maximum 18, minimum 12 millimeters.)

Here is in short Kramer's method. We push the catheter as far as the rear wall of the naso-pharynx. Then we draw it back 15 millimeters and turn it outward.

There are a number of details to be watched.

On the floor at the entrance there is a ridge across the nose which is covered with cutis. The mucous membrane starts on the inner side of it. The catheter has to be lowered so that its beak is horizontal in order to pass this ridge.

The thumb and the two first fingers grasp the rear third of the catheter perpendicular to its axis (not slanting like a pen.) Then the arm is raised to a right angle.

The catheter, when its beak has passed the ridge, *must be perpendicular to the plane of the face.* The beak touches the floor lightly and continues to do so while the catheter is pushed forward. It leans against the septum until it reaches the naso-pharynx. Deformities of the septum often cause an obstruction behind the entrance of the nose. It is sometimes so close to the floor that the catheter cannot be advanced with its beak turned down. A beginner ought always to examine the nose with a nose speculum and a reflector in order to determine the cause and the shape of the obstruction. In passing around it not the slightest force or pressure ought to be used. It is better to try to find the course of the lower duct by making large curves outward or inward and upward with the outer end of the catheter. We should always remember that the catheter which touches with the end and the convexity of the beak *at the same time* acts as a lever, the short end of which is in the nose, while we have the long end in our fingers. The pivot is the curve of the beak. We have to make large curves with the hand to bring about small motions with the short beak. A slight pressure with the hand is multiplied at the end of the beak according to the distance of the end of the beak and the hand from the pivot. The beak usually enters without any difficulty if we make those curves towards one or the other side and upward. Care has to be taken that we do not lose touch with the floor and the septum. As soon as the beak has passed the limit between the hard and soft palate it can be easily turned to either side, at least in the cadaver. Frequent reflex motions are caused in the living. The soft palate rises like a cupola, the cartilages of the tubes protrude from both sides and the catheter may be immovably caught if the patient keeps on swallowing. To relieve the condition you ask the patient to breath quietly through his nose and close his mouth. You use the moment between two motions to give the beak its original direction downward, its position being indicated by a ring on the outside of the catheter, then bring back the rest of the catheter perpendicular to the plane of the face.

We now take a firm hold of the bony part of the nose with the two last fingers. The weight of the hand rests on the patient's head which has to follow all movements. The catheter can usually, without any further interference, in the position we give it, be pushed ahead till it touches the rear wall of the naso-pharynx. It must not be left there long because this sensation causes the patient to gag. The two most disagreeable moments of the whole procedure are, first the passage of the entrance of the nose, where the mucous membrane begins, and second a prolonged touching of the rear wall of the naso-pharynx. In either of these two moments we have to keep an eye on our patient, because he may suddenly raise his hands and pull out the instrument. We draw the catheter back 12 to 18 millimeters as soon as it has touched the rear wall. It has to maintain the same relative direction of beak and shaft. How far we have to draw it back depends upon the size and form of the head of the patient. Now we rotate the catheter between our fingers outward and upward till the beak points upward and outward at an angle of 45°, that is, in the direction of the outer angle of the eye. We feel the beak catching in the tube, when we slightly push the outer end of the catheter against the septum. We recognize this when we can not rotate the catheter any further upward, nor push it any further inward, and because it does not move in swallowing; our hand and arm must rest steadily on the ridge of the nose of the patient while the catheter touches the rear wall of the naso-pharynx or remains in the tube. The patient must of course be cautioned against moving backwards.

We recognize the correct position of the catheter also by the air douche. We connect the catheterized ear of the patient with ours by a rubber tube (called auscultation tube, otoscope). Under normal conditions we hear the compressed air strike against the drum membrane with a continuous noise similar to that caused by rain falling on leaves in the woods. The air enters much more easily when the patient swallows during inflation.

The most frequent mistakes are, firstly, that the beak at the beginning of the nose, enters the middle meatus which is more sensitive than the lower one. Secondly, that the catheter in the naso-pharynx deviates upwards from its direction of a right angle with the plane of the face when its beak touches the roof of the naso-pharynx. Thirdly, that the catheter is not drawn back far enough and is rotated too soon. The beak then, instead of entering into the tube, enters into Rosenmüller's fossa where it may catch between folds and scars of the mucous membrane, giving the operator the sensation of having been caught in the tube. (Compare Fig. 13). A noise is produced by inflation which may be heard at a considerable distance similar to that of the wings of a flying bird. The beak of the catheter in this case has to be turned down and advanced again to the rear wall of the naso-pharynx to start anew.

There are a number of other methods of inserting the catheter besides the regular one just described. You have to know them because you may succeed better sometimes by one, sometimes by another.

Politzer in his text book advocates the so-called *Kuh* method which differs from *Kramer's* in that the beak of the catheter is turned outward till it touches the side wall as soon as it has touched the rear wall of the naso-pharynx. Continually touching the side wall it is drawn back and falls into Rosenmüller's fossa, then into the tube after having passed its ridge. I prefer the first method for the reason that the beak does not come in contact with so much ciliated epithelium.

By the third method we do not start from the rear wall, but from the rear end of the nasal septum. The beak, when it has reached the soft palate, is turned in the opposite direction from the tube we want to catheterize, till it is horizontal. Pressing it slightly against the lateral wall of the nose the catheter is pulled back till the beak is caught at the rear margin of the septum of the nose. The beak will now reach the tube if we turn it downward 180° plus one eighth of a turn upward and press the catheter against the septum.

The fourth method may be used when the nasal passage is very oblique and when the beak of the catheter turns outward almost of its own accord. We may try in that case to insert the catheter directly into the tube. We can try the same method when the distance of the tube from the point of the nose is known from former treatments of this patient, who does not stand the touching of the rear wall of the pharynx very well.

A fifth method may be tried when the lower meatus is obstructed. We insert the catheter through the middle meatus. When the beak has arrived in the naso-pharynx we often succeed in pushing the catheter down into the lower duct, whence we proceed as in *Kramer's* method.

The sixth method tries to arrive at the point with the beak of the catheter turned upwards. This is indicated when the lower turbinal hangs very low and at the same time the septum is considerably deviated and thicker than normal. We start the insertion with the beak turned downward. We make a wide curve as soon as we meet an impassable obstruction till the ring of the catheter points upward. The concavity of the beak in this position hugs the convexity of the lower turbinal. The catheter often passes easily a comparatively narrow and crooked canal. We advance in this position to the naso-pharynx where we turn the beak downward. In order to succeed in this we must not turn towards the tube, but in the opposite direction. The beak being turned downward we advance to the rear wall of the naso-pharynx and proceed from there according to *Kramer's* method.

The removal of the catheter which we have not yet mentioned requires special attention in the last named method. The rule is to remove the catheter in the same way it was inserted. Serious damage may be done if we do not follow this rule in the last method. The beak of the catheter can only be turned downward, not upward on account of the protrusion of the cartilage of the tube. The convexity of the beak will be caught against the convexity of the turbinal as soon as we try to extract the catheter in this position. The more we pull, the tighter it will be wedged in. A false passage will be bored in the mucous membrane of the floor of the nose with the point of the catheter, the moment we try to push the instrument back into the nasopharynx, if it has already arrived at the hard palate. The action of the lever that we spoke of before, helps to make matters worse. In order to disengage the instrument in this position probes have been inserted, or air inflated, which sufficiently explains the emphysema which was reported several times in the literature. It is therefore essential in this method that the convexity of the catheter be turned downward for the removal as well as for the insertion.

Seventh Method:—We may reach the tube from the opposite nostril when the same side is absolutely closed to the catheter. Deviations of the septum are the most frequent causes for this. An abnormal width of the other side is a frequent consequence. A very strongly curved catheter may be introduced through that nostril to the rear wall of the naso-pharynx. It is rotated according to *Kramer's* method into the opposite tube. Auscultation will convince you whether or not the air enters into the middle ear. It is even frequently possible to catheterize both tubes if both ears are diseased, with the same strongly curved catheter, on account of the great width of the cavities of the nose.

The eighth method deals with the introduction of the eustachian catheter *through the mouth*. This is impossible under normal conditions on account of the reflex movements of the palate. It would require another rectangular curve of the catheter. The insertion through the mouth of our ordinary catheters offers no difficulties *in congenital clefts of the hard and soft palate.* The action of those muscles (described on page 22) which arise from the tubes and have their insertion in the soft palate is seriously interfered with in cleft palates. As a consequence the tubes and middle ear are very poorly ventilated. Repeated inflations of air at regular intervals are necessary to avoid damage to the ear. The lower meatus generally takes part in the deformity. Therefore the only path for the catheter leads through the mouth. We can not see the opening of the tube, but we can find it from the rear wall of the naso-pharynx through the cleft. Sometimes the rear end of the lower turbinal is visible, which may be of help to us. The success of the air douche can often be heard, sometimes seen by the bulging drum-membrane, or proved by the considerable improvement of hearing.

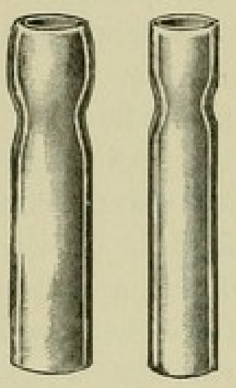


Fig. 15.
¾ natural size.

Either *Politzer's* single bulb or *Lucae's* double bulb may be used for *inflation of compressed air.* In double bulbs one acts as reservoir for the compressed air. Its advantages over the *Politzer* bulb is that the pressure can be regulated much better with the reservoir, than by compression of the bulb with the hand. The second point is more important. The double bulb emits a long lasting current of air, the entrance of which into the middle ear can be heard much better with the auscultation tube. Many a noise which may be caused by disturbance of secretion, etc., is lost to auscultation on account of its short duration in inflation with the *Politzer* bulb.

The compressed air enters the middle ear more vigorously *if the tube is opened by the act of swallowing while inflating.* There is a clasp on the rubber tube from a compressed air reservoir which is given to the patient, so that he may open it himself the moment he swallows, in order to have the compressed air enter during swallowing.

The air is compressed in some various clinics with other mechanical contrivances, instead of a bulb. (*Lucae.*)

The introduction of inflation by *Politzer's* method marked a great progress in otology. The insertion of the catheter in children can often be accomplished by force only. *Politzer's* method does away with the catheter. Every physician is able since then to treat successfully those extremely frequent diseases of the middle ears of *children* which are the origin of numerous persisting troubles.

The double bulb is best used for *Politzer's* method. A short wide glass tube (compare fig. 15) is attached to the rubber tube of the reservoir. The glass tube is inserted in one nostril, the rest of which as well as the other nostril, are hermetically closed over it with the thumb and index finger of the operator. The fingers of the other hand close the rubber tube below the glass tube. We let the air enter into the nose the moment that the soft palate closes the nose and nasopharynx in swallowing or crying. Little children can not be induced to swallow. They are laid on their back, their nose is closed with the glass tube in it. An assistant is ready to pour half a teaspoonful of water into their mouth when the tube is simultaneously opened. This is often the only way to force air into the middle ear of children only a few years old, or to recognize a small hole in the drum membrane from the noise of perforation, or to throw some secretions from the middle ear into the external meatus. *Politzer's* method often succeeds during crying also.

This procedure can of course never fully take the place of the air-douche through the catheter. The current of air cannot be confined to one ear exclusively and its force cannot be controlled as safely. Valve-like occlusions of the tube are furthermore not infrequent occurrences. They may be absolutely impassable for Politzer's method, while the beak of the catheter easily enters them. Finally the noises which we hear through the auscultation tube are more unreliable in Politzer's method than those which are caused by the long lasting current of air through the catheter.

Finally to force air into the middle ear there is the experiment known as *Valsalva's* test, because it was he who made it known. It consists of a forced expiration while the nose and the mouth are closed. It is used only in suppurations of the middle ear to force secretions through a perforation in the drum-membrane into the external meatus.

LECTURE V.

Examination of the Middle Ear by Operation.

Gentlemen:—Another avenue for reaching the middle ear is by opening the antrum and cells by means of an operation.

For the present we shall see only in a general way at which places it is easiest to reach the antrum and cells by operation, i. e., where they are nearest to the surface of the bone.

The mastoid parts of the temporal bones are so different one from the other, that it is difficult to find a fixed point from which to take one's bearings. As such I chose a little bony ridge on the rear and upper limit of the entrance to the meatus. It is found there pretty regularly and is also mentioned by *Henle*. I used it therefore for taking measures on the cadaver as well as for operation on the living.[1] I called it spina supra meatum. (*Schwalbe* later on tuberculum supra meatum.) The floor of the antrum mastoideum lies in a horizontal plane through the spina.

The topography of the antrum and of the soft tissues of the outside of the skull can be studied very well in a horizontal section with the soft tissue still in place (comp. fig. 16). You see on such a specimen that the concha is not fastened to the side wall of the skull directly behind the meatus, but that there is a thick layer of tissue between the cartilage and the periosteum of the pars mastoidea. *The fold which the skin makes in reaching from the rear surface of the concha to the side wall of the skull, is on an average, 15 millimeters behind the auditory canal.* The rear end of the antrum as you see does not reach as far back as this fold. This fold is on the contrary opposite the sigmoid sinus which is often very close to the outer surface of the bone. It is therefore of no advantage to cut the skin as is often recommended in a curve *behind* the insertion of the concha, but, if we want to reach the antrum by the shortest road, we must cut in a straight tangent *through* this line. We are opposite the antrum, if we push the soft parts and the periosteum forward. The antrum is found at an average depth of 12 millimeters if we open up in a transverse

[1]) The perforation of the mastoid process from an anatomical standpoint. Monatsschrift f. O. 1873 No. 11 to 1874 No. 2.

direction inward directly behind the spina supra meatum, which should be located in every case.

The *acute* suppurations of the middle ear which call for these operations have their focus often not exclusively, in many cases not at all in the antrum, but in some of the cells of the periphery, the large terminal cells. The operation therefore cannot be confined to the opening of the antrum, but must be extended to the cells. Therefore the *whole* external wall of the mastoid process must be removed. We generally find one or several cells in the tip of the mastoid filled with pus. A cavity with smooth walls all around, which is open wide towards the outside has to be formed

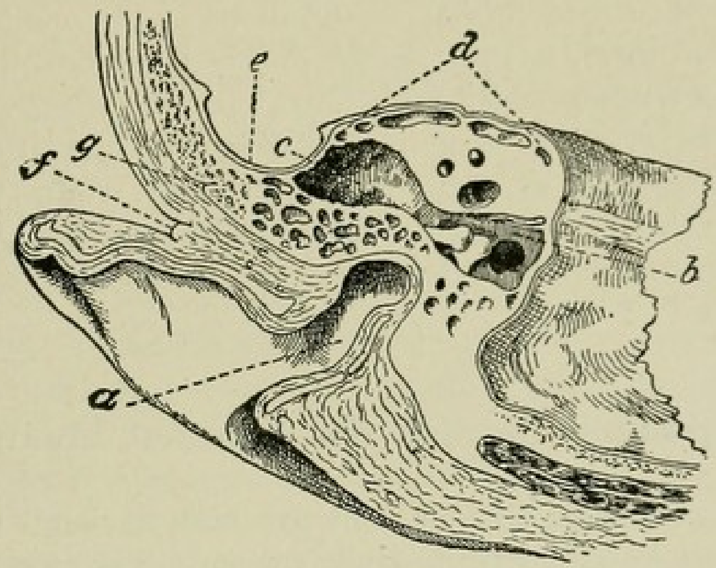


Fig. 16.

Horizontal section through the temporal bone in the level of the spina supra meatum. The soft tissues are left intact.

a external meatus, *b* drum-cavity containing the hammer and anvil, *c* antrum mastoideum, *d* pneumatic cells surrounding the labyrinth, *e* sinus sigmoideus, *f* posterior limit of the insertion of the auricle, *g* cut through the mastoideo-squamous fissure.

out of all the cells. Sometimes on account of local inflammations we are obliged to open cells which are not in the mastoid process but in its surroundings.

A large cell filled with pus is especially often found on the floor of the temporal bone inside the incisura mastoidea. This cell can be sufficiently exposed in some cases only, by removing the inner surface of the mastoid process and the bony floor of the suppurating cavity. In this connection we must not forget that often this medial wall which is covered with pus and granulations may be the wall of the sigmoid sinus, which also may be wanting. Usually a swelling of the *neck below* and *around* the mastoid process points to the deep-seated suppuration. In other cases the appearance of a drop of pus in one of the uncovered cells points to one of those deep-seated pus cavities.

Cells filled with pus are found in rare cases *behind* the mastoid process and at the *root of the zygomatic process.* Both of those places are usually betrayed by the swelling and sensitiveness to pressure of the soft parts covering them.

The rear end of the antrum in very small children is only very slightly below the outer plate of the bone. The mastoideo-squamous fissure runs over it in a vertical direction. In order to lay bare the field of operation the concha together with the periosteum must be loosened from the bone up to the meatus in very small children as in adults. Neither the spina supra meatum nor the crista temporalis is clearly visible in very small children, which makes the topography of the outer surface of the mastoid process at that age very difficult. There are no cells except the antrum which in the new-born is of the same size as in the adult.

It is not sufficient in *chronic* suppurations of the middle ear which must be operated upon, to open up the spaces temporarily; we have to make a *radical operation* which keeps them open *perpetually*, in order to control them forever after. For that purpose we remove the outer wall of the antrum, together with the outer wall of the aditus which is the rear and upper wall of the external canal. The peripheral cells in such cases are usually completely obliterated on account of the preceding years of inflammation.

Examination through the External Meatus.

The third avenue of access to the ear leads through the *external meatus*, of which we now wish to study the form and topography.

The ear surgeon must know the form and the position of the meatus very accurately. The most important of our diagnostical examinations, the inspection of the drum membrane is accomplished through it, as also a number of operations on the drum membrane and in the drum cavity. Changes of its form like swelling or sagging of the posterior upper wall, fistulas, etc., may give us important information as to diseases of the spaces of the middle ear around it. Finally an accurate knowledge of its form is an absolute necessity for every one who wants to use instruments to remove foreign bodies which so frequently get into the meatus. Blind zeal and lack of knowledge in this respect have destroyed the hearing and even the life of a number of children.

Whoever wants to operate in a meatus which is occluded by some foreign body or new formation (exostosis, etc.) must know its form so well that he can reproduce it before his mind's eye at any time. This ability can not be acquired in dissecting nor in studying series of cuts in different directions. There is only one means of seeing the form of a complicated cavity as a whole and preserve it in our memory, namely by making a number of *casts* of it.

The meatus commences from the rear surface of the tragus, where the cartilage of the concha turns inward and becomes tube shaped. The entrance of the meatus is an oblique plane just as its other end, the drum membrane; oblique though in opposite directions.

The cartilaginous part is not quite one third of the whole meatus. The cartilage does not form a tube, it forms only a groove open at the top. The gap is filled by membranous parts. It has two fissures which are *perpendicular to its axis* in the lower anterior wall called incisurae Santorini. They are of practical importance because abscesses in the neighborhood, for example in the parotid gland may perforate through them into the meatus, or furuncles of the meatus, may enter the surrounding soft tissues by gravity. The anterior lower and some of the rear part of the bony meatus of the adult is formed by the groove shaped os tympanicum. The rear upper and uppermost part belong to the squamous portion. There is some fibrous tissue between the cartilage and the outer rim of the os tympanicum which permits straightening of the curved canal by drawing the auricle backward and upward. Abscesses of the neighborhood may perforate here also. The perforations are often arranged in the shape of a rosary.

The *aperture of the meatus* is oval. It runs horizontally inward and a little forward. There are however two deviations from this direction.

The first is a *zigzag bend,* the second *a spiral shaped twist of the axis.*

The first bend is between the wall of the tragus and the cartilaginous meatus, where we also find the external incisura Santorini. The wall of the tragus runs forward and inward, the meatus backward and somewhat upward. The *second bend has an opposite direction.* It is between the cartilaginous and the bony meatus which runs in a slight curve inward, somewhat forward and downward.

The *spiral* shows the best in a series of cuts from the outside inward which are perpendicular to the axis.

The aperture at the entrance changes its form and size (compare fig. 21, I. page 37) according to the position of the lower jaw, whether the mouth is open or closed. A cross cut here is nearly oval. The longer axis is vertical. It may become so narrow in old people, that it forms simply a vertical slit, especially in women with flabby skin, (compare fig. 22).

The floor of the cartilaginous meatus rises towards its inner end, which accounts for the fact that this part becomes narrower. A form like an isthmus results where it joins the bony canal, which however varies greatly in different individuals (compare fig. 21 II).

The cross cut of the bony canal has somewhat the shape of a tunnel. The anterior and the lower wall which are formed by the os tympanicum are nearly straight (compare fig. 21, III). The rear and upper part of the wall which belongs to the squamous portion forms a highly curved arch over it. The bony canal persists in its shape of a tunnel throughout its length and runs in a slight curve inward and somewhat downward and forward.

The beginning of the bony canal is considerably wider than the isthmus at the end of the cartilaginous canal (compare fig. 21 II. and III.). It becomes narrower again towards the inner end, where it is

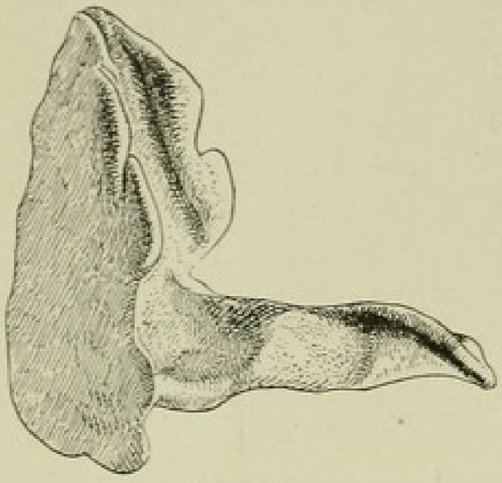


Fig. 17.

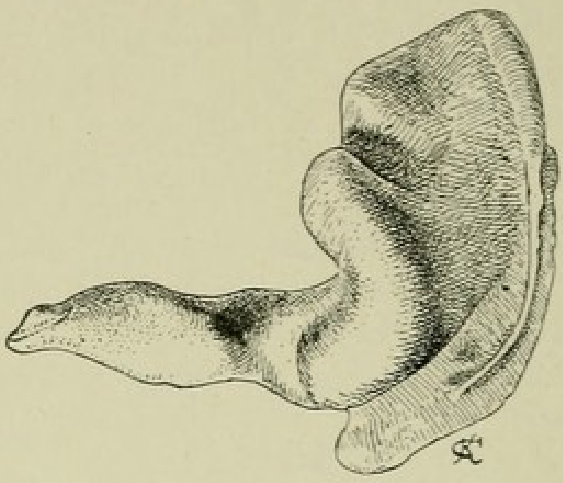


Fig. 18.

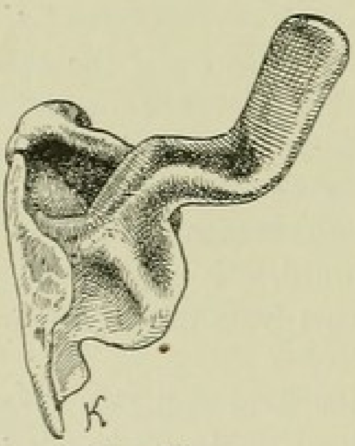


Fig. 19.

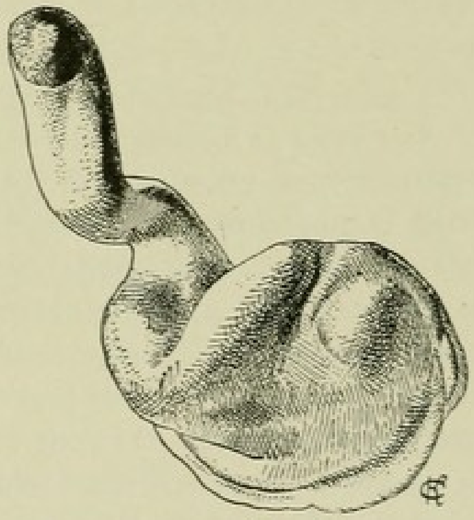


Fig. 20.

Figs. 17–20.

Cast of the external canal. In Fig. 17 as seen from in front, in Fig. 18 from the rear, in Fig. 19 from above, in Fig. 20 from below.

more the horizontal diameter which shrinks, so that the tunnel becomes flatter (compare fig. 21 III. and IV.).

Comparing the cuts through the aperture in fig. 21 I. to IV. you will notice that the upper end of the long diameter turns more and more forward so that at the end of the canal (cut IV.) it has an angle of only 45 degrees with the horizon, while in the beginning it was 90 degrees. The spiral twist of the axis is thereby proven.

You will understand now why neither horizontal nor sagittal cuts through the skull can give an accurate impression of the form of the meatus. The inner end in a horizontal cut seems enlarged on account of the spiral twist. Much less can vertical cuts give a clear picture, since the spiral twist as well as the zigzag shape are lost to view.

The arabic numbers in fig. 21 give the *average length* of the longer

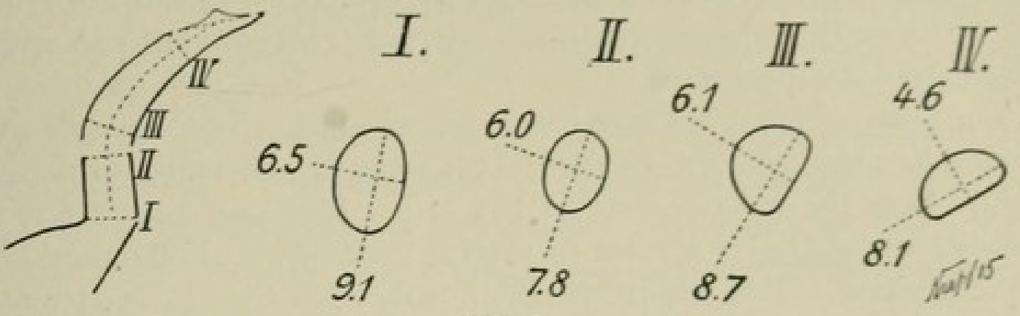


Fig. 21.

Section through the meatus perpendicular to its axis.

I at the entrance, *II* at the end of the cartilaginous part, *III* at the beginning of the bony part, *IV* at the end of the bony part.

and shorter diameter of the different cuts through the meatus. I obtained those numbers by measuring a great many corrosion casts of the canal. The most important cut is the innermost. Its longer diameter is 8.1, its shorter 4.6 millimeters. It forms the door for examinations of the drum membrane with the ear speculum as well as for the introduction of the instruments in the operations on the drum membrane and drum cavity. It is a matter of every day experience that a moderate swelling of the walls in this place can convert the narrow oval into a slit which hides the drum membrane from our view.

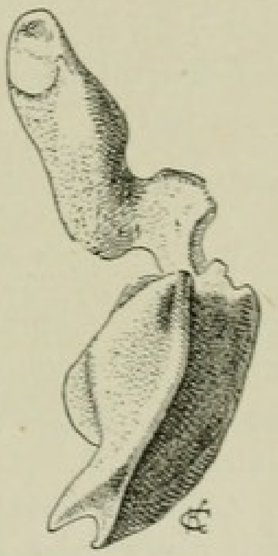


Fig. 22.

Cast of the meatus of an old woman, as seen from above.

The *length* of the canal from the point of the tragus to the anterior and lower end of the drum membrane is 35.2 millimeters. Its length from the rear part of the rim of the entrance is according to *v. Troeltsch* 24 millimeters, with which my measurements nearly coincide.

It simplifies matters to speak of *two walls* of the canal only instead of *four* on account of its partly oval, partly tunnel-like shape. The anterior wall in the depth becomes the anterior and lower wall. The posterior wall in the deeper parts becomes the rear and upper wall which there forms the highly curved arch over the anterior wall.

We have to consider the *innermost* part of the meatus, which is medial from cut IV. The lower anterior wall is the continuation of the anterior wall with its slight spiral twist. In place of the upper and posterior wall there is the drum membrane which cuts through the canal in a very oblique direction (compare fig. 17 to 21).

The plane of the drum membrane is very oblique as compared to the sagittal plane of the skull. Its upper and rear margin is much more lateral than its lower and anterior edge. Supposing the membranes of both ears be sufficiently enlarged, they would meet in a line in front of the head, which runs in the median plane slanting from forward and upward to downward and backward.

The *form* of the drum membrane depends upon the oblique direction in which its plane cuts the meatus. If it were perpendicular to the axis, it would have the form of cut IV (fig. 21). It is oval however or has somewhat the shape of a heart in playing cards as a consequence of its oblique position. The largest diameter runs from the rear and upward to the front and downward. It is on an average of 9.2 millimeters long according to the measures taken on casts. The shorter diameter runs from the rear part of the base to the front of the top and measures 8.5 millimeters.

The rear upper wall of the meatus passes in a *slight curve* into the drum membrane, so that there is no angle of 140° or less, as some text books give it. The limit between the rear wall of the meatus and the drum membrane can under normal conditions only be recognized from the difference in color of both. It is very liable to disappear when there is injection of blood vessels or infiltration. These points are often very important.

The angle of *the lower and anterior wall* and the drum membrane according to the casts is much more acute than it appears from our inspection or from former authors. This angle in casts is from 23 to 31.5°, *on an average 27½°*. The drum membrane changes its position very little as we shall see in the description of the triangular reflex. The different size of that angle depends therefore in the first place upon the smaller or larger curve of the canal and the protrusion of its lower and anterior wall.

The *recessus meatus* is the space in the acute angle between the drum membrane and the lower anterior wall of the canal. This space may be hidden from our view through the speculum when the anterior and lower walls protrude considerably. Perforations of the drum membrane and foreign bodies may remain there undetected by our eye. In rare cases this protrusion may cover more than the anterior lower half of the drum membrane. Usually however we are able to see this space as well as the remainder of the canal and drum head (compare sulcus reflex page 46). The meatus of the *new-born* and of children of a few years is quite different. They have no bony canal at all. The os tympanicum is not a tube, it is merely a ring, called the annulus tympanicus in which the drum membrane is inserted. The tube shape is developed later on when the horizontal part of the squama is formed and the annulus tympanicus becomes a bony groove. An irregular round defect of ossification which is closed by connective tissue only, often remains in the anterior lower wall up to the fourth year and exceptionally even in the adult. The external meatus of the new-born, the walls of which are membranous throughout, leave only a little horizontal slit between themselves and the drum membrane. This slit is filled after birth with vernix caseosa. The membrane can be seen only very incompletely in the first few months of life even if all the vernix is removed.

The meatus of an adult contains about one cubic centimeter according to *Hummel.* We measure it by filling it with water. This method of measuring may become of practical importance in those comparatively frequent cases where large pathological cavities communicate freely with the meatus.

We will now proceed to describe the *surroundings* of the meatus. The *parotid gland* encloses the cartilaginous meatus *downward and forward. The glenoid process of the lower jaw* lies close to the *upper part of the anterior wall.* In opening the mouth the entrance of the meatus becomes wider. Pains in the joint of the jaw are often described as ear-ache by the patient. Pressure in front of the tragus while the patient opens his mouth gives us information about the real seat of the pain. Crepitus sometimes can be felt in the joint. *Large cells of the mastoid process* often lie close to the *rear* wall of the bony canal. Fistulas may lead into the canal through this wall. *The mastoid antrum, the aperture of which is often not more than five millimeters from the aperture of the canal,* is medial from these cells. It runs in a slight curve over and behind the rear wall (compare fig. 5 page 9). Destruction of the rear wall of the bony canal leads frequently to communications between the meatus and the cells of the mastoid process. Small pneumatic cells are sometimes found in the roof of the meatus. They not infrequently communicate with the large cells at the base of the zygomatic process.

LECTURE VI.

The Picture of the Tympanic Membrane on Examination with the Ear Speculum.

The rapid progress of otology in diagnosis and therapy became possible only after *v. Troeltsch* taught us to throw light with a perforated reflector on the drum membrane when it became visible to the eye of the observer.

For illumination of the meatus and the drum membrane we use wherever it is possible diffuse day light in a room with one window only. The distance from the window is irrelevant. A concave mirror is used, the diameter of which is 10 centimeters, its focal distance 15 centimeters. It has to be held at a distance of 12 centimeters from the entrance of the meatus in order to have the focus on the drum membrane because of the length of the meatus.

Anomalies of refraction or accommodation in the examiner must be corrected with glasses.

We use a forehead mirror of a larger focal distance (18 centimeters) for operating in the canal, in order to leave space for the hand to act.

Nernst lamps and Welsbach lights are preferable for artificial illumination. Their light is concentrated by means of lenses or the so-called "*Schusterkugel*" which was introduced by *Oertel* into laryngology. The advantage is the large area of light for the examination. A kerosene lamp however may give sufficient light to see the drum membrane.

Politzer's hard rubber ear specula are used to straighten and enlarge the cartilaginous meatus. Their aperture is round and of three different sizes. The ear speculum must not be inserted deeper than the cartilaginous meatus. The canal is straightened by pressing the rear wall of the speculum against the rear wall of the meatus and simultaneously pushing or pulling back the auricle with the middle finger which is inserted into it. The use of the speculum as well as the insertion of the catheter have to be learned in special courses.

Light has to be thrown into the meatus before inserting the speculum in order to recognize fistulas and other changes around the entrance.

Looking through the speculum one must not forget that the walls of the meatus and the larger part of the drum membrane can be seen foreshortened and with *one* eye only. An accurate *estimate of the depth* is therefore very difficult. It can be learned only by constant practice in examining a large number of normal ears.

The condition of the drum membrane, as we see it through the speculum gives us information concerning pathological changes which are located in it. Even though it may not be diseased itself, its partial transparency and easy changeableness of form put us in a position to draw conclusions as to diseases which are located in the drum cavity or in distant parts of the middle ear.

First you ought to know accurately how a normal drum membrane looks. It is however at least as important to know from your own experience the many variations which may be present without interfering with hearing and which therefore must be considered as relatively normal. From my own experience I cannot recommend to you a better field of practice than to offer your services for the *examination of school children.* The interest which at present the work of physicians in the schools has aroused will afford you ample opportunities for such study.

The drum membrane consists, as you know, of three layers, the cutis of the external meatus, the *membrana propria,* and the mucous membrane. The membrana propria has two layers an outer in which the fibres are arranged radially, and an inner one with circular arrangement. The rim of the drum membrane is thickened and is called the *limbus tendinosus.* The limbus tendinosus is inserted into the sulcus of the os tympanicum like the crystal of a watch is inserted into the rim. The sulcus goes only as far as the os tympani reaches. We have heard that this is wanting at the top and that the horizontal part of the squama fills the gap. There the membrane is attached directly on to a sharp rim of the squama and forms the incisura *Rivini,* which is a small notch either round or scalloped. The meatus and the aditus ad antrum meet in this sharp rim at an acute angle.

The part of the drum membrane which covers the notch has no membrana propria like the rest. It is therefore thinner and flabby. We call it the pars flaccida *Shrapnelli,* while the rest of the membrane is called the pars tensa. The line which marks their division is the thickened upper end of the membrana propria, which can be recognized from the outside as two short cords. The anterior one is usually more pronounced than the posterior one. They are called the two liminal strands. They start from the anterior and posterior corner of the incisura *Rivini* and run downward towards each other in a very obtuse angle. They meet in the little *protuberance* which the *short process of the malleus* forms in the drum membrane.

Prussak's space is a small flat pouch on the *inside* of *Shrapnell's* membrane, between this membrane and the neck of the hammer which runs upwards from the short process. Its upper limit is the transverse ligament of the hammer, its anterior limit is the anterior liminal strand of the drum membrane. It opens in the rear towards the aditus ad antrum.

The protuberance of the short process is the best point from which to take our bearings for the surface of the drum membrane. It usually shows as a yellow spot even when the cutis is much swollen and injected. The short process and the neck of the hammer are often intact when the drum membrane is destroyed very extensively.

The outer edge of the handle of the hammer is usually visible as a whitish, straight or slightly curved line running from the short process downward and slightly backward to a little below the center of the membrane. Sometimes it looks only like a small crest which forms the limit between the anterior and posterior half of the membrane.

You divide the drum membrane in four quadrants, by prolonging the line of the handle of the hammer to the lower and posterior rim, and drawing a perpendicular line to this through the end of the handle. This division is generally accepted and practical. The quadrants are not equally large, the two rear ones are larger than the front ones and the upper ones larger than the lower ones.

The *color* of the drum-membrane is influenced by its transparency. It is pearly gray although it is covered with white epidermis. Towards the center it has a yellowish tint from the bone of the promontory which lies close behind it.

The thinnest part of the drum membrane, the intermediary zone, appears diffusely pinkish, whenever the blood vessels of the inner wall are injected. On the other hand, an injection of the blood vessels of its cutis shows mainly along the handle of the hammer, where the main blood vessels of the cutis run, and all along the periphery, where a great number of radial blood vessels pass over from the meatus to the drum membrane.

The thicker and therefore opaque parts of the membrane are more whitish (compare table of drum membranes, fig. I). As landmarks of the membrane we recognized the anterior and posterior liminal strands, the short process, and the handle of the hammer. Frequently *there is a lighter spot* at the lower end of the handle of the hammer called the umbo of the drum membrane. It is produced partly by a spatula-like enlargement of the lower end of the handle of the hammer, partly by a closer arrangement of the radial fibres of the drum membrane. The limbus of the drum membrane appears often as *a narrow white zone which is sharply circumscribed in its outermost periphery.* The cutis of the rear and upper part of the bony meatus contains the blood vessels and nerves of the drum membrane enclosed in a layer of subcutaneous cellular tissue. The rest of the bony meatus however is lined with thin cutis which is closely connected with the periosteum. The thicker layer of connective tissue passes together with the blood vessels and nerves over to the drum membrane, and there forms a light stripe in the rear and upper quadrant, which runs parallel to the handle of the hammer. It is wide on top, but becomes narrower further down. It terminates in a sharp line at the end of the handle.

The contours of parts in a drum cavity are recognizable through the drum membrane as lighter lines. The posterior fold of the drum membrane which forms *v. Troeltsch's* rear pouch may appear in the rear upper periphery as a downward concave line which ends at the handle of the hammer. The rear part of this contour may be formed by the chorda tympani, which runs along the posterior fold of the drum membrane, and, after having passed the handle of the hammer, runs into *Glaser's* fissure. *A shorter light streak may appear below this contour,* when the drum membrane is very transparent. It is *nearly parallel with the handle of the hammer.* There is *frequently another light streak* running backwards from its end towards the periphery at right angles to the first one. The vertical streak is *the lower end of the long process of the incus.* The horizontal one is *the tendon of the stapedius muscle,* and is not the rear horn of the stirrup, as was generally believed according to *Politzer.* This is shown firstly by the fact that this streak is always straight, and secondly, one can see it with one's own eye whenever there is a large defect in the rear upper quadrant of the drum membrane. The *entrance to the niche of the round window* can be seen sometimes as a dark spot in the rear lower quadrant. The upper anterior quadrant appears darker than the rest of the drum membrane on account of its deeper position and the shadows which are thrown upon it.

The picture of the drum membrane is very much influenced by *its different curves.* We did not enter into a description of details in order not to complicate matters.

The drum membrane as such is funnel shaped. The opening of the funnel is directed towards the meatus. The periphery forms a plane through the sulcus tympanicus around the rim of the funnel. Every radius of the funnel is slightly convex towards the meatus.

There are no folds in the drum membrane under normal conditions except the two liminal strands. The development of folds which were described in the normal drum membrane has to be attributed to past or still existing pathological processes. It is important to state this fact since it influences our judgment of the findings of the drum membrane. We can therefore infer from a typically normal drum membrane, which has no folds whatsoever, that there were never any pathological processes, especially of the tubes, which always leave persisting changes of the drum membrane whenever they have lasted for some time.

The form of the drum membrane changes as soon as the equilibrium of the air pressure on the outside and on the inside of it is disturbed.

Whenever the air in the spaces of the middle ear is rarefied, which many people can accomplish by swallowing while their nose and mouth are closed, the convexity of the radial fibres of the drum membrane disappears and *the exact form of a funnel* becomes more or less pronounced. (Compare Fig. 23c.)

Whenever the air in the middle ear is compressed as for example in Valsalva's experiment, the drum membrane bulges visibly, and the convexity of the fibres of the funnel outward increases considerably. (Compare Fig. 23 b.)

All these changes of form of the drum membrane are clearly recognized in examinations of the drum membrane through the ear speculum, from the alteration in the form of the light reflexes which occur on the surface of the drum membrane. Their description will be considered in the next chapter.

The so-called normal reflex of the drum-membrane (compare Fig. 23a and 24) has the form of a triangle, the apex of which is in the

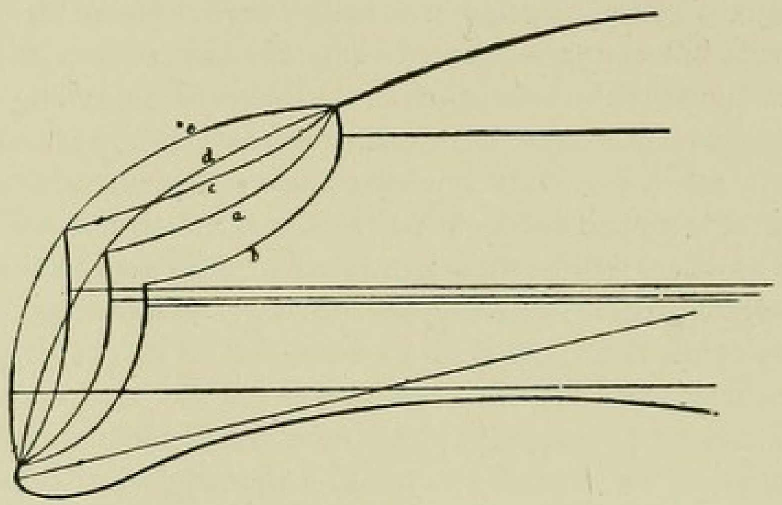


Fig. 23.

Section through the tympanic membrane in the axis of the meatus through the middle of the triangular reflex.

a normal curve, *b* bulging, *c* funnel shaped slight retraction, *d* pan shaped (moderate) retraction, *e* kettle shaped (highest degree of) retraction.

umbo, the base is directed towards the anterior and lower part of the periphery. The base does not quite reach the periphery and is indistinct. The funnel shape of the drum membrane is the cause of the triangular form of the reflex. The constant location of the reflex in the anterior lower quadrant is explained by the doubly oblique position of the drum membrane The illumination of the surface of the drum membrane is effected by the reflector, the axis of which is also our axis of vision. A reflex can only be seen on such parts of the drum membrane as throw back the light in exactly the same direction as that in which it came. The radius of the wall of the funnel which is *perpendicular to our axis of vision,* and its immediate surroundings fulfill that condition. The direction of our axis of vision with the drum membrane being determined by the axis of the meatus, and the position of the membrane being determined by the same axis, it is easily recognized from Fig. 23, that the triangular reflex can only occur in the lower anterior quadrant. Supposing the funnel shaped surface of the drum membrane were directed downward, the triangular reflex would run *vertically* downward from the umbo. The reflex would be seen *horizontally* forward, if the funnel shaped surface were directed forward. It is evident that the direction of the light reflex must be between the two directions, since the obliquity of the drum membrane is *between* the two just named directions. We are even able to infer the degree of obliquity in one or the other direction from the more vertical or more horizontal position of the reflex, provided the funnel be regularly shaped. We learned that the funnel does not reach the periphery of the membrane, therefore the light reflex can not do so either.

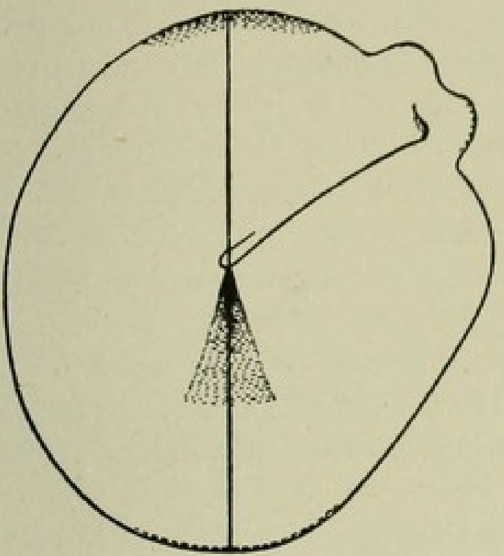


Fig. 24.

Schematic demonstration of the normal reflexes of the tympanic membrane.

A triangular reflex would be impossible if the drum membrane were so oblique that no radius of the funnel were perpendicular to the axis of vision. The normal reflex was absent in 4.1 per cent of 614 ears which I examined in school children. I became convinced at that time that it does not influence the function of the ear whether it be triangular, distinct or indistinct, whether it be interrupted in its length or in its width, or whether it be reduced to a simple indistinct spot in the umbo. There is *one* condition absolutely necessary in order to give the reflex the predicate normal, that is, it must reach to the umbo, or very nearly so with its point, be it ever so indistinct. This is possible only under the condition that the drum membrane has preserved its shape of a funnel. It is immaterial if the point of the funnel be dull, since this is occasioned by the enlargement of the end of the handle of the mallet.

The great regularity of the normal reflex must be taken as a proof for the following facts: *the relative position of the drum membrane and the axis of the meatus is the same in all people, because the lower anterior quadrant of the membrane is always met in the direction of the axis of the meatus by the sound rays, that is in a perpendicular direction.*

The form of the normal reflex will change of course whenever the drum membrane *is retracted or bulges.* In the *first* case it becomes narrower and longer, because the membrane becomes more funnel shaped (compare Fig. 23c) ; in the second case it becomes wider, shorter and more indistinct (compare 23b). Its point however reaches the umbo as long as the drum membrane keeps the shape of a funnel.

Another *small reflex of light* is found sometimes on the *short process of a normal drum membrane.* It is a reflex from the convexity of the ball shaped cartilaginous covering of the process.

Two more *reflexes as from a hollow ball* are found on the drum membrane. The *first one* is found at the anterior limit of Sharpnell's membrane. It is not always seen on the normal membrane; whenever it expands over a large part of the surface of the Sharpnell's membrane it is pathological. The other reflex is seen constantly *at the lower and anterior periphery of the drum membrane.* It is a narrow streak of light like a line of light of several millimeters, which is not located on the membrane itself, but is formed in the groove between the external part of the sulcus pro tympano and the wall of the meatus. I called it therefore the "sulcus reflex." It can be seen only when the recessus of the meatus is not concealed by the protruding anterior and lower wall of the external canal. Whenever we are able to see it, we know that we can see the *whole* drum membrane. In many cases it can be made visible only by a forcible straightening of the meatus. The beginner in examination has an assurance of focusing correctly when the sulcus reflex appears. I found it covered by the wall of the meatus in 30.6 per cent of the ears which I examined in pupils of the public schools. *This shows that we are able to see the whole drum membrane in at least two-thirds of all children,* if the meatus is otherwise normal.

Another *crescent-shaped reflex* appears finally *on the rear and upper periphery* of the drum membrane whenever it bulges very much, either as a consequence of the air douche or *Valsalva's* experiment. Its lower limits are indistinct. It occurs because the rear and upper periphery becomes perpendicular to the axis of vision. (Compare Fig. 23b, and 24m).

The position of the three reflexes just described, the triangular, the sulcus and the reflex of the bulging is characterized in that a line which cuts the triangular reflex lengthwise in two halves, also cuts the other reflexes in two halves. (Fig. 24.)

All other reflexes which may become visible on the drum membrane, as also the removal of the triangular reflex from the umbo, are not normal, but indicate pathological changes of the form of the drum membrane. This is one of the reasons for entering carefully into the description of the form and origin of the normal reflexes of the drum membrane. The origin of the different pathological reflexes will be studied in the special part.

LECTURE VII.

Physiological Preface.

Gentlemen:—We should know at least the most important points of the complicated *mechanical contrivances* which help to produce the sensation of hearing in order to understand the disturbances of the function of hearing.

The external canal together with the auricle must be considered as a collecting pipe for the sound waves. It allows, whenever it is very wide, a part of the sound waves to pass without deflection, so that they strike the lower anterior quadrant of the drum-membrane perpendicularly. Another large part of the sound waves is reflected inwardly from the walls of the concha and meatus, so that they also reach the drum membrane more or less perpendicularly.

Narrowness of the meatus, even if only a very small aperture is left has little influence on the acuteness of hearing. I became convinced however that it is not entirely a matter of indifference for the perception of high sounds.

The *sound conducting apparatus* consisting of drum membrane, ossicles and ligamentum annulare forms a mechanism of wonderful precision.

Most of the simple words like numbers can be understood in a whisper at a distance of 89 meters and more, in an absolutely quiet room, according to examinations which I induced *Morsak* to make.

The mathematician *Riemann* found by calculation that the magnitude of the movements which are exactly transmitted by the drum membrane to the foot plate of the stirrup of a person who hears at such normal distances, are far below the limit of our microscopical observation. Newer investigations showed that the movements of the foot plate of the stirrup must actually be much smaller than *Riemann* thought they were.

Ed. Weber advances the theory that the whole sound conducting apparatus together with the column of water which runs up the scala vestibuli and back the scala tympani, moves backward and forward *as a whole* with each sound wave. The very flexible and yielding *membrane of the round window acts as a siding*. *v. Helmholtz* found the mathematical proofs for the accuracy and even necessity of this theory.

v. Helmholtz taught us furthermore that the drum membrane together with the ossicles forms a wonderful lever apparatus, which is able to convert large movements of low power into small movements of high power at the foot plate of the stirrup which is suspended at the ligamentum annulare.

This whole apparatus, according to *Riemann*, is so well balanced that the smallest amount of energy is sufficient to over-balance it.

There are two pairs of antagonists acting on the drum membrane and the sound conducting apparatus, which explains how this requirement which is a priori necessary, is fulfilled.

The first pair are the *radial and circular fibres* of the *membrana propria* of the drum-membrane. The second pair are the *two muscles in the drum cavity*.

The antagonism of the radial and circular fibres of the drum membrane is visible in the convex form of the funnel of the drum membrane. (*v. Helmholtz*.) The tensor tympani muscle, by its elastic traction which lasts even while the muscle is at rest, stretches the axis ligament and the other ligaments which have their insertion on the neck of the hammer. Secondly it tries to straighten the radial fibres of the drum-membrane. This effect is not very strong because its insertion on the handle of the hammer is not favorable, it being far away from the most efficacious place, namely the lower end of the handle of the hammer. Nevertheless this effect from which the muscle has its name, can not be doubted. The radial fibres, if they existed alone in the drum-membrane would be drawn straight by the tendon of the tensor muscle, of which they are a continuation. Their form, which is convex towards the meatus, can only originate from the circular fibres which are somewhat elastic on account of their length, run on the inside of the radial fibres and have their insertion on the handle of the hammer. Their bracing effect is the most pronounced in the intermediary zone of the funnel of the drum membrane.

Each phase of the sound waves, positive as well as negative, strikes the *whole* surface of the drum membrane evenly, on account of their great length, at least as far as they belong to the musical part of the sound scale. They travel in the direction of the meatus.

The circular fibres are always the first to be affected by the positive as well as by the negative pressure which acts on the drum membrane. The elasticity of the circular fibres is favored during rarefaction of the air in the meatus, i. e., the convexity of the funnel is increased. The positive pressure in the meatus on the other hand works against their action and supports the traction of the tendon of the tensor muscle, which tries to straighten the radial fibres. *v. Helmholtz* found by calculation that fibres of so flat an expansion are moved very easily and very extensively by the weakest pressure, and that they communicate their very much smaller, though very much stronger motions to their point of insertion which, in our case, is the handle of the hammer. "It is very similar" he says "to the increase of power by means of a lever."

It is quite extraordinary that *v. Helmholtz* did not notice the antagonism of the *second* pair of powers which act on the chain of ossicles. They are the two muscles in the drum cavity. He studied only the action of the *tensor muscle* and not that of the *stapedius muscle.*

The great importance of this muscle for the fixation and motion of the sound conducting chain may be inferred from its mode of insertion which is nearly at a right angle. Hardly any other muscle in the whole body is situated so favorably.

The fibres of its tendon, which comes from the rear and a little down-

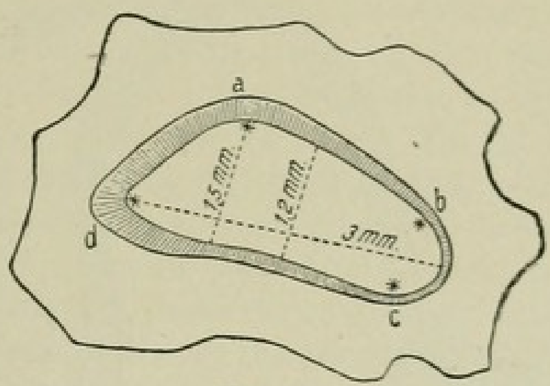


Fig. 25.

Right foot plate of the stapes together with the ligamentum annulare, according to *Eysell.*

as seen from within, *b c* axis ligament of the foot plate.

ward and upward, are inserted, according to *Rüdinger,* partly on the head of the stirrup and partly on the rim of the joint of the processus lenticularis which belongs to the long process of the incus.

Let us contemplate its effect on the stirrup alone.

In an early paper by *Eysell* we find a very good description of the manner in which the foot plate of the stirrup is connected with the pelvis ovalis by means of the ligamentum annulare.[1]

The picture (fig. 25) which is taken from *Eysell* shows that the foot plate of the right stirrup as seen from the vestibulum resembles very closely the sole of the right foot. The rear part of the ligamentum annulare all around the heel is very narrow and thick. It becomes broader and thinner towards the front (compare fig. 26). It is widest in front and upward (a to d fig 25). A vertical part of the ligamentum annulare nearest the rear pole of the foot plate "acts as an axis ligament" during the traction of the tendon of the stapedius muscle. The rear

[1]) "Beiträge zur Anatomie des Steigbügels und seiner Verbindungen," by Eysell, Cand. Med.. Arch. f. O. Vol. V. 1870.

horn of the stirrup is the fulcrum. The large part of the foot plate of the stirrup which is *in front* of the axis *b c* moves towards the drum cavity, the smaller *rear* part towards the labyrinth. According to *Eysell* the movement towards the outside on the front pole is eleven times larger than the inward motion at the rear pole. I verified this kind of motion of the stirrup by actual measurements by means of the labyrinth manometer, and found the only difference to be that the axis ligament of the stirrup runs a little obliquely from the rear and upward to forward and downward.

Politzer established the antagonism of the two muscles in the drum cavity long ago. It is supported by their different innervation, the stape-

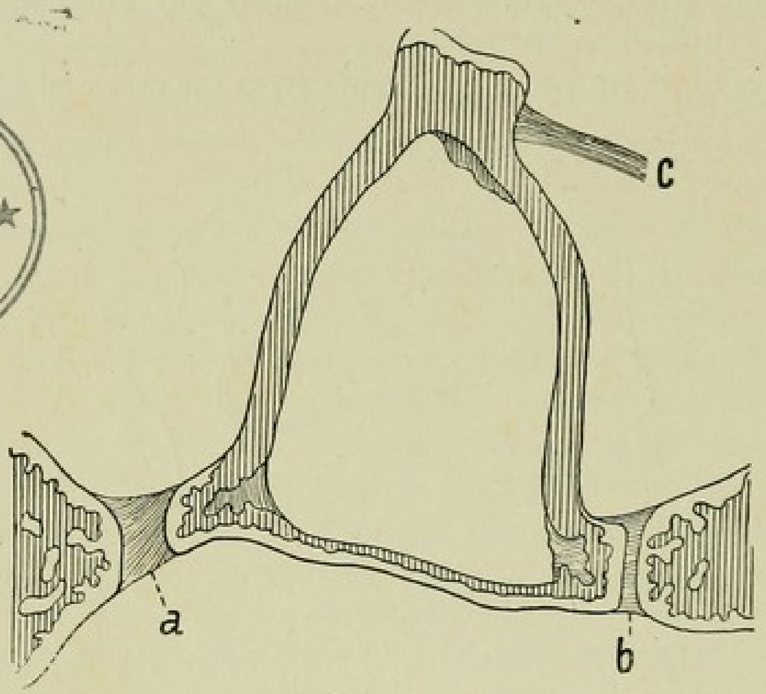


Fig. 26.

Section through the stapes and the pelvis ovalis, according to *Eysell.*
a anterior, *b* posterior part of the lig. annulare, *c* tendon of the *M.* stapedius.

dius muscle from the facial nerve, the tensor muscle from the motor branch of the trigeminus nerve. The stapedius muscle, by stretching, thus elongating the chain of ossicles, is able to move the chain of ossicles and the drum membrane *outward* and thereby increase its convexity in opposition to the tensor muscle.

Considering the coöperation of the two muscles we find that the tensor muscle tightens the axis ligament of the hammer, while on the other hand the stapedius muscle alone tightens the axis ligament of the stirrup on account of the course of its tendon which is from the rear and somewhat medial. This bracing effect is increased by the pressure which the traction of the tensor muscle exerts simultaneously against the head of the stirrup through the processus lenticularis of the long process of the incus. Both muscles acting simultaneously, the part that is stretched the least is the anterior upper part of the ligamentum annulare, which is also the broadest and thinnest part of the ligament. Here the action of the tensor is opposed to that of the stapedius muscle. The tensor muscle is six times as large as the stapedius muscle. This difference in size is completely counterbalanced by the very favorable insertion of the tendon of the stapedius muscle, as compared to the tensor which acts high up on the handle of the hammer. The processus lenticularis starts horizontally from the long process of the anvil. It forms also a very obtuse angle which is open towards the rear and which during traction of the tendon of the stapedius becomes even more obtuse, until it is nearly a straight line. There is therefore the same principle of action as in the printer's press.

v. Helmholtz in studying the joint between the hammer and incus found that, on account of a catching tooth on the hammer as well as on the incus, they act like the stem in a stem winding watch, inasmuch as the hammer in each motion inward acts together with the incus like a solid bent lever, while whenever the hammer moves outward the incus does not follow its motion. *v. Helmholtz* sees in this (no doubt correctly) a protection against a pulling of the stirrup which might occur whenever the air in the drum-cavity is compressed, as in blowing the nose. The very minute movements inward and outward, which are produced by the sound waves, act differently. Here the antagonistic action of its two muscles presses the glenoid surfaces of the joint between the anvil and stirrup against each other, so that even in a very small movement outward they cannot separate. This effect extends backward to the joint of the hammer and incus. Experiments with the manometer convinced me of the accuracy of this postulate.

Firstly. The *sound conducting apparatus* on account of all these deliberations must be considered as a mechanical combination, the parts of which are connected in such a manner that to each motion of one part, the others have to make a corresponding motion. This chain transmits the inward and the outward *movements of the drum membrane. Secondly, the anterior upper part of the ligamentum annulare must be considered as a membrane which is just as movable and just as well balanced as the drum membrane itself,* on account of the co-operation of the whole apparatus. The movements of the drum membrane are transmitted to the foot plate of the stirrup and the ligamentum annulare through the chain of ossicles without any loss. They arrive there smaller but so much stronger, as through a pantograph. *Politzer* also "sees an important function of the muscles in the tympanic cavity in offsetting the changes of tension of the ossicles and the contents of the labyrinth, caused by changes of air pressure; in other words, to regulate the tension of the apparatus of hearing." (Arch. f. Ohrenheilkunde 1869 Vol. V Page 23.)

Observations of the diseased ear gave us further particulars of how the sound conducting apparatus transmits the sound-waves from the air to the end organs of the acoustic nerve.

The manifold defects and fixations of different places of the sound conducting apparatus which we meet with have one common effect. They do not diminish hearing uniformly throughout the sound scale, we find a greater decrease in the hearing of the *lower part* of the sound scale, the more so the lower we descend. We find a *complete loss* of hearing of a smaller or larger part at the lower limit, which may amount to one or several octaves, as soon as there are serious anomalies of the sound conducting apparatus. On the other hand hearing is the less interfered with in anomalies of the sound conducting apparatus, the higher in the sound-scale we climb. The complete loss of the drum-membrane, the hammer and anvil notwithstanding, the highest part of the sound scale which is produced by the Galton whistle for example, can be heard nearly to its full length and to its normal upper limit, with the stirrup alone. The upper limit of hearing may also remain intact in partial fixation of the foot-plate of the stirrup. A considerable remnant of hearing at the upper part of the sound scale may be left even when all of the stirrup is absent and replaced by a movable occluding plate. Deafness with an intact labyrinth results only when both windows are immovably closed (*Habermann*).

The slightest overbalancing, on the other hand, of one or another of the sound conducting apparatus is sufficient to destroy the hearing of the lowest one and a half octaves. Examples are the slight increase in the tension of the drum membrane in swallowing with the nose closed, or the wilfull contraction of the tensor tympani muscle, or a small traumatic perforation of the drum-membrane.

All the different changes of the sound-conducting apparatus, as soon as they alter its well balanced condition, have without exception the same effect, they interfere with the conduction of the lower sounds from the air to the labyrinth; the more so the deeper in the sound-scale we descend.

We are therefore justified in the statement that it is the function of the sound conducting chain to transmit the large slow and weak movements, which are produced in the air by the lower half of the sound scale smaller, but stronger to the column of fluid in the labyrinth. This is accomplished by the wonderful lever apparatus consisting of drum-membrane, hammer and anvil. The rythmical vibrations of the air in the higher parts of the scale are smaller and more rapid. They need this lever apparatus less, the higher in the sound-scale they are. It seems that the highest part of the sound-scale does not need this apparatus at all, it is transmitted to the labyrinth through any plate which occludes the oval window.

I want to describe to you another function of the ear equally as wonderful as the accurate reception and transmission from the air of

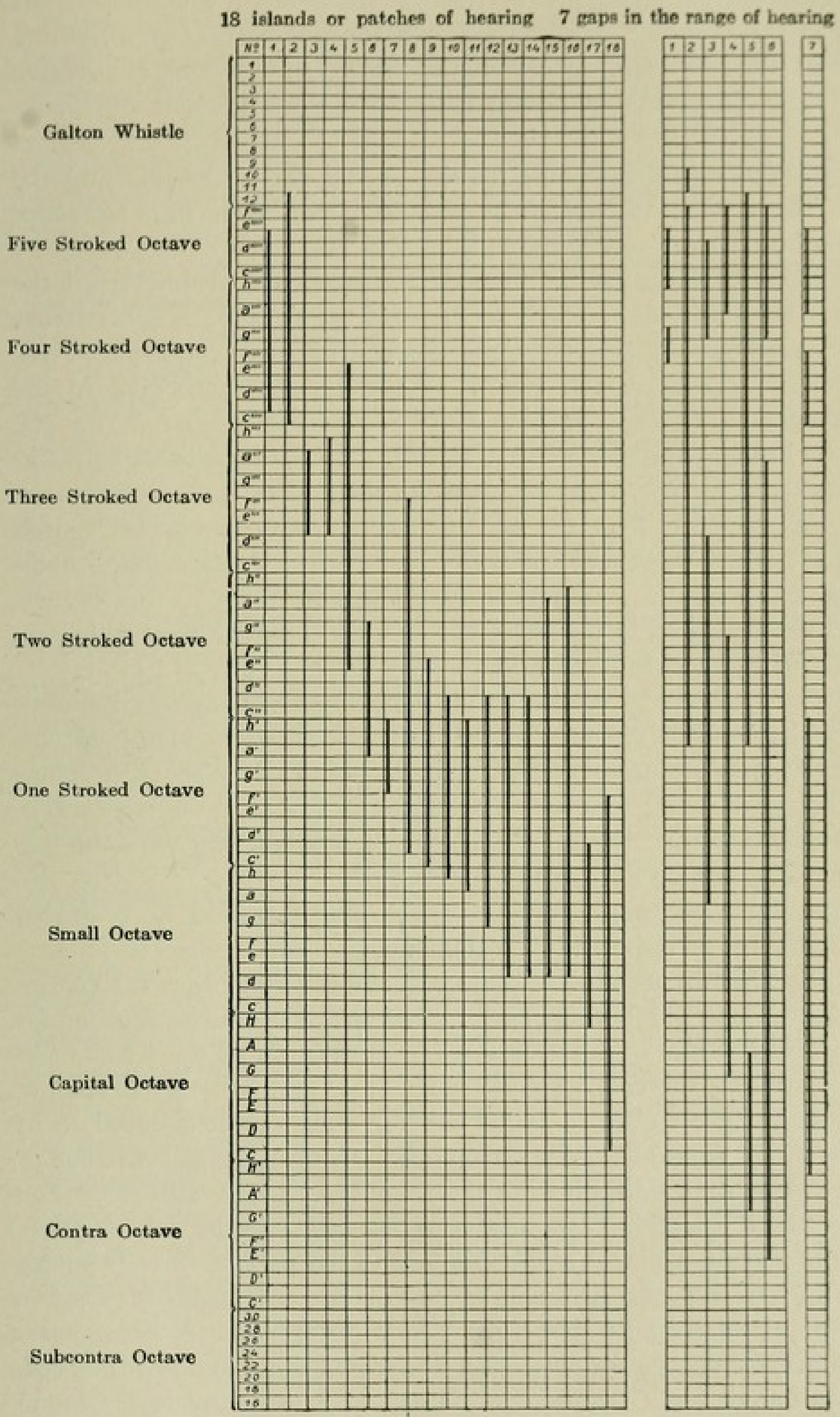


Fig. 27.

Fig. 27. The islands or patches of hearing and the gaps in the range of hearing in the ears of 59 deaf-mutes whom I examined in 1898.

even the weakest sounds of every pitch. It is able to distinguish the pitch itself, which ability, especially in the middle part of the sound-scale, amounts to the accuracy of differentiating *the numbers of vibrations to fractions of one vibration.* Most wonderful of all, it is able to perceive separately all different sounds and noises which act upon it *simultaneously.*

v. Helmholtz explained this faculty of the ear by establishing the theory of the *mechanical analysis of impressions of sound in the cochlea,* which you know from physiology, viz.:

The fibres of the zona pectinata in the basement membrane of the cochlea are stretched out similarly to the cords of a piano. They increase in length nearly twentyfold from the shortest fibres in the basis convolution, to the longest in the cupola of the cochlea, according to the measurements by *Hensen. v. Helmholtz* recognized resonators for the whole scale in these cords, which are stretched by the complicated stretching apparatus of *Corti's* organ and transmit their vibrations directly to the layer of rod-shaped cells of the acoustic nerve. Any number of sounds which reach these cords *simultaneously* will cause a corresponding number of them to vibrate *simultaneously.* The perception of the highest sounds is accomplished in the basement coil, and of the lowest sounds in the cupola of the cochlea, according to this theory.

It is one of the most beautiful and most important tasks of the otologist to verify by observing the diseased ear the accuracy of this theory, which has become so indispensable for understanding the act of hearing:

There are a small number of pathologic anatomic findings where the local destruction of the cochlea coincided in the living with the loss of hearing of a certain part of the sound-scale.

In the living we find another valuable corroboration of *v. Helmholtz's* theory by reviewing the great number of partial defects of hearing which we find by means of accurate functional tests with the continuous sound-scale in very deaf people, and in such as have no hearing for speech. You will find in fig. 27 a graphic illustration of the islands and gaps of hearing in the *course* of the sound scale and the large defects at its lower and upper ends as I found them in functional examinations of the pupils of the Central Institution for deaf mutes in Munich in 1898.

The heavy black lines give the extent of hearing for each ear. You see from this illustration that defects of hearing may be found *everywhere* in the sound scale, *at either end* and in the *middle.* Fragmentary elements of hearing even as small as one or two half tones may prove deficient or may have been preserved. As a general rule however hearing for a greater or smaller succession of tones is either lost or preserved. More than one or two circumscribed defects of hearing are rarely found within the remaining succession of sounds. *The defects of hearing in the ear of the deaf mutes were actually found with those characteristics which we had a priori to expect, if v. Helmholtz's theory prevailed,* namely, that the elements of hearing are spread over an extensive anatomical field in diatonic succession. A comparison will make the idea clearer. The destructions which we found in our examinations are located in the cochlea. They appear exactly as though one or several pieces of plaster had fallen from the ceiling on the strings of a piano and had destroyed a series of strings either in the middle or at one or both ends.

A better and more convincing confirmation of *v. Helmholtz's* theory can hardly be conceived than the demonstration of so many well circumscribed defects of hearing, as lie before us.

We are justified therefore in locating the destructions in the cochlea exactly where we expect them according to *v. Helmholtz's* theory, whenever we find such defects of hearing in examining patients.

It explains most completely even today all the facts established by observation, although a number of new theories have been advanced. There is therefore no reason to dwell upon the latter.

The researches of *Kreidl* seem to show that fish who have no cochlea do not hear. This makes it plausible that in the phylogenetic series of animals hearing only begins where the cochlea begins to be developed as a part of the labyrinth.

The remainder of the labyrinth serves other functions. *Flourens* made many experiments on animals which became the starting point for a great many others, and established the following facts: *the semicircular canals* and their *ampullae,* are *organs of equilibrium, which give us information concerning rotation in the three dimensions of space.* The end organs of the nerves in the *sacculus and utrilicus* with their *otolith* keep us informed *as to the position of our head* in rest, and *as to changes of velocity of movement in a straight line,* according to experiments of *Breuer* and others.

Studies in the pathology of the ear have given us much valuable information as to the importance of the labyrinth, especially of the semicircular canals for our knowledge as to our position and the position of different parts of our body in space, furthermore about the relation of irritation and paralysis of its nerves to the reflex movements of the eyes. We have learned to draw conclusions as to the location of *irritation in the labyrinth* from the *presence of dizziness* and nystagmus in different directions. We are also justified in inferring the *destruction* of end organs of nerves in the ampullae and vestibulum from the *absence* of dizziness and nystagmus during and after rotation of the body around its own axis.

LECTURE VIII.

Examination of Hearing by Means of Tones.

A. In Air Conduction.

Gentlemen:—Physics makes a distinction between *tones and noises.*

New investigations made it very plausible that *all noises* are nothing but a *mixture of tones,* the pitch of which is very close together, therefore they are unharmonious. Some of them are very low. I might mention the wind instruments as an example of the accuracy of this explanation of noises. They are resonators if you consider them as a whole, of different size for each different pitch. Upright vibrations of the air in them are caused by the noise of blowing. All tones which the instrument is able to produce must therefore be contained in this noise.

It is of fundamental importance for our examination of the function of hearing that all noises can be placed in the line of the sound-scale. *We have therefore completely examined the hearing, as soon as we know quantitatively the hearing for all tones, and do not need to care for the noises.*

These considerations, besides a number of others, induced me to construct a series of instruments which produce all the sounds the human ear can perceive. I showed them in 1890 to the otological section of the international congress of physicians in Berlin.

Prof. Dr. *Edelmann* of Munich who is known all over the world for the manufacture of the finest instruments of precision, improved the "continuous sound-scale" as he called it so that it now consists of ten tuning forks with movable weights at their prongs, and three covered whistles with movable pistons. *Two* points had to be considered in its manufacture.

Firstly, all tones which *the human ear is able to perceive ought actually be contained in it.* This is accomplished by moving the weights of the tuning forks or the pistons of the whistles, by which method *any* audible number of vibrations may be produced. To those who are not musical an engraved scale of half-tones shows the pitch.

The second task is to create as clear tones as is possible, i. e., to exclude the overtones which all our musical instruments possess, and which give them their individual character of sound. Weighted tuning forks and covered whistles were suggested by *v. Helmholtz* long ago as instruments *which serve this purpose best.* It is well nigh impossible in *Edelmann's* weighted tuning-forks, no matter how hard they are struck, to detect a trace of overtones even close to the arc, which is the place where they would be heard the easiest. The whistles were made free of overtones by regulating the width of their mouths according to the pitch.

The sounds of the tuning forks at the lower end of the scale seem weak to the ear which is not used to hearing clear tones. The large vibrations with the heavy weights correspond in reality to a considerable amount of energy, which you will notice if you hold the fork close enough to the ear. The large number of deaf-mute pupils who are able to hear even the lowest end of the sound scale [1] furnish the best proof that the sounds of the continuous series are strong enough to consider deaf all those people who do not hear them. We need stronger sounds just as little as the ophthalmologists need the sun instead of diffuse daylight in order to prove blindness.

The correct use of these tuning forks is not very easy. To strike them in a sufficiently elastic manner has to be learned like the playing of a musical instrument. Think for example of the difficulty of playing the kettle-drum. The lower forks are best struck with the ball of the thumb, the higher ones with a rubber hammer.

The *healthy* ear perceives, according to my examinations of a great many individuals from 12 double vibrations, (*"vibrations doubles,"* abbreviated v. d.) or even a little less up to 41,000 vibrations. (0.5 of the third whistle, which is a Galton whistle, modified by *Edelmann* gauged with *Kundt's* glass tubes, containing lycopodium powder.)

In older people the upper limit becomes somewhat lower, about 2.0 of the Galton whistle, which is 23,500 vibrations. The lower limit remains the same, that is 12 vibrations.

We test the diseased ear by passing the sound-scale in small intervals of pitch before the ear. We find out whether it is heard throughout by air conduction, or whether there are any deficiencies at either end or in the course of the scale. We talk of "gaps" whenever circumscribed portions in its continuity are not heard. We call it an "island" when *only one* section of the sound scale is heard not larger than three octaves. The recording of these remnants of hearing can be accomplished very easily and clearly, as you see from fig. 27, which shows the islands and defects which were found in 1898 in my examinations of the pupils of our deaf-mute institution.

We have just now described the examination of the *quality* of hear-

[1] In fig. 27 I only gave a diagram of the hearing of pupils who heard but a limited extent of the sound-scale (islands), or where interruptions in the continuity of the scale were found (gaps).

ing which reveals the total loss of hearing of some parts. A complete examination has to consider also the *quantity* which shows the *accuracy of hearing* in different parts of the sound-scale.

We analyse the function of all the elements of hearing which constitute Corti's organ, by examining the quality and quantity of hearing within the above described limits and with the above stated supposition that all noises are but a sum total of tones.

We measure the time that each tuning-fork is heard in order to examine the quantity of hearing.

First, every one of us must determine how long each tuning-fork of his own set, after giving it the hardest shock, can be heard by the normal ear.

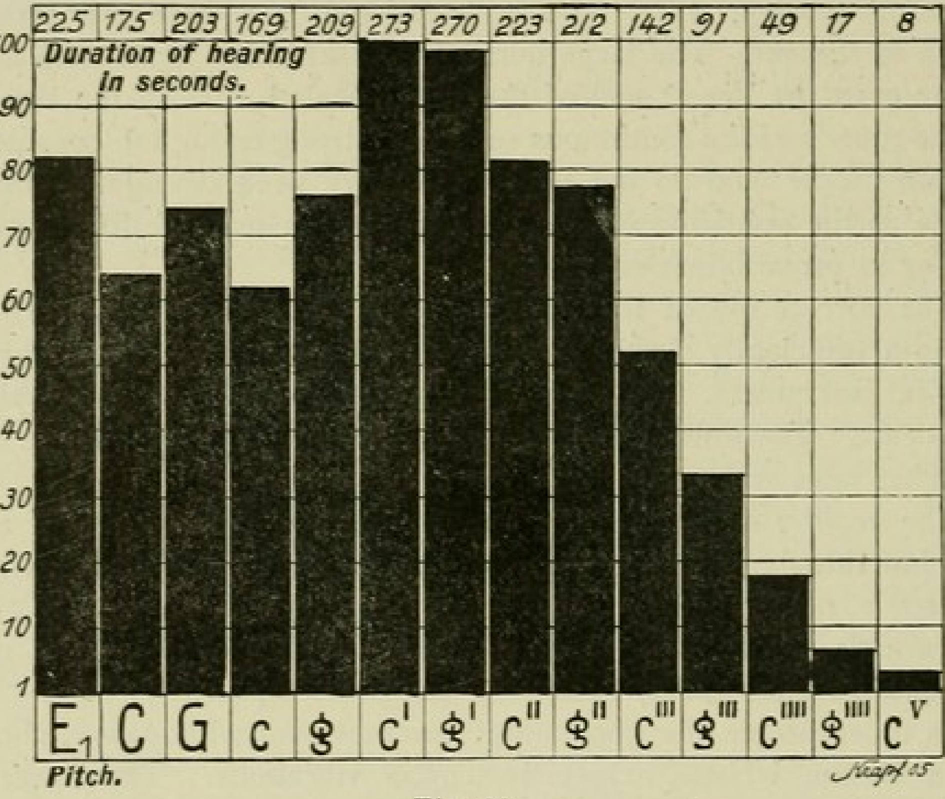


Fig. 28.

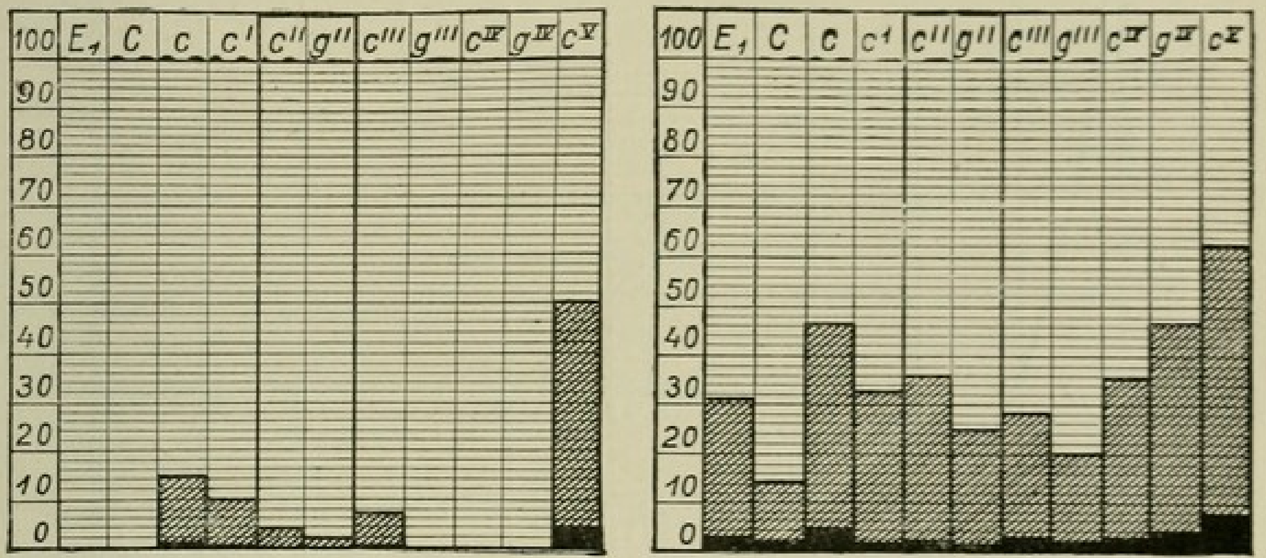
The normal durations of hearing of my continuous series of sounds.

It requires too much time to do this for all tones of the scale. It is sufficient to confine the determination of the duration of hearing to the octaves of c, and in the most important part, upward from c^I to the tones of c and g. We remove the weights from the forks, since with the weights they do not sound long and the results are inaccurate. The sound-scale, when the weights are removed, consists of c and g forks, to which up to c^v inclusive, forks without weights must be added. (The lowest fork is E_1 instead of C_1 without the weight.) We need not pay any attention to the numerous overtones of the forks without weights, since for the determination of the duration of hearing, the *end* of the duration of sounding has to be ascertained, at which time the overtones have long disappeared.

We hold the handle of the fork lightly between the first three fingers, prongs downward after striking them very hard. We approach it to the ear of the patient at *irregular* intervals, longer at first and shorter later on. Touching even of the hair has to be avoided, and so has the possibility of the patient seeing the fork. He has to raise a finger every time he hears it till he does not hear it any more, even if the fork is held as close to the ear as possible.

The tuning-forks of different pitch do not sound equally long to the normal ear. You will find a diagram in fig. 28 of the duration of hearing of my own c and g forks without weights.

The time of sounding from g^{II} upward decreases very fast as you see. The time above c^{V} would be so short that it could not be measured.



Right. Left.

Fig. 29.

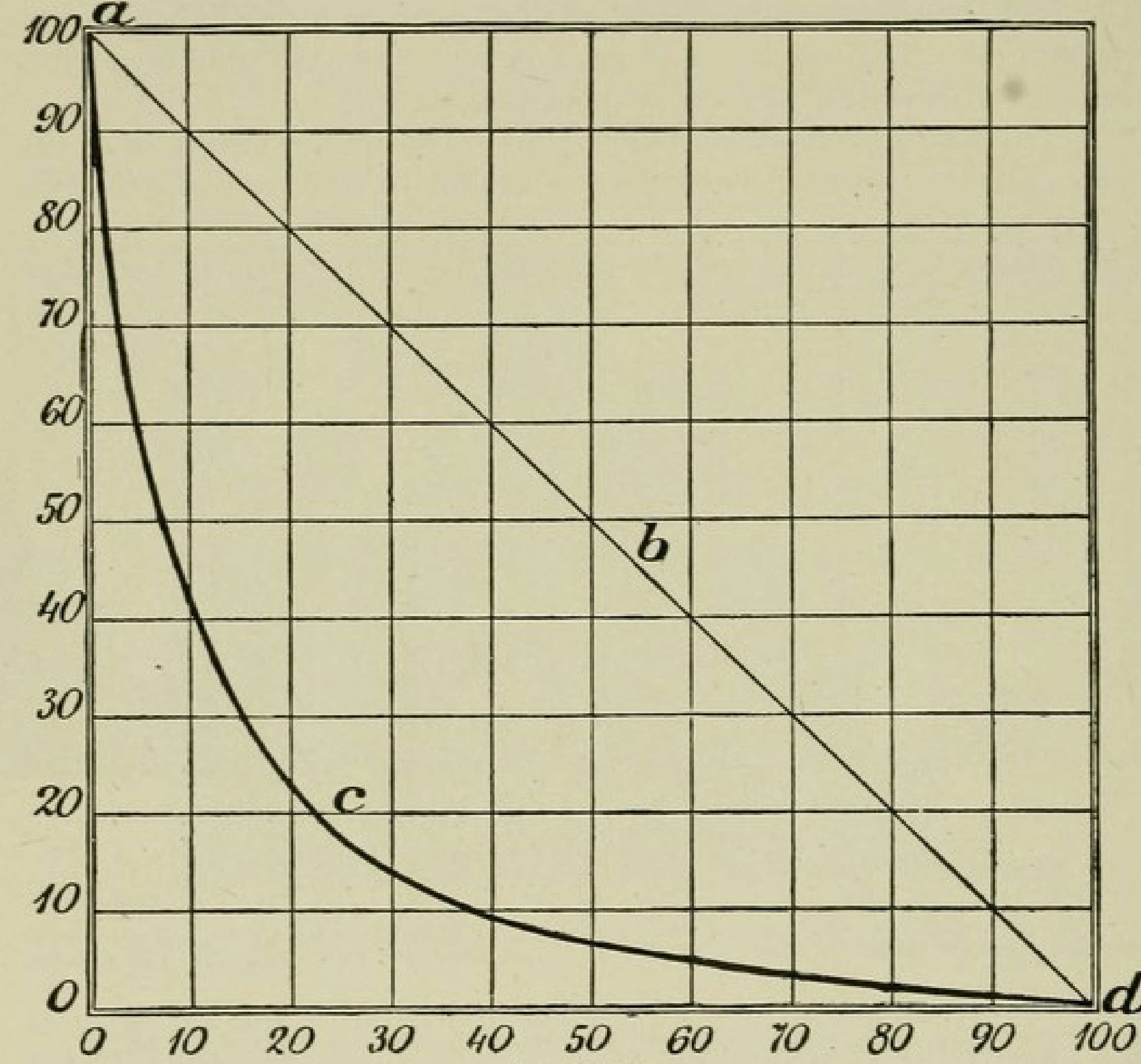
Diagram of the remnants of hearing in the right and left ear of a deaf-mute.

The darker parts show percentages of the normal duration of hearing, the black parts the corresponding figures obtained by taking into account the amplitudes of each tuning fork (*See Fig. 30*).

The determination of the duration of hearing is the less accurate the shorter the time is during which a fork sounds. A mistake of 2 seconds in a c^{I} fork, for example, which is heard for 273 seconds does not make any difference, while it is one-fourth of the whole duration of hearing of c^{V} sounding 8 seconds.

It would be wrong to try and make all tuning-forks uniform, so that all forks of the same pitch would have the same duration of hearing. It could only be accomplished to the detriment of the best forks which can be produced. The longer a tuning fork vibrates the more reliable are the measurements taken with it. Take for example a shortening of 20 seconds for a tuning fork c^{I} sounding 273 seconds which can easily occur on account of the day's noise, it is a mistake of 7% only. A mistake as small as that can not be avoided in our hearing tests which are made in daytime. Our examinations with speech show sufficiently that we have to be satisfied if, in several repetitions of the same test, the difference is not more than 10%.

The examiner, after having determined the duration of hearing for his forks without the weights on a number of people with normal hearing, may record the duration of hearing of a diseased ear for all c, or c and g forks in *per cents* of the normal, according to *Hartmann.* He may



Amplitudes.

100 42.2 22.6 13.5 9.2 6,5 4,5 3,1 1,9 5,83 0,32

Acuteness of hearing in fractions of 1.

0 0,006 0,015 0,024 0,035 0,049 0,071 0,107 0,15 0,39 1

Fig. 30.

enter the results of all the forks in a diagram, which we may call "field of hearing."

You find for example in fig. 29 the diagram of hearing of the right and left ear of a deaf-mute. He has sufficient hearing in his left ear to follow instructions of hearing, which is not the case in his right ear. This gives us a general idea of the extent of hearing in the deaf ear, upon which we can base a reliable judgment about the possibility of hearing speech. My examinations of deaf-mutes with remnants of hearing showed this sufficiently.

The numbers which are obtained this way can be used of course only for comparison. The real number for every single tone is not by any means accurately expressed.

Fig. 30 will help me to explain why. We measure the *time* that a tuning fork is heard, which is an arithmetical proportion like the line a b d in fig. 30. *The amplitudes of the vibrations* however decrease very fast in the beginning, later on more slowly, in a nearly geometrical proportion, as the line a c d in fig. 30 shows (*Jacobsen, Barth, Thiry*).

The actual power of hearing of a diseased ear decreases at a much greater ratio than the time during which it hears the tuning fork. Therefore we can not measure the power of hearing by the time an ear hears the fork and compare it with the normal. The actual power of hearing is much smaller than the time, as may be recognized very easily by comparing the curve a c d which shows the decrease of the amplitudes of the vibrations, with the straight line a b d in fig. 30, which marks the progress of time. The next few paragraphs will illustrate these points.

The curve a c d shows the decrease of the amplitudes of vibration after the fork is struck very hard, till it can not be heard any longer by the normal ear. For the construction of this curve we could use only the lowest tuning forks, whose vibrations are very large and whose amplitudes can be measured comparatively easily until the fork can not be heard any longer. The abscissa of the diagram show the duration of hearing for all forks, reduced to the number of 100. The ordinates give the proportion of the amplitudes and the time of hearing after the fork has been struck hard, the first amplitude being set=100.

You see from fig. 30 that after one-tenth of the whole time during which the fork is heard, the amplitude is only 42.2% of the largest amplitude, and after one half this time only 6.5%, etc.

Supposing that the height of the amplitudes were *simply* inversed proportionate to the accuracy of hearing, we would be able to calculate in an easy manner the real degree of accuracy of hearing for any moment from this curve of averages. The lowest row of numbers of fig. 30 shows this, accepting normal hearing as equal to 1.

Ostmann solved the laborious task of measuring directly all the amplitudes of the higher tuning forks (as far as g) till they could not be heard any longer. The values of hearing which we found by calculation, and which by us were called approximately correct only, were entirely rejected by *Ostmann, Schmiegelow* and others. Their reasons for doing so are, firstly, that they found different curves for the decrease of the amplitudes of vibrations in different tuning-forks, secondly, that the energy of a vibrating tuning fork does not correspond to the simple amplitude, but to its square.

There is this to be said about the first reason. The differences of the curves of the decrease of the amplitudes of forks of different *pitch* and of *different forks* of the same pitch are considerable only directly after the strongest shock, and become smaller probably as soon as the vibrations effect an equilibrium between the interior resistance of the fork and the surrounding elastic medium, viz: the air. The strongest vibrations in the beginning are important for practical measurements in the very deaf only, where hearing of speech is absolutely excluded. There is no practical value in making distinctions of such high degrees of deafness.

This must be said about the second point: We are not justified in basing our calculations of the accuracy of hearing on the square of the amplitude, since the whole of the energy of the vibrating tuning fork does not act on our ear. It is even very probable that a smaller part of the maximal vibrations is effective than of the later vibrations, since the *sound conducting apparatus* can not as well follow the vibrations with large amplitudes as it can those with smaller ones, for the transmission of which it is much better adapted.

The extremely small intervals with which *Ostmann* and *Schmiegelow* want to measure the acuteness of hearing do not correspond to the rough estimation of intensity of sound, which our ear is able to make according to my experience.

The acumen of hearing of the normal ear for tones of different *pitch* varies greatly. The physicist *Wien* established by means of very interesting experiments with the plate of the telephone, that our ear is much more sensitive for tones of the middle part of the sound-scale than for those at either end. The fact is very important for an accurate judgment of the value of defects of hearing especially in the middle part of the scale where, as we shall see, the tones of speech are to be found.

I do not think it is suitable for the purpose in view, that *Ostmann,* as he did lately, take also the curves that *Wien* found for the different hearing of tones of different pitch into consideration for the calculation of acumen of hearing. It would confuse matters very much if we did not take the hearing of the normal ear as the standard and=1, for *each* tone be it high or low. There are different qualities of the *elements* of the ear, and we must refrain from comparing the quantity of sounds of different pitch with each other, at least in our practical examinations.

These complicated questions are just at present the center of interest in otological literature. They can not be passed without mention. We shall see, in discussing the examinations of hearing especially of deaf-mutes, that a *determination of that duration of hearing* in per cents of the normal for the c tuning forks (and maybe g), is entirely sufficient to judge accurately of the hearing for speech. The high theoretical value of an *objective* measure of hearing for some diseases and their differential diagnosis is not contested.

The examination of all ear patients with all sounds of the scale, as was described, cannot be carried out, if, for no other reason than because of the loss of time.

It is however absolutely necessary in the examination *of all pupils of deaf-mute institutions.* The accurate establishment of the quantity in remnants of hearing which are present in a great number of deaf-mutes, *decides* whether their ear can be used for future instruction. These are assigned to separate classes for instruction by means of hearing. The others have to learn to understand speech by observing the mouth of the teacher, and speaking by instruction in articulation.

The examination with the whole scale is necessary for the establishment of complete *deafness* in one or both ears,

In *one sided deafness* the normal ear can be excluded with greater difficulty the higher in the scale we ascend. The apparent picture of hearing of the deaf ear will be met with and studied again in the description of necrosis of the labyrinth. Such cases must of course be examined with the whole sound-scale in order to find out defects or islands.

In very serious suppurations of the middle-ear the examination with the whole sound-scale may be of great importance for our diagnosis and therapy. It will help us to decide whether the labyrinth is still intact, or whether the process has penetrated through its wall, and how much further it has advanced.

There are therefore only the patients with the highest degrees of deafness which require an examination with the whole sound-scale. The duration of hearing for tuning forks in them is generally very much shortened. The time therefore which is consumed by a complete examination with the sound-scale is not too long.

We can limit our examinations with the sound-scale by air conduction to the establishment of total defects in the lower and upper *ends* of the scale in all cases of deafness of medium and minor degrees. The functional tests will help us to make a differential diagnosis in all cases of deafness with negative findings of the drum-membrane. They are finished in a few minutes. The examinations with speech and by bone conduction give us in practice usually a sufficient amount of information to render superfluous the examinations with the whole sound-scale, which require so much time.

Nobody expects that each general practitioner own all the instruments of the sound scale nor make examinations with them. I deem it necessary however to give them at least a general idea of the existence and the importance of a method of examination which allows us to analyze the function of the organ of hearing so completely.

It may be desirable however for general practitioners who have to examine ear patients once in a while or even give expert testimony in court, to have one or two low forks with weights, which contain the sounds from G_2 to D_1, and D_1 and A_1. They put them in a position to establish a defect of hearing at the *lower* limit which is a constant finding in diseases of the middle-ear. A *Galton whistle* furthermore will enable him to find out defects of hearing at the *upper* limit of the sound scale, which are frequent in diseases of the inner ear. The practitioner without these two means of examination has to desist from making any diagnosis in all of those numerous cases of deafness with negative findings in the drum-membrane.

One or two more tuning-forks without weights an a^{I}, and an A are furthermore necessary for the examination of air conduction. They lie in the course of the scale and are indispensable to the practitioner who wants to examine bone conduction.

LECTURE IX.

Examination of Bone Conduction.

Course of the Examination.

Gentlemen:—Two tuning-forks are usually sufficient for the examination of the bone conduction.

The first one is the middle tone of the scale, a common a^1 tuning-fork which is also used by musicians. The second fork is two octaves lower, a large A fork without weights; a G or c fork of the continuous tone series without the weights may be used instead of A, if it sounds long enough in bone conduction.

A few remarks about the *physiological condition of bone conduction* have to precede an explanation of its use for diagnostical purposes.

Our usual act of hearing is performed exclusively by means of the sound conducting apparatus. Even the small fraction of very strong sound waves which passes from the air to the surface of the skull is perceived only to such an extent as it is able to cause transverse movements of the whole sound conducting apparatus.

The labyrinth and the sound conducting apparatus vibrate together with the other bony parts whenever the sounding vibrations of a solid body are transmitted *directly* to the skull. This occurs whenever a sounding tuning-fork is pressed against some point of the skull or any distant part of the skeleton. *Lucae, Politzer,* and others proved by experiments on the cadaver, that the movements are transmitted in this way.

It is very probable that we perceive, in air as well as in bone conduction, only those sound waves which, on their way to the labyrinth, have *passed through the sound conducting apparatus.* The sound waves which *reach the labyrinth directly,* i. e., without appropriate intervention of this apparatus, are to us inaudible.[1]

The function of the sound conducting apparatus for the perception of hearing consists therefore in transforming the *longitudinal* sound waves of the air, as also the longitudinal waves which pass directly through the skull, into *transverse* vibrations of the sound conducting ap-

[1] Weitere Untersuchungen über Knochenleitung. Z. f. O. XLVIII, 1 and 2.

paratus (as a whole together with the column of the labyrinthine fluid). These transverse vibrations alone are able to effect such concomitant vibrations of the end organs of the acoustic nerve, as can be perceived.

Accepting this theory, we will understand an observation which constantly can be made on the diseased ear but which at first sight appears very odd. It is however supported by a great number of physiological experiments on the normal ear:

In all diseases of the sound conducting apparatus we do not find a diminution of hearing by bone conduction, which corresponds to the diminution by air conduction, but the opposite, we find *an increase of hearing by bone conduction over the normal,* while hearing is equally bad for air and bone conduction in diseases which are confined to the nervous apparatus.

There are three methods by which we test the improvement or deterioration of bone conduction respectively.

Weber's test has been known the longest and is used the most. The handle of a vibrating tuning fork is placed in the sagittal line on the vertex of the head. The patient has to decide with which ear he hears it best. We use for this test an a^1 or aA tuning fork. *Ed. Weber* established the fact that it is sufficient to close either external canal with the finger to increase hearing by bone conduction in that ear.

The tuning fork which is placed on the vertex of patients with one-sided affections of the sound conducting apparatus, or in whom the affection is more developed on one side in an analogous manner is heard exclusively in the affected, or at least better in the more affected ear. This localization of the sound in the diseased ear in most cases strikes the patient at once. Children especially almost always give accurate information in this respect. The idea that their diseased ear must hear worse under all circumstances is often so powerful, especially in patients who belong to the better educated classes of adults, that their statements in the beginning are wrong. We can however easily convince ourselves of their mistake by repeating the experiment while the patient shuts his good or less affected ear with the finger. We know that he does not observe correctly when he says, now "of course" he hears in the diseased ear.

In one sided diseases of the inner ear the decision for many patients is much more difficult. It does not occur very rarely that even after exfoliation of sequestra of the labyrinth, the patient thinks he hears the tuning fork which is placed on his vertex, in the deaf ear. This evident error of the patient has led a number of authors to the risky assertion that the acoustic nerve alone is able to perceive sound waves.

The statements as to localization of diseases of either inner ear [1] are correct, at least in the majority of cases, according to my own examina-

[1] We call (here and in the next paragraphs,) diseases of the inner ear the changes in the labyrinth, diseases of the acoustic nerve, its cerebral tracts, and its part of the cortex. The findings of the functional examination as to bone conduction etc. are the same in all of them according to my examinations.

tions which extend over many years. The sound is heard of course in the healthy or better ear, provided that the sound conducting apparatus is not changed. It is not very rare however that patients declare they are not able to locate the sound.

More reliable than in *Weber's* test are the statements of the patient in the next two tests which we use in the examination of bone conduction. *The second test is the comparison of the duration of bone conduction of the diseased ear with that of the normal ear (Schwabach's test), the third, the comparison of the duration of bone conduction with the duration of air conduction in the diseased ear (Rinne's test).*

We measure the duration of bone conduction for two tones of different pitch with tuning forks without weights, A and a^1, or neighboring tones. The tuning fork is placed on the vertex of the patient after it was struck as hard as possible. He has to indicate the moment when the sound ceases. The duration of hearing thus found is compared with the duration of hearing by bone conduction in a healthy ear with the same fork. The positive or negative difference is entered into our records as *Schwabach* test $+$ x or $-$ x or as $\pm$ o (if the patient hears it just as long as the normal), or simply as o, (if he does not hear it at all).

The manner in which the tuning fork is struck becomes irrelevant if we measure the difference of time directly. Namely, in prolongation of bone conduction, we place the tuning fork, after it has stopped sounding in a normal hearing ear, to the ear of the patient. In shortening of bone conduction we do the opposite, that is we measure the time that the fork is heard by the normal after it is not heard any longer by the diseased ear.

The duration of bone conduction need only be ascertained from the vertex for both ears at the same time and not for each ear separately from its mastoid process, because in placing the tuning fork on the mastoid process, the other ear can be excluded but very incompletely. The preceding *Weber's* test has already revealed to us in which ear the fork is heard loudest.

The prolongation of an A tuning fork, whenever there is an impediment to the conduction of sound, is greater than for a^I. It occurs frequently that the *Schwabach* test with A fork shows a prolongation while a^I shows a shortening of bone conduction, from which we draw the conclusion that the inner ear also is affected.

The determination of the time when a sensation ceases to be perceived, that is, the determination of the liminal intensity in physiology as in psychology is counted amongst the most reliable methods. Nevertheless *Schwabach's* test although it is one of these determinations has several deficiencies. We do not need to hesitate in using it for diagnostic purposes whenever the duration of bone conduction from the vertex of the patient is *very much* shortened or altogether lacking, or on the other hand it is considerably prolonged, for 15 seconds and more. We have to depend however too much upon the gift of observation and the attention of our patient whenever the difference of time is relatively short one way or the other, positively or negatively. Both the gift of observation and the attention ought always be very keen on account of the many noises in our surroundings, which so closely resemble the sound of the low forks that are mainly used for *Schwabach's* test.

A number of anomalies of the roof of the skull, consisting of traumatic changes with depressions and adhesions of the bone to the dura, etc., seem to have some influence upon the bone conduction from the vertex, according to a number of observations made on patients of the psychiatric department. Bone conduction seems to be considerably shortened in those cases *normal hearing for air conduction notwithstanding,* according to investigations of *Wanner* and *Gudden.*[1]

The most reliable results are furnished by the third test, which compares the *duration of hearing of the diseased ear by bone conduction with that by air conduction.* This test was described as early as 1855 by a general practitioner by the name of *A. Rinne,* who recognized its great importance for differential diagnosis of diseases of the middle and inner ear.

An a′ tuning fork is usually sufficient for *Rinne's* test.

A sounding tuning fork, the handle of which is pressed against the mastoid process of a normal ear (*Rinne* put it against the teeth with similar success) is heard again when its prongs are brought close to the external meatus, after the sound has died away on the mastoid. My a′ tuning fork is heard by air conduction for 90 seconds. When its sound has died away on the mastoid process (that is, has stopped to be heard by bone conduction), it will be heard for 30 seconds longer by air conduction if its prongs are held in front of the external canal.

The air conduction under normal conditions is therefore far superior to bone conduction. The superiority of air conduction becomes more marked the lower the tuning fork we use.

The *Rinne* test is the most sensitive indicator for all derangements of the sound conducting apparatus. Every change of equilibrium of this apparatus prolongs hearing by bone conduction at the same time that it shortens it by air conduction. The difference between bone conduction and air conduction which is measured in *Rinne's* test, diminishes very quickly whenever the derangement of the sound conducting apparatus progresses, and it soon becomes negative, i. e., the bone conduction becomes of longer duration than air conduction, which is the opposite of the normal. We therefore mark it in our records as a negative number.

We use the following abbreviations in our records of *Rinne's* test.

We call t the time that the tuning fork is heard by *air*-conduction when it is struck hardest, till the sound dies away; ϑ the duration of bone conduction. *Rinne's* test is the difference t—ϑ. It may have several

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[1]) Die Schallleitung der Schädelknochen etc. "Neurol Centralbl." 1900. No. 19 to 21.

modifications in different degrees of diseases of the middle and inner ear, viz.:

Rinne's test, as it is found in the normally hearing, is recorded *Rinne* $a' + 30$ (seconds). This number diminishes gradually with the increase of derangement of sound conduction. It remains positive until the duration of bone conduction is just as long as the air conduction, which is $t - \vartheta = 0$. This finding is recorded as *Rinne* $a' \pm 0$. Whenever the derangement of sound conduction is still stronger, the tuning fork will be heard a number of seconds longer by bone conduction than by air conduction, which we record as *Rinne* a'—the number of seconds found. This negative number may reach as high as 15 seconds. We find, whenever the derangement of sound conduction is so great that hearing by air conduction is suspended altogether (while bone conduction may still be present, or even better than in the normal ear) that in the difference $t - \vartheta$ air conduction $t = 0$. We record this condition as *Rinne* $-\vartheta$.

The difference between air conduction and bone conduction remains about the same in diseases of the *inner* ear in which the sound conducting apparatus is not affected, the air conduction and bone conduction being *equally* reduced. *Rinne's* test remains $+30$ or a little less. The tuning fork fails first to be heard by bone-conduction, whenever hearing decreases still further in diseases of the inner ear. In the difference $t - \vartheta$ $\vartheta = 0$ which we record as *Rinne* $a' = + t$. The tuning fork finally ceases to be heard by air-conduction only in complete deafness.

The following series of expressions for *Rinne's* test embraces every possibility.

Normal ear	Small interference with sound conduction.
Rinne $=$ R $= +30$ sec.	*Rinne* less than $+30$ sec. to R ± 0.

Greater derangement of sound-conduction to loss of air-conduction.
Rinne —x sec. to *Rinne* $-\vartheta$.

Diseases of the inner ear exclusively.

Minor degrees	Higher degree to loss of bone conduction.
Rinne $= +30$ sec. or less.	*Rinne* $= + t$.

It is an every day experience that the patient on an average finds it easier to give accurate information in *Rinne's* test than in either of the two others, *Weber's* and *Schwabach's* test. We will not omit either of the latter in all cases of negative findings of the drum membrane, where the diagnosis depends exclusively upon them, especially since they require but very little time.

Rinne's test is subject to a serious restriction in diseases of one ear, when the other is normal or nearly so, and whenever there is a disease of one middle-ear and the other inner ear. A short negative *Rinne* test is possible in disease of the inner ear, because normal or even prolonged bone conduction of the other ear may mask the result of the functional tests. A positive *Rinne's* test of normal duration or nearly so, may be considered characteristical for diseases of the inner ear in one sided affections.

The prolongation of bone conduction above the normal in changes of the sound conducting apparatus was accepted in our discussions as a fact pure and simple which we meet with in all our observations. Opinions differ widely as to its *physiological explanation.*

Here is the simplest idea of the different reaction of the sound conducting apparatus in conduction of sound through the air or through the bone: *There is a different optimum of regulation for each of the two mechanisms.* An uninterrupted conduction through the *air* is alone conceivable if the first link of the chain, the drum membrane, as well as the last link, the foot plate of the stirrup with the ligamentum annulare, are extremely well balanced, that is little stretched. Every alteration of this complicated apparatus will disturb the equilibrium of the antagonists and lead to a tighter stretching of the radial fibres, which form the ligamentum annulare.

The conditions of bone conduction are different. They may be compared to a so-called string telephone. A sounding body which is connected with the ear by a string will be heard so much stronger, the tighter the string is stretched. Thus the vibrations, which are transmitted by *bone* conduction to the outer rim of the ligamentum annulare, are carried more easily from the rim to the foot plate of the stirrup, by means of these fibres, the tighter they are *stretched* on account of the disturbance of the equilibrium.

The greatest facilities for simultaneous vibrations of the fibres of the ligamentum annulare in transmitting sound waves from the surrounding *bone* to the foot plate of the stirrup, are produced when the fibres are tightly stretched. The tight stretching interferes however with the transmission of sound waves which are received from the air. The interference becomes more effective the lower we descend in the sound scale. The whole sound conducting apparatus must be able to make large excursions to and fro in order to correspond to the large amplitudes of the vibrations of the lowest sounds which can be heard.

This assumption explains both the preponderance of bone conduction and the loss of the faculty of hearing the lowest part of the sound scale by air conduction in diseases of the sound conducting apparatus.

Reference to larger text books and monographs has to be made as to further methods of testing the hearing as with *Gelle's* test or *Bing's* test and others, which are used by some few authors only.

Examination of Hearing by Speech.

We finally consider the use of *speech* for hearing tests.

There is hardly a better means, nor will there ever be any to obtain quickly a general survey of the ability of hearing.

The elements of speech have a certain pitch just as well as any other noise. *Donders and v. Helmholtz* by means of resonators and other methods ascertained the pitch of each vowel.

Oscar Wolf established approximately the pitch of the consonants.

The sound of the different letters is spread over 8 octaves, according to *Wolf*. The sound "R" is the subcontra octave, the sounds of "M," "N," "L," in the small octave, while the sibilant or hissing consonants are in the three to five stroked octaves. The results of these examinations, namely that the noise of each pronounced letter has a certain pitch, were further confirmed by the results of hearing tests in a great number of deaf-mutes with remnants of hearing. The letters which were pronounced could be heard only when the patient could hear those parts of the sound scale which contained the pitch of those letters. The letters "M," "N," "L," "U," "O," are never heard when hearing of the *lower* half of the sound scale is wanting; the letters "S," "sh," "th" and "J" never when the *upper* half is lost to perception.

The part of the sound scale from b′ to g″ proved by far the most important for hearing and understanding of speech, the sounds of most the vowels and consonants being contained in it. Children who did not hear tuning forks within that limit at all, or heard them for a very short time only after they were struck as hard as possible, were incapable of sufficient perception of speech to learn it by means of the ear, even though they had extensive remnants of hearing upward *and* downward from b′ to g″.

To learn to speak in the natural way, that is by means of the ears can be expected whenever, combined with otherwise normal mental gifts, the hearing is relatively good for this small part of the sound scale (a duration of hearing of 10% of the normal). The sounds of "S," "Sh," have to be learned by looking at the mouth of the teacher and by articulation exercises, whenever under these circumstances the upper part of the sound scale is wanting; the sounds "R," "M," "N," "L," when the lower part is wanting.

On the other hand it is permissible in testing the hearing of hard hearing people by *means of speech,* to draw conclusions as to the predominant affection of those parts of the sound scale in which the sounds of some pronounced letters lie, which are heard very poorly or not at all.

The examination of hearing with speech takes much less time than tests with the whole sound scale. It is therefore practical to begin hearing tests of hard-hearing patients, except of partially hearing deaf-mutes, by tests with speech, in letting them repeat a series of words pronounced for them.

Whispering has to be used for these tests, as conversation would be understood by the majority of hard-hearing people at such great distances that our rooms would not be large enough.

We use conversation or loud speech for hearing tests only exceptionally whenever the whisper close to the ear is not accurately understood, or where, as happens often, there is a decided disproportion between understanding whispering and loud speech.

We use for the whisper the *residual air only*, that is, the air which remains in the lungs after a light, not forced, expiration, and whisper always at the *same intervals of time*, in order to obtain results which may be compared with each other.

20 to 25 meters is accepted as the *distance* at which a normal ear can perceive all whispered words in a comparatively quiet room away from the noise of the street. We shall see however that the distance is much larger for young people in an absolutely quiet room.

I use the words of *numbers* from 1 to 100 for hearing tests as do a great many authors. They contain all the different sounds sufficiently complete.

The criticism which was often made, that numbers may be guessed at so much more easily than other words will not stand. The main point for us is that any words we use for examination can be guessed at either equally well or equally badly.

The results of our tests would become much more unreliable and variable if we used words which may or may not be familiar to our patients, than if we know that all patients are equally well acquainted with all words used. Words without any meaning at all should be used if we wish to exclude all possibilities for combination. This cannot be recommended because we want to test the comprehension of the patient for the familiar language. Numbers are indispensable as test-words especially in younger children whose vocabulary is very limited.

I became fully convinced during my "Examinations of infantile organs of hearing in schools"[1] that the test with numbers is completely sufficient. I found among 1,918 school children, whom I examined, using numbers exclusively, nearly 26 per cent who had only one third of normal hearing, or less (that is 8 meters or less) in one or both ears. The number "100" which is the most difficult to understand was even excluded.

The general result of this examination of large numbers of children is of so high a general interest, reaching far beyond the territory of otology that I reproduce here a diagram of it (compare fig. 31).

The curve is very easily understood. It gives a survey of the hearing distance for whisper of 3,836 organs of hearing of children which I examined. The abscissas correspond to the distances in which whispered numbers (except 100) were understood. They are taken starting from 16 meters or more downwards in equally decreasing distances, each being half the distance of the preceding one. The numbers of ears which understood everything at the distances contained in the abscissas, were entered as ordinates.

[1]Bergmann, Wiesbaden, 1885.

I do not want to enter into a discussion of the high theoretical importance[1] of this curve, which is certainly remarkable on accouunt of its regular course.

The curve ends in an ascending line which corresponds to those children who hear best. This is due to the fact that there was no larger space at my disposal than the gymnasiums which were not more than 20 meters in length. The curve would have descended no doubt on the other side in a similarly regular way, if the spaces for examination had been many times larger. The result would have been a line similar to *Gauss's* curve of errors.

The following practical rule, the importance of which for our hearing tests may easily be recognized, can be deduced from this curve; the *hearing distance of a patient must be measured so much more carefully, the shorter it is,* since wherever hearing has decreased considerably a centimeter means more to the patient than a meter at the limit of normal hearing.

The moistened finger of an assistant must be inserted with considerable pressure into the depth of the *other ear* in order to surely exclude it. One is often in a position to convince oneself how incompletely the occlusion of the other ear is effected, if it is

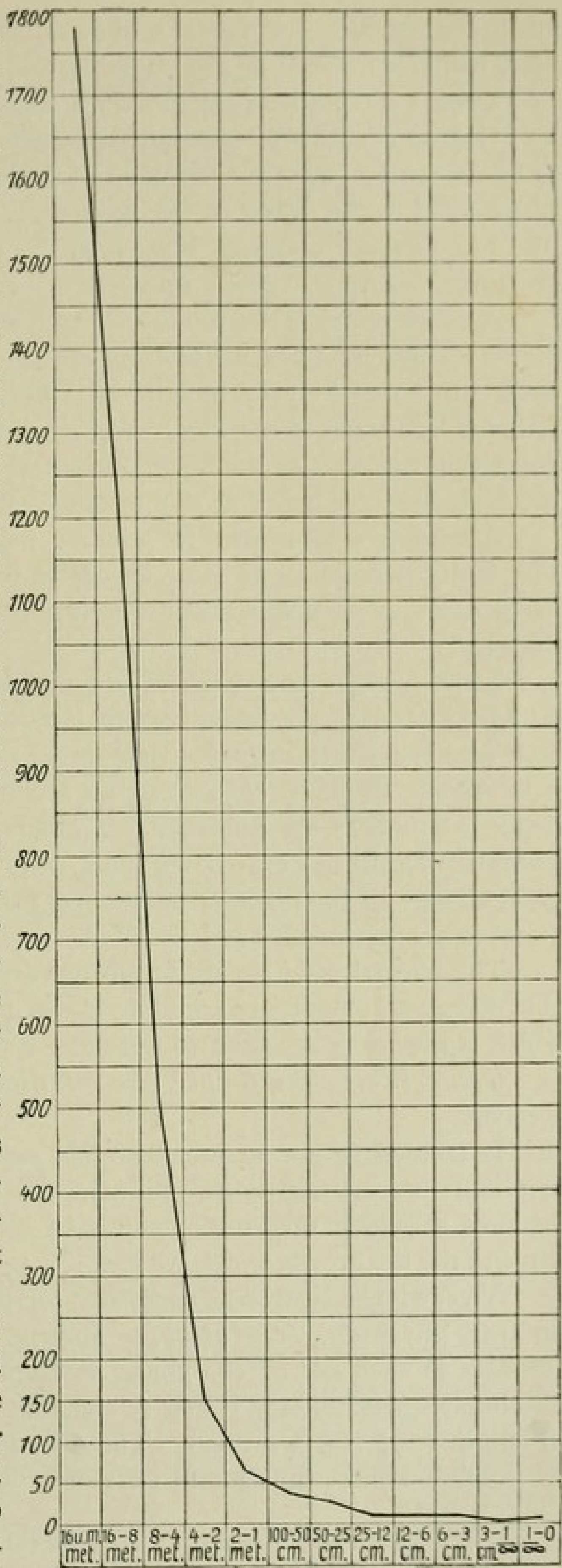

Fig. 31.
Diagram of the power of hearing for whisper in 1918 school children.

[1]Schuluntersuchungen, page 20.

left to the patient, by the results of examination of cases of one sided deafness, which is assured by the objective finding.

Even a simple hearing test with speech is laborious and takes time if it is done accurately, since all the words of numbers from 2 to 9 have to be repeated in different double connections so that the patient becomes accustomed to the organ of the speaker.

The distance at which some numbers are heard the least is recorded as hearing distance. These numbers are added in parenthesis.

A room which is not too narrow and about 8 to 10 meters long is sufficient for practical hearing tests on account of the noise of the day, which never can be entirely excluded. It is possible to hear at a much larger distance in a narrow corridor. We are justified in considering the hearing within the limit of the normal whenever all the numbers (the number 100 included) are heard at this distance (8 to 10 meters).

Attention was drawn to another point by *Oscar Wolf* long ago. The faulty perception of some letters of high or low pitch alone enables us to draw at once diagnostic conclusions as to the probable disease of the ear.

Some mistakes of numbers are met with constantly in all who are tested, as soon as we transgress their normal distance of hearing. The man who is used to make hearing tests is easily able, from a simple test with speech, to detect *shamming,* on account of this thousand fold experience. Numbers are mistaken for others, in the most impossible way, contradicting all our experience, and, what is especially committing is the great change in the distance of hearing for different numbers, as soon as the eyes are excluded.

The normal ear hears different words, as well as numbers, at a variable distance, sometimes exceeding by far the distance of 20 to 25 meters, which is generally accepted as normal for the perception of a whisper.

Oscar Wolf[1] ascertained the hearing distance for the *sounds* of speech.

It seemed to me an indispensable support for the judgment of the results of our examinations of hearing, to know accurately not alone the distance at which the single sounds of speech are heard by the normal ear, but the test words which we use.

A very large room was necessary for these investigations. I induced an army physician, *Dr. Morsak,* to find the limit of hearing for whispered numbers in each ear of 100 young soldiers. The tests were made in an absolutely quiet military riding school which offered a space of 89 meters in length (289 feet 3 inches). The distances for hearing the whispering of simple numbers thus found were as follows:—

[1] „Sprache und Ohr," Brunswig, ed. by Vieweg and son, 1871.

	Aver. of all examinations.	Minimum.	Maximum.
The word "hundert" (pronounce "hoondert") is heard at	37.6m.	19m.	81m.
The word "fünf" (pronounce finf) is heard at	58.0m.	22m.	89m.
The word "neun" (pronounce noine) is heard at	59.8m.	23m.	89m.
The word "drei" (pronounce dry) is heard at	72.3m.	39m.	89m.
The word "sechs" (pronounce sex) is heard at	74.2m.	35m.	89m.
The word "zwei" (pronounce tzvy) is heard at	75.6m.	40m.	89m.
The word "acht" (pronounce ackt) is heard at	76.3m.	33m.	89m.
The word "vier" (pronounce feer) is heard at	77.2m.	40m.	89m.
The word "sieben" (pronounce seeben) is heard at	77.5m.	39m.	89m.

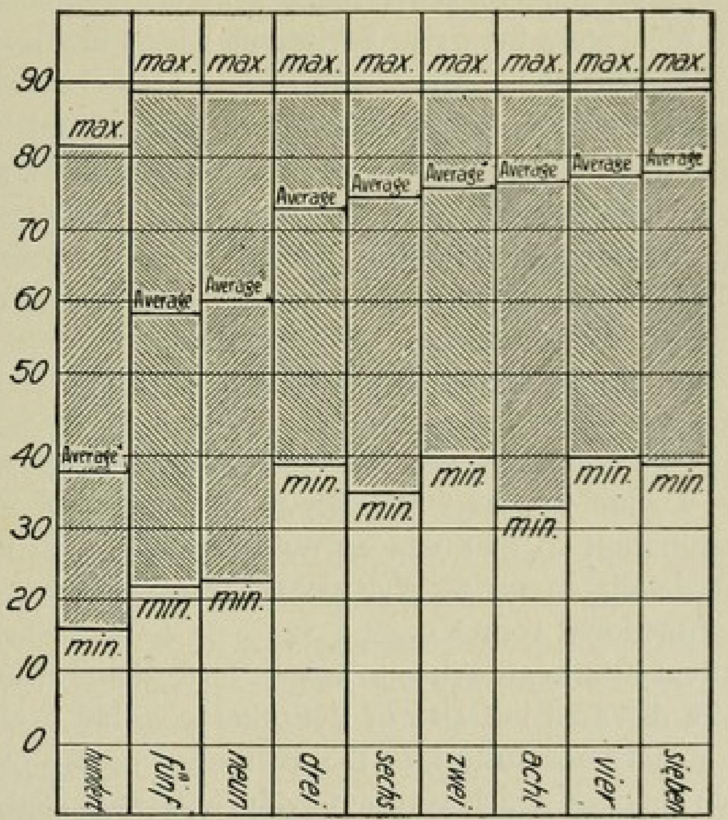

Fig. 32.

Diagram of the distance of hearing whispered numbers by 200 normal organs of hearing, arranged according to the averages for each number.

Although we had an uncommonly large room of 89 meters or 289 feet 3 inches in length, 17 meters or 55 feet and 3 inches in width, and 9 meters or 29 feet and three inches high at our disposal, it was only possible to ascertain averages and minima of hearing distances for the normal ear. The maximum was reached only for the word 100, as none of those tested were able to repeat that word at a larger distance than 81 meters or 265 feet 3 inches. All the other words were understood and repeated by some through the whole length of the riding school, and would probably have been understood often at considerably larger distances, had a suitable room for the examination been at our disposal. This is apparent from the fact that some men heard all the whispered numbers from two to nine throughout the entire extent of the room (89 meters). It is even more evident from the position of the averages between the minimum and limit of the room. The averages are all, with the exception of that of "hundert," where the opposite is the case, nearer to the limit than to the minimum, as is very easily recognized from the diagram in fig. 32.

The results of these hearing tests of young normal ears seem to me nevertheless valuable enough to reproduce them here. *The average distances of hearing* the whisper of words which are the most frequently used as test words, are hereby established, and we know especially the succession of hearing distances at which the normal ear is able to perceive them.

This puts us in possession of the necessary foundation needed in order to judge accurately the great variations which hearing tests in certain diseases of the ear show, and which always recur in a similar way.

The succession of hearing distances for different test words varies greatly for different diseases. The deviation from the normal is quite characteristic, for example the word "seeben," which is heard at the longest distance by the normal ear, can in some diseases be heard only at the shortest distance, etc.

The Course of the Examination.

Gentlemen:—Before entering into a description of the special pathology of the ear, I want to give you a few points as to how to arrange the course of examination so that you do not lose too much time nor miss any important details in taking the history, the objective findings, and especially the functional tests.

It is practical in all cases first to take a look at the drum membrane, not alone of the diseased but also of the other possibly healthy ear, even before entering more carefully into the anamnesis of the disease.

The visible changes which you find in the external canal, on the drum membrane, or, when the latter, and maybe even a part of the walls of the meatus are defective, in the drum cavity, will save you a number of unnecessary questions, the answers to which are only liable to mislead you.

You must never forget to examine the other, perhaps normally hearing ear, since, firstly, the statements of the patient as to normal hearing are very unreliable, secondly, because the picture of the drum membrane of the other side, although there may be normal hearing, gives us a chance to compare the ears, and judge accurately small differences of color and form in the diseased ear. A number of diseases which have run their course long since, may leave traces on the drum membrane, although a complete or nearly complete restoration of function has taken place, so that often we can read a whole history from the drum membrane of the ear which is apparently well.

You will find the drum membrane more or less concealed by ear wax, fluid secretions, dried up crusts, masses of epidermis, etc., in about one fourth to one fifth of all patients whom you examine.

It is better to remove carefully such dry masses by the dry method than with a syringe, using a probe or a pair of forceps, if beyond the obstruction you can see a very small part of the drum membrane.

The first requirement is of course an accurate knowledge of the form of the meatus. The necessary technic can be learned only gradually, and requires a very light and steady hand. An injection might, in case a perforation of the drum membrane existed, throw collected masses, and with them numerous germs of infection and decomposition, into the spaces of the middle ear. The light reflexes which we need for our diagnosis change whenever the membrane becomes wet. We are not able after an injection to ascertain whether there still exists some abnormal secretion in the middle ear or whether it has ceased. Finally the position of the masses which gathered in the external canal and their continuation into the spaces of the middle ear may be of value for our diagnosis. It is for example not at all rare that dry crusts are seen clinging to the upper pole of the drum membrane. They must be very carefully loosened with a probe and extracted with a forceps, when we will find that they have often a continuation far inward, through an opening in the upper pole of the membrane, into the aditus ad antrum, and consist of moist white masses of cast-off epidermis. A discovery of this kind will direct our diagnostic endeavors at once to the right course.

We cannot dispense with the syringe when there are fluid secretions, or when the masses which gathered in the meatus cover up the membrane completely, so that there is no free space before it. The removal in the latter case has to be accomplished by softening the masses with some antiseptic watery solution, and then gradually increasing the force of the syringe. The meatus, before it can be examined, must be cleaned with cotton wrapped around a probe whenever there are fluid and fetid masses.

I want however to caution you right here to *avoid carefully every instillation or injection of fluid whenever the history points to the possibility of traumatic rupture of the drum membrane, or a fracture of the temporal bone.*

The appearance of the drum membrane explains whether there are inflammatory processes in it or beyond it, or whether there are changes of form, which indicate rarefaction of air in the middle ear cavities, and coincident disease of the eustachian tubes. It shows whether there are fresh or old defects in the drum membrane or in the walls of the meatus, which in turn may uncover another succession of changes and defects in the drum cavity and the adjacent spaces. The drum membrane may show scars, or cloudiness, or incrustations with lime salts, or adhesions, etc., which put us in a position to draw conclusions as to past suppurations. We may find, on the other hand, a more or less normal drum membrane which in itself allows of no further conclusions as to the location and pathogensis of the disease of the ear, although the patient complains of deafness, otalgia, subjective noises in the ear, etc.

You can see, gentlemen, from these few intimations, how, after a simple inspection of the drum membrane, we can exclude in advance a whole series of diseases, and, on the other hand, receive a number of suggestions indicating in each case in which direction we must advance with our questions and examination.

By comparing the objective findings with the statements which you obtain from the patient and his relatives, you will learn to truly estimate the wonderful lack of reliability of those statements. The further course of the anamnesis and of the examination will suggest itself, after ascertaining by inspecting the drum membrane, to which of the different larger groups of diseases that were just enumerated, a given case belongs, provided you are familiar with the special pathology of diseases of the ear.

Finally I have to remind you again that a complete test of hearing with all tuning forks for air and bone conduction which requires so much time, is necessary for practical purposes only in a comparatively small number of patients.

Let me shortly repeat what was said before. It is absolutely necessary in every case to test each ear for whisper, the healthy one as well as the diseased. In case whispering is not understood they must be tested for conversation. The ear which is not being tested has to be excluded as much as possible.

In all cases where there are objectively visible signs of inflammation or destruction of the sound conducting apparatus, no other functional tests but for whisper and *Weber's* test are necessary. An accurate examination of the function is however indicated, when the deafness for speech is so great that it is out of proportion to the amount of hard hearing which we should expect according to our experience from the visible signs of inflammation. We must be especially careful and make repeated careful examinations of the power of hearing whenever there is a sudden marked decrease of hearing in the course of inflammatory or destructive processes.

Careful tests of the function cannot be dispensed with in any case of deafness in one or both ears, in which the finding of the drum membrane is altogether negative, or does not completely explain the deafness. This is done in the interest of a differential diagnosis of disease of the middle or inner ear, or both, which will afterwards govern our therapy. It is usually sufficient in such cases to find the upper and lower limit of hearing for air conduction, the duration of bone conduction for A and a^{I} from the vertex, *Rinne's* test for a^I and perhaps the duration of air conduction for a^I, the middle tone of the whole field of audition.

We cannot dispense with the *test with the whole series of tones* in those cases of high degree of deafness, where we must expect to find and locate gaps in the field of audition or *patches of hearing*.

This is furthermore the only means by which we can ascertain total deafness in one or both ears.

The test with the whole series of tones by air conduction is finally necessary in all deaf-mutes, in order to discover possible remnants of hearing which may be used for instruction by means of the ear. The future plan of instruction must be framed accordingly. Hearing tests by means of bone conduction give unreliable results in deaf-mutes and may be dispensed with for practical purposes.

SPECIAL PART.

LECTURE X.

Diseases of the External Ear. The Auricle and Its Surroundings.

General Considerations.

Gentlemen:—Diseases of the auricle are observed in but small numbers by otologists. They represent only 1.8 per cent of all diseases of the ear which I saw from 1869 to 1896, during which time I kept my otiatrical statistics. Even the cases of eczema of the auricle which usually involve simultaneously also the external canal are included in this number. Only 0.6 per cent of diseases which are confined to the auricle and its surroundings remain if we deduct eczema.

Diseases of the auricle occur undoubtedly much oftener but a great number of affections of the auricle present themselves only exceptionally to the otologist. I need scarcely mention the affections which occur as parts of general infections, namely the great number of acute and chronic exanthemata which occur in the course of general infectious diseases like erysipelas, which so frequently migrates over the auricle, or eczema of the face and head, very often implicating the external ear. Those patients usually consult the internal clinicist, the paediatrician or the dermatologist. The surgeon, on the other hand, sees the injuries and new formations of the auricle.

Notwithstanding these considerable limitations to which the material of observation of the ear surgeon is subjected, the small number of diseases of the auricle must surprise one, who considers the position of the auricle which exposes it to so many insults, as for instance changes of temperature, traumatic and other injuries, which are liable to affect it. I never saw for example a frost bite of higher degree. We are therefore justified in drawing the conclusion that the auricle, on account of this relative immunity against all kinds of damaging influences, has an exceptional power of resistance compared to other parts of the body which may be found perhaps in special vasomotor apparatus rendering it much more indifferent to cold, etc. Its great elasticity and its power of evading injuries are furthermore safeguards against traumatisms which must not be underestimated. Even injuries like extensive tearing of the auricle away from its base heal after simple suturing without leaving any deformity whatsoever. There are even a number of reports of cases in which auricles completely severed from the head grew on again.

The diseases of the auricle require here a special consideration only in as far as they offer peculiarities compared with other regions of the skin, and in as far as they attack also the meatus and the mastoid process.

Deformities.

There are mainly three congenital deformities of the auricle which are of interest to us: fistula auris congenita, the appendages of the auricle, and the rudimentary auricle with atresia of the meatus. This latter deformity will be considered under the heading of diseases of the meatus, as the deformity extends over the meatus, the drum membrane and ossicles.

The fistula auris congenita is a bag lined with cutis, which lies before and above the tragus, where also its opening is found. It may become inconvenient to the bearer on account of continual gathering of softened masses of epidermis in the canal. These masses often decompose and cause abscesses. The excision of the whole bag of skin is indicated in such cases. It is accomplished similarly to the excision of a fistula of the anus, by inserting a thick probe, under the direction of which the excision is done.

The appendices of the auricle are rudiments of cartilage which lie under the cutis most frequently in front of the tragus (compare fig. 42 page 100). They can easily be removed by excision, whenever they form disfiguring protuberances.

Eczema of the Auricle and Meatus.

Eczema is by far the most frequent disease of the auricle. According to my statistics it amounts to two thirds of all diseases of this region. One may even say that the auricle is a place of predilection for eczema.

Eczema is found oftenest in the concha and in the entrance to the meatus. The reason for this fact must probably be ascribed to the frequent irritation of this region by attempts at cleaning with the finger and by means of instruments. It develops there also in children in connection with neglected suppurations of the middle ear. In many cases it is a local manifestation of a widespread eczema of the scalp and face. It is most obstinate in the fold between the rear surface of the auricle and the mastoid process, where rhagades develop which are torn open at each harsh attempt at cleaning, thereby rendering healing slow and difficult. Eczema at this same place is found not only in children but also in women who approach the climacteric years. A frequent starting point for eczema is found in the holes for ear-rings in the lobule.

Eczema of the auricle does not differ in any important particulars as to form or course from eczema of other parts of the skin. It is only much more obstinate in this place on account of the rhagades which occur in the fold behind the auricle, in the concavity of the helix and around the entrance of the meatus. They always furnish a new starting point for recurrences after the surroundings are healed. Another feature is especially harmful: The epidermis of the meatus is constantly saturated with secretions which are in putrid decomposition, whenever the cleaning is incompletely done in moist eczema of the entrance of the meatus.

We often see a form of moist eczema in children, which either starts acutely by forming little vesicles or by exfoliation of large pieces of epidermis. A red glossy surface appears, from which, after wiping, little drops of fluid well up quickly everywhere (eczema rubrum). The secretion becomes purulent sooner or later, and adherent crusts are formed (eczema impetiginosum).

We find the different forms or rather stages of the moist eczema much more frequently in children of the lower classes, in our free clinics, than among better situated people. This may be taken as further proof that it is mainly the want of care which is the cause of children's eczema and also of its becoming chronic.

Moist and warm applications must be considered especially favorable to the development and maintenance of moist eczema, and every bandage, etc., which covers a secreting eczema acts as such. We see vesicles arising even on the healthy skin, as the beginning eczema miliare whenever moist heat is applied for some time. The maceration of epidermis together with the fluid furnish favorable culture media for numerous germs. By and by hypertrophy and thickening of the corium lead to deformities and enlargements of the auricle and even to adhesions at different places, as consequence of the protracted action of all these damaging influences. The free margin of the helix along the fossa navicularis is most frequently bound down by adhesions, but stenosis and even complete occlusion of the entrance of the meatus were formerly often observed as consequences of eczema which was neglected for years. The disappearance during the last decades of equally bad cases, which mostly came from the country, points to the fact that there also better care is now taken of children.

Extensive swellings of the lymph glands of the neck may develop after long standing eczema of the ear.

There is one peculiarity of the eczema of the entrance of the meatus; it never extends far into the depth of the canal. The whole epidermis of the meatus including that of the drum membrane may become macerated when the eczema lasts very long, and, in very neglected cases, especially when there is at the same time a suppuration of the middle ear, the whole lining of the bony canal may be excoriated and the whole surface covered with a tightly adherent diphtheritic exudation. However as soon as we dry out the depth of the meatus and keep it aseptic, the false membrane is cast off, the sore spots are covered with epidermis and the secretion stops. Little pustules of eczema can never be seen in the bony meatus or even on the surface of the drum membrane in acute cases.

Spontaneous occurrences of moist eczema in the *adult* is relatively much rarer than in children. We find here more frequently forms of eczema squamosum, in which scales are formed on the surface of the epidermis. They are mostly located at the entrance to the meatus and in the concha but are found also behind the auricle, mainly in elderly women. Exudation of fluid secretions takes place mostly in the rhagades which appear after the disease has lasted very long and improper attempts at cleaning were made.

The eczemata of the ear are just as amenable to *treatment* as those of other parts of the body, if we give due consideration to the local peculiarities.

Our main task is above all to locate a starting point of the eczema. Ear-rings must of course be prohibited whenever there is a disposition to eczema. (In one case I found the ear lobes very much swollen and covered with eczematous crusts. I had to remove by operation little buttons of metal which had been screwed in and were completely surrounded by new formed tissue.)

The ear must be carefully examined in every case of eczema to ascertain whether there is not a perforation of the drum membrane and a suppuration of the middle ear, concealed by masses of epidermis. The relentless antiseptic treatment of the suppuration of the middle ear in such cases, which occur not at all rarely especially in children, is often sufficient to make the eczema disappear.

We have to take care in every case, even where there is no suppuration of the middle ear, that the meatus is dry and aseptic down to the curved end of its recessus. This is accomplished by regular daily injections with 4 per cent warm boric acid solution, followed by drying out with a thin bent probe without a probe-end, wound with cotton, and dusting of the bony meatus with dry boric acid powder. The injections, which are indispensable for the removal of fetid masses of epidermis, are never harmful if afterwards the canal is carefully dried out as was just indicated.

The rhagades at the entrance of the meatus, below the helix and behind the auricle must be handled with special care. Every brisk forcing apart will tear again the rigid tissue which has become brittle. After the crevices are carefully cleaned and dried, they are cauterized with a pure or mitigated stick of nitrate of silver, and covered with powder.

The crusts and scabs on the ear are softened, as in eczema of other parts of the body, with non-irritating oils or salves, like unguentum diachylon (*Hebra*), zincoxyd salve, borated vaseline, *Lassar's* paste, etc. The crusts, after having been covered over night with the salve, are very carefully removed the next morning, and finally the whole eczematous region is covered with a thick layer of powder consisting of equal parts of corn starch or oxyde of zinc and boric acid. *Lassar's* paste with or without salicylic acid (1 to 2%) remains in situ and is renewed twice each day till recovery takes place.

The tar products, like oleum cadini, rusci, fagi, naphthalan, etc., ought only to be used in squamous eczema when there are no more excoriated spots and no crevices. They must be very energetically applied till all scales are removed from the surface. A camel's hair brush, the hairs of which have been cut short and even, is best suited for the purpose.

The whole surface may be painted with a 4 per cent solution of nitrate of silver after all scales are carefully removed whenever there are small secreting spots on the scaling surface.

The treatments with nitrate of silver as well as the painting with tar products may be continued to advantage for a long time.

A few words may be said about the secondary eczemata.

Besides the eczemata just described, occurring in connection with suppurations of the middle ear, we must consider especially the secondary eczemata caused by medicines which we use in our treatments.

Acute eczema may develop on the intact skin and spread over large surfaces after the use of iodoform, bichloride of mercury, orthoform and even after the mild boric acid.

A better evidence for the extremely varying individual disposition to eczema can hardly be imagined, than this idiosyncrasy of some few people against some medicaments which thousands can stand in any quantity without the slightest irritation of the skin. The occurrence of eczema in such cases can be explained in no other way. Some assistants are absolutely unable to change a dressing with iodoform and have to be careful of every trace of it. They at once, after the slightest touch, develop erythema and swelling of the hand and wrist as far as the upper arm, as I have seen with my own eyes.

Of all the eczema due to medicines the eczema due to iodoform is that which we see most frequently, on account of the regular use of this substance in surgical dressings. It appears absolutely like an acute moist eczema with much swelling and redness of the auricle and the other parts of the cutis which are covered by the dressing. Numerous miliary pustules appear on some especially exposed places of the auricle. The whole surface which is attacked becomes red and glossy if the iodoform continues to act for some time, and small drops of serum well up everywhere. The iodoform eczema has by no means like the genuine eczema a preference for children; it attacks adults just about as frequently. It is usually sufficient to leave out the iodoform gauze and dress with borated vaseline in order to effect healing which takes place with the shedding of the epidermis.

Orthoform which is such an excellent analgesic I have discarded, because in a case of necrosis in the drum cavity causing unbearable pain which regularly disappeared after a dusting with it, it by and by caused considerable casting off of epidermis and afterwards a leatherlike shrinking of the cutis of the whole meatus. Other authors reporting similar experiences, induced me to discontinue its use altogether.

Solutions of bichloride of mercury in dilutions of 1 to 1000 may in rare cases cause acute eczema on an intact skin.

It is finally most extraordinary that violent cases of eczema developed even after the use of boric acid powder which otherwise never irritates. It is true that this occurred in very rare cases only. Round shallow excoriations of the size of a pin's head appear once in awhile (about once in 200 or 300 cases), in the cutis of the meatus after boric acid powder had been insufflated several times. The white epidermis around these excoriations is thickened and there is some discharge of serum. There is another form which is much rarer still than the foregoing. An acute eczema appears which spreads at once over the auricle and its surroundings. There is no question as to effect and cause of this eczema and the use of boric acid, for I observed it in the same way on the same individual when boric acid was used for a second time years after a first occurrence. In another patient who had an acute suppuration of the middle ear, first on one side then on the other, a diffusely secreting eczema of the auricle, the cheek and the neck developed a second time in the same way, and after boric acid had been used for the same length of time. It only disappeared gradually many weeks after treatment with boric acid had been discontinued.

LECTURE XI.

Othematoma.

Gentlemen:—There is a disease which is peculiar to the auricle. Large circumscribed extravasations of blood are formed which detach the pericondrium from the cartilage over a large area.

I find one case of othematoma to every 2,000 ear patients in my statistics.

The well circumscribed elevation which has the form of a bag, was in the cases which I saw, confined to the upper half of the anterior side of the auricle. It was bluish, flabbily fluctuating and protruding more or less convexly. The upper limit of the bag is usually the helix, the lower is either the lower ridge of the fossa intercruralis or it may reach farther down into the upper half of the concha where the root of the helix forms its limit (compare fig. 33).

Fig. 33.
Othæmatoma.

It was formerly thought that othematoma was in connection with diseases of the brain because it was often seen in insane asylums. *Gudden's* researches, however, made it very probable that the origin is repeated traumatisms in the insane as well as in boxers, which is supported by the fact that it occurs mainly on the left ear. For prize-fighters it was considered so characteristic that the Greeks reproduced it plastically. It has become relatively rare in our insane asylums according to personal communication from many of our alienists. Othematoma is found more frequently in epileptics who are exposed to injuries which can not be avoided.

A preceding trauma was not always established in the anamnesis of my cases. The possibility of its formation independently of trauma as a consequence of a circumscribed degeneration or abnormal vascularisation of the cartilage can not be denied. In the plurality of cases however repeated strong traumatisms against the auricle are admitted.

The contents, which in the beginning are pure blood, become later on a viscid clear fluid.

Drainage of the fluid by operation, which was recommended, did not seem indicated in any of my cases on account of the flabbiness of the bag and on account of the lack of inflammation. The therapy which was indicated by *Wilh. Meyer* consisted in daily paintings with iodine, careful

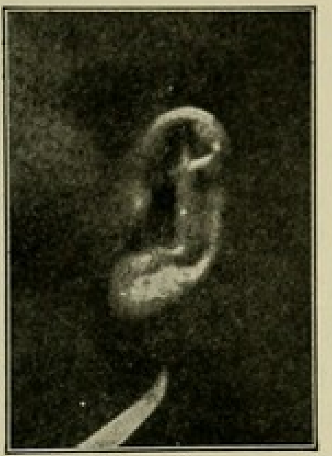

Fig. 34.

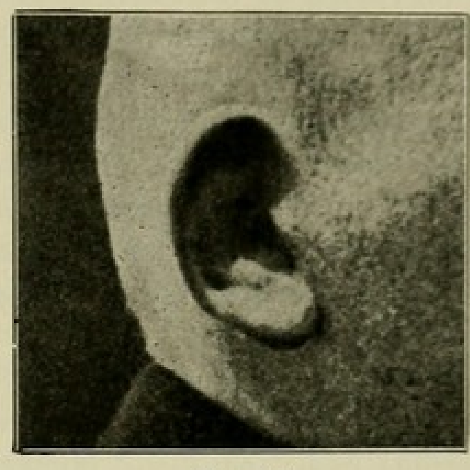

Fig. 35.

Fig. 34. Othæmatoma healed spontaneously leaving a deformity of the cartilage.

Fig. 35. Othæmatoma on the other ear of the same patient healed under a compressive bandage.

massage and a tight dressing with a pad behind the auricle. The complete absorption of the contents takes a rather long time. A lasting deformity from shrinkage of the cartilage which otherwise can be seen often, resulted in no case that we could follow to the end (compare figs. 34 and 35).

Perichondritis.

Elevations of the perichondrium of the auricle by exudations which are sometimes like synovia, sometimes like pus, are even more rarely observed than hematomata. They are located on the anterior surface of the auricle like hematomata. The cuticular covering shows pronounced symptoms of inflammation, such as heat, redness and *irregular* thickening, which travel slowly over the whole anterior surface of the auricle, with the exception of the lobule which has no cartilage. The swelling is painful to pressure. Fluctuation cannot be felt everywhere as superficially, nor does it reach everywhere to the periphery as in othematoma.

The course of the disease may extend over several months, during which time the cartilage may become partly necrotic. The irregular swelling of the soft parts disappears only slowly and leaves more or less of a deformity.

Local tuberculosis of the auricle which is very rare may run its course similar to perichondritis.

The treatment of perichondritis is antiphlogistic. Applications of ice are used when it begins with the symptoms of a phlegmonous dermatitis. The swelling has to be slit open vertically throughout its whole length as soon as fluctuation is felt. Necrotic cartilage, if there is any, must be removed and granulations curretted. The wound is dusted with iodoform powder, and a drain of iodoform gauze is inserted. The auricle is well padded in the rear and a dry dressing applied. Deformities and shrinking of the auricle as final results of perichondritis can not altogether be avoided. The occurrence of *secondary* perichondritis of the auricle under the dressing, after total opening of the mastoid process (radical operation) and covering of the gap with plastic flaps from the meatus was repeatedly reported of late. It caused permanent deformities. Neither I nor any of my disciples have ever seen an inflammatory reaction of the cartilage or perichondrium after plastic of the meatus. The cause for such inflammatory processes with necrosis, according to my judgment, is to be found in the after-treatment, and I believe that moist dressings which are strictly proscribed in our clinic are usually responsible for it. The effects of a great many bacteria, especially of germs of decomposition, bacillus pyocyaneus and others can only be absolutely avoided by dry dressings.

Erysipelas.

The auricle and its surroundings are often attacked by erysipelas. It may start from excoriations and rhagades at the entrance of the meatus, or at the auricle. It travels however more frequently over the ear from its surroundings. The whole bony meatus and the outer surface of the drum membrane become invaded by the disease, whenever it travels over the auricle and the entrance to the meatus. This is evident from the swelling, and occasionally the subsequent casting off of a bag of epidermis resembling the finger of a glove, which is the lining of the whole meatus and drum membrane. *A small perforation of the drum membrane and an acute suppuration* of the middle ear on the afflicted side are not infrequent consequences. The course of a suppuration of the middle ear after erysipelas is as a rule quick and mild. It does not differ from the course of a genuine suppuration of the middle ear, except that in the latter the perforation is from the start a little larger. These facts, which were gained by careful observation, are especially remarkable because they show that the streptococcus (*Fehleisen*) which is distinguished by such a high degree of virulence in the skin; leads very exceptionally to cerebral complications when it has a chance to invade the middle ear. I saw pyemic symptoms only once in the course of an acute suppuration of the middle ear after erysipelas. They disappeared after the mastoid process was opened by operation and the internal jugular vein was ligated.

The *secondary erysipelas* which follows wounds of the ear is of special importance. It is a general experience that erysipelas, of all infectious wound diseases, is the most difficult to exclude from hospitals. I saw a comparatively small number of cases of erysipelas following operations in our hospital. It was nevertheless evident that even the most careful desinfection of the rooms and the objects that were used proved insufficient to absolutely check the spreading of the disease to other individuals. A safe-guard against such infection of wounds are broad and tight dressings underneath which the patients cannot enter with their fingers in order to scratch. We are never absolutely safe from this complication of our operations, not even in private practice. Erysipelas occurred in *one* case after I had inserted a lead drainage tube with some force into the opening in the mastoid process which had become too narrow. In another case it developed after an interne, coming from a post-mortem, changed a dressing, although he previously had desinfected his hands very carefully. Operations and dressings of wounds of the ear are therefore to be avoided just as well as work in obstetrics immediately after occupation in the post-mortem rooms.

A granulating surface, when attacked by erysipelas, becomes dark red and dry, as though it were varnished. The healing process of the wound is perhaps a little protracted, but otherwise not materially interfered with, according to my observations.

I saw only *one* case terminate fatally from consecutive meningitis after a primary erysipelas which started from the ear and progressed over the whole scalp. No operation was performed in this case.

Other Affections of the Auricle and Its Surroundings.

A number of *other affections* of the auricle and its closest surroundings must be mentioned.

Abscesses of the soft parts of the auricle and the entrance to the meatus may be primary or secondary, like, for example, abscesses by gravitation from the closest vicinity, as from furuncles in the meatus. They usually heal after a simple incision.

Atheromata, ranging in size from a cherry to a walnut, may be found on the lobule or in the tragus, or on the rear surface of the upper half of the auricle. An atheroma should be peeled out together with its entire capsule and entrance, a procedure which does not offer any real difficulties.

Ulcerations of the auricle may be due to trauma, to frost bite, to burning, or to the action of chemicals. They may be caused by dyscrasias, as in *scrophulous* and *atrophic* children, or they may be *tuberculous* or *luetic* ulcers.

Primary syphilitic affections of the auricle are so rare that *Politzer* could find only three cases in the whole literature.

The different forms of *lupus* locate very rarely on the auricle according to my experience.

Oedema of the auricle and its surroundings may occur after stings of insects or after touching the hairs of certain caterpillars.

Herpes may affect the auricle and its neighborhood. The eruption of herpes over the mastoid process was, in one case, which I observed, preceded by a serious neuralgia over the whole region, which lasted for several months. Paralysis of the facial nerve and anesthesia of the acoustic nerve were observed in rare cases together with herpes of the external ear.

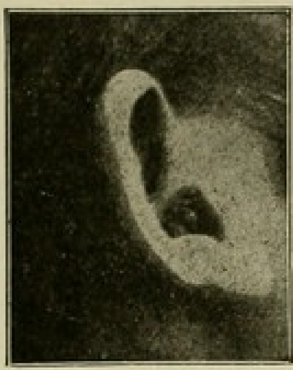

Fig. 36.
Angioma.

Arthritic nodules are sometimes found in old people along the rim of the helix, having the form of a crown of irregularly shaped white concretions.

One or several slits in the lobule are found in the rare congenital deformity of a double lobule. They are much more frequently caused artifically by the weight of ear-rings. *Keloids of the scar* and *fibromata* of smaller and larger size may in rare cases arise from the hole in a pierced ear lobule. Both deformities may easily be corrected by operation. *Passow* portrayed two ugly cases of deformities caused by tuberculosis of the skin which started from the piercing of the lobules. Records were published of an ulcus durum starting from the same source.

Telangiectases and *erectile tumors of blood vessels* may extend to the auricle from the neighboring parts, or may be confined exclusively to the auricle. The little vascular tumor which is shown in fig. 36 developed suddenly during labor pains. It would have been very easy to remove it with the galvanocautery snare had the woman returned to the clinic.

The diseases in the vicinity of the auricle which the otologist sees the most frequently are the following:

Inflammatory diseases of the joint of the lower jaw, the pains of which the patient usually locates in the ear. Pressure on the joint while opening the mouth increases the pain and sometimes causes the feeling of crepitus in the joint.

Emphysema of the skin behind and above the auricle occurs in very rare cases after traumatic or inflammatory rupture of the continuity of the outside surface of the bone.

Parotitis causes considerable swelling below and in front of the ears.

Perforations of suppurations from the parotid gland into the auditory canal are such rare occurrences that I observed only two cases.

Noma of the Cartilaginous Meatus, the Auricle and Its Surroundings.

Noma of the ear is such an extremely rare disease that only few otologists seem to have seen any cases at all. I have observed two cases in the living and made the post-mortem of a third. Nevertheless I want to give a description of this dreadful disease which is so very characteristic.

Noma of the ear is a form of gangrene which is in every particular identical with the well known noma of the face and genitalia. It does not, like the other forms of gangrenous destruction of different parts of the auricle, follow after phlegmons, perichondritis, deep ulcers after high degrees of frost bites, etc., all of which may lead to partial loss of the auricle. It manifests itself as a terminal deep destruction which cannot be checked, in very weak anemic and atrophic children in the first few years of life. It leads to death within a very few days in all cases that I saw, just like noma of other parts of the body.

Eitelberg[1] described a case which undoubtedly was noma as "dry gangrene of the auricle," and collected some few cases from literature which may come under this heading. *Politzer* mentions a case in his text book which *Hutchinson* called noma of the auricle.

The clinical picture of noma of the auricle according to my own observations is about like this:

The disease seems to attack without exception poorly nourished and atrophic children of the lower classes who are not more than a few years old and are still under the influence of some serious general infectious disease, which is usually measles, but may be typhoid fever, scarlatina, or small-pox. It may develop together with chronic catarrh of the bowels, scrofulosis and tuberculosis.

Measles preceded noma in two of my cases, while the third one suffered from chronic catarrh of the bowels. Symptoms of scrofulosis and tuberculosis were present in all of them. Chronic suppurations of the middle ear with destruction of the drum membrane were found in all three cases. *The starting-point for the nomatous destruction* was however not the middle ear, but in all cases *the cartilagenous meatus,* through which the fetid secretions passed.

The case on which a post-mortem was made is the most instructive regarding the beginning of the disease and the identity of noma of the ear with noma of the face, etc. I had a chance to observe the beginning of the disease at the entrance of the meatus.

The child was 4¾ years old and died of tubercular pleuro-pneumonia. The auricle was intact, but all the soft parts of the region of the tongue and chin were destroyed by noma. The cartilaginous meatus, with the exception of a small bridge on the top, was separated from the bony meatus by extensive gangrenous destruction of the soft parts, which spread also between the anterior bony wall of the meatus and the joint of the lower jaw, laying bare the whole os tympanicum and the outer surface of the pars mastoides. The hearth of destruction has the size of a quarter, and consists of blackish green shreds of tissue which had a fetid smell like carrion and tore like tinder. Pieces of the cartilage of the meatus, partially denuded and of dirty color, hung from the shreds.

The drum membrane had two perforations, one in front, the other

[1]Wiener med. Wochenschr, 1885, No. 21.

behind the handle of the mallet, which was still in situ. The mucous membrane of the drum cavity was not discolored, but yellowish and only slightly thickened. The aditus and the antrum were filled with a yellowish gray pad of mucous membrane which was semi-transparent and discharged transparent serum when it was pricked.

The process on the ear was more progressed in the second case which I observed during life:

It was a very atrophic child of one year and three months, who suffered from chronic catarrh of the bowels. Both ears discharged since birth, the discharge of the right ear being very fetid for some time. The auricle of the right ear projected from the head, but did not stand at an angle as in subperiostal abscess. The soft parts in front and below the ear were swollen, and enlarged glands could be felt. No swelling or sensitiveness could be found over the mastoid process. Bubbles of gas which had a putrid smell were discharged from the meatus upon pressure on the swollen parts. There was a large ulcer in place of the cartilaginous meatus in which discolored pieces of cartilage floated freely. The child had complete paralysis of the facial nerve two days later, when the gangrene had progressed over the tragus, transforming it into a blackish, dry, shriveled-up crust. A swelling of the size of a walnut had formed behind the ear, on the top of which a distinctly circumscribed part of the skin was like parchment, dried up and blackish. The child died a few days later.

Fig. 37.

Noma of the ear.

I could watch the process for the greatest length of time in the third case.

It was a laborer's child of two years and four months who had a fetid discharge from the left ear 1½ years previous, and measles a fortnight previous. It had furthermore spina ventosa of several phalanges, caries of several vertebrae and whooping cough. Paralysis of the left facial nerve had existed for four days. The ear was raised from the head, with a swelling the size of a plum over the mastoid process, on top of which there was a distinctly circumscribed blackish part of the skin about the size of an almond. The whole meatus was filled with gangrenous rotten masses which were sharply demarcated towards the entrance and consisted partly of free pieces of cartilage. The temperature was 103.5° F. Three days later the swelling was greenish black, sharply outlined from the surrounding healthy skin, and was 7 centimeters broad and 5½ centimeters high. The lower part of the auricle, together with the tragus and antitragus, were now implicated in the process (compare fig. 37). A large piece of cartilage was wiped out of the meatus. The temperature being normal for the next few days and the child having good appetite, I excised the gangrenous masses with the consent of the director of the children's hospital, privy counsellor *v. Ranke*.

The cut was made ½ centimeter from the limit without narcosis, as no pain whatsoever was felt in the whole region. Hardly a few drops of blood escaped from the incision. The cut looked like marble and was not discolored. Black masses which tore like tinder had to be left around the big blood vessels of the neck. The whole os tympanicum and the outer surface of the mastoid process lay exposed and were not discolored after the scurf was removed. The process progressed in all directions, incessantly after the excision, as shown in a photograph (compare fig. 38), which was taken five days after operation. The child died seven days after the operation.

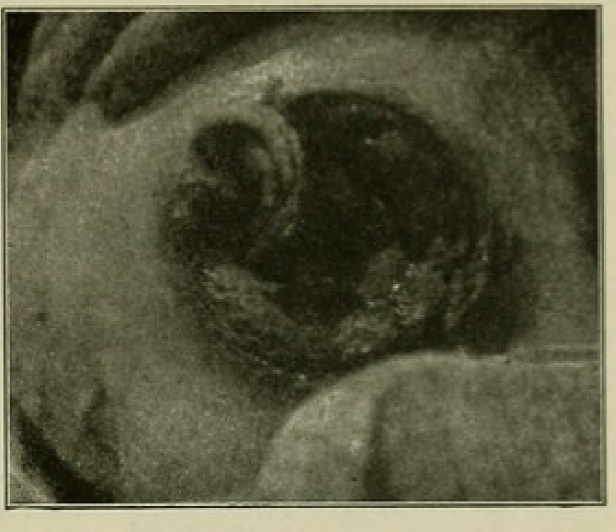

Fig. 38.
The same five days after excision.

Noma of the ear is a very characteristic disease and cannot be mistaken for anything else according to the picture which was just given. A chronic suppuration had existed for a long time in these children which were furthermore much weakened by some serious general disease. The gangrene started *in each case in the cartilaginous meatus*, where deep destruction of the soft parts was found. It probably started from some excoriation which was exposed to infection from the pus of the middle ear constantly flowing over it. The gangrenous process very quickly destroys all soft tissues to the tympanic bone, the joint of the jaw, the mastoid process, and causes paralysis of the facial nerve. As soon as the cartilaginous meatus is destroyed the black decomposition appears behind the ear, where it spreads excentrically in a few days until death occurs. The absolute absence of hemorrhage at the operation in the surroundings which were not discolored justifies the supposition that all blood vessels were thrombosed to a large distance.

The tissues which are doomed to necrosis are interwoven with an anaërobic form of streptotrix, which forms a thick mycelium of very fine threads of the fungus in the neighborhood of the rim of demarcation, according to examinations of *von Perthes* (Arch. für klin. Chir. 1899), which were confirmed by a number of later investigators. *Von Ranke* found that the mycelium of the fungus grew through the arteries. The striking black discoloration of the tissues has to be ascribed to a decomposition of the coloring matter of the blood, as the mycelium has no color whatsoever. The inoculations of the nomatous tissue into different animals and of the mycelium which was anaërobically cultivated, have given so far no positive results. It is therefore premature to consider the fungus the cause of this disease, although it was found in every case in which it was looked for according to the method of *Perthes*. The tissue which was necrosed for one reason or another may have formed a favorable culture medium for its growth. Its regular appearance seems however to give the disease its characteristic stamp.

Wilde speaks in his "Practical Observations about Diseases of the Ear" (translation by *Haselberg* 1855, page 208) about a disease which is either closely related to noma, if it is not identical with it, and calls it pemphigus gangrenosus. At that time the people called it "the burned hole," or "the black ear," "because it often appears on the ears or behind them." *Wilde* says that this disease was so frequent at that time that 17,799 deaths were ascribed to it within 10 years. In the *United States* a small epidemic of 16 cases of noma after measles was lately described (American Journal of medical sciences Nov. 1901 page 587).

The therapy can only be a surgical one on account of the irresistible progress of the destruction.

A far advanced case of noma of the face was cured in Prague 13 years ago by extirpation of the cheek and partial resection of the superior maxilla. *Springer* showed it in the meeting of the association of German physicians of Nov. 13, 1903. *Von Ranke,* who has a very large experience with noma, saw three cases of noma of the face and one case of noma of the genital organs in the children's clinic in Munich, which were all cured by extirpation in the early stage, even without great deformity. It was on his suggestion that I tried the excision in the above described hopeless case, more as a preparation for future cases.

You can see from our observations that the diagnosis is not difficult, even in the beginning when the process of destruction in the ear is confined to the cartilaginous meatus, which seems to be the regular starting-point. The fact that in all our cases *the middle ear remained free to the end from nomatous changes,* must be considered of great practical importance. A complete extirpation during the first few days is very possible in the ear, yet up to today not a single recovery by operation has been recorded.

The cut has to be made at least one centimeter away from the well defined black line of demarcation, parallel with it, according to our experience.

The healthy part of the auricle has to be raised with the knife like a flap, the upper part of which remains connected with the head (compare fig. 38). It is used to cover the defect, together with *Thiersch's* skin grafts, which is also done in epithelial carcinoma of this region, as we shall soon see.

Malignant Neoplasms of the Auricle and of the Meatus.

I saw one case of sarcoma and six cases of epithelial carcinoma of the auricle and the meatus, besides malignant tumors which invaded the auricle and the meatus from the surroundings, especially from the parotid gland. Malignant growths of this region are therefore very rare occurrences.

Fig. 39.
Cancroid of the external meatus, the auricle and its surroundings.

The patient with sarcoma was a girl of 9 years. The tumor grew to the size of an apple in a few weeks and had perforated behind the auricle and in front of the tragus, where it caused violent hemorrhages. The auricle, raised to a considerable distance from the skull, was situated on top of the tumor completely intact.

The tragus, the antitragus and a part of the concha adhered closely to the tumor and had to be removed together with it, when it was extirpated. After the tumor was peeled away from the os tympanicum and pars mastoidea, granulations had to be scraped out of the bony canal and the drum cavity before the probe could be inserted into the tube.

The tumor was histologically an angiosarcoma, consisting of spindle-cells with very many blood vessels. It started probably from a molluscum at the entrance of the meatus.

Recovery took place almost without deformity, notwithstanding the large defect. The meatus was kept open and a considerable remnant of hearing was saved for the girl.

No recurrence has been noticed up to today which is for three years.

The epithelial carcinomata of the external ear were confined to the auricle, its nearest surroundings and the external canal, with the exception of one case which will be described later. The patients were mostly women over 50 years of age. The growth of the tumor was always very slow extending over many years. No involvement of the neighboring glands could be diagnosed. The development of the neoplasm starts usually from the entrance of the meatus. The surface shows the well-known picture of an easily bleeding cancroid with a cauliflower-like surface, many furrows and a somewhat overlapping rim. Severe pains which last for years are always connected with the later course of the disease.

The ulcerating surface may become covered to a large extent by a smooth epidermized scar in some cases which are characterized by the slowness of their progress. A few places of the periphery only, keep on advancing slowly though irresistibly (epithelioma cicatricans). Pain may be entirely absent in those cases. The progress of the disease at the periphery amounted to only a few millimeters in several years in the case which I observed.

This case concerned a colleague of 76 years. The affection started 14 years ago after the patient had been stung several times by wasps at the outer angle of the eye. The appearance was that of an eczema which progressed under the form of separated ulcerating surfaces towards the entrance to the ear and behind the auricle. The ulcerations were burned many times with the Paquelin cautery. They showed no tendency to heal, according to the records of the dermatologist who treated him then, so he stopped this treatment. An arterial hemorrhage occurred two years ago, after a cauterization with chloride of zinc. It necessitated the ligation of the temporal artery. All ulcers were nearly healed 1½ years ago by treatment with X-ray. They became more extended than ever when this treatment was further continued (compare fig. 40).

Fig. 40.
Epithelioma cicatricans of the auricle, spreading to the eye.

When I saw the patient first, two years ago, there was an ulcer about an inch in diameter at the entrance to the meatus and in front of it, with steep irregular margins which stopped abruptly at the entrance to the meatus, leaving the meatus entirely free. Around this main ulceration there was a large area of scar tissue which was surrounded by a large circle of smaller ulcers, some of which were raised, others flat. The rear surface of the auricle and the outer surface of the mastoid process were partly ulcerating. The branches of the facial nerve which supply the forehead and the cheek were paralysed.

The central ulcer diminished to about half its former size with mild dressings of boric acid powder and boric acid salve. The patient upon my suggestion, treated the ulceration for three months with light and eosin. During this period the ulcers again grew considerably larger and the region of ulcerations had extended more than a third of an inch all around (compare fig. 40). The auricle had become adherent to the mastoid process, and under the synechias the ulcers grew larger and deeper. It must be added that the patient lately used continual moist and warm applications covered with gutta percha. The secretion was profuse and very fetid.

Dry treatment with boric acid powder and boric acid salve, and drying out of the meatus caused the peripheral region of the ulcers to become almost completely covered with skin, and the central ulcer to diminish in size. The secretions remained odorless.

I decided to desist in this case from an excision on account of the age of the patient and the pronounced tendency to healing under mild dressings.

This history shows you what a bad effect every active treatment has in similar torpid ulcerations. Our main task in every ulceration at the entrance of the meatus is *to dry out the meatus down to the drum membrane and keep it always and absolutely dry;* besides we must use great caution in every change of dressing and carefully clean the whole ulceration. This is the only possibility of preventing decomposition over the whole region of ulcers, covered by dressings.

Epithelial carcinoma of the auricle and the auditory canal was excised in two cases after they had both lasted for seven years. The tragus, the concha, and the antitragus were destroyed in both cases, while the neoplasm, at least in one case, did not invade the middle ear, but remained confined to the cartilaginous canal. The deformity in both cases after recovery was very small as the defects could be very well covered by suturing the remnant of the auricle to the head, and covering the remainder of the wound with *Thiersch's* skin grafts. A wide meatus and good hearing was obtained in the first case which was operated upon five years ago (compare fig. 41). No recurrence was noticed up to today.

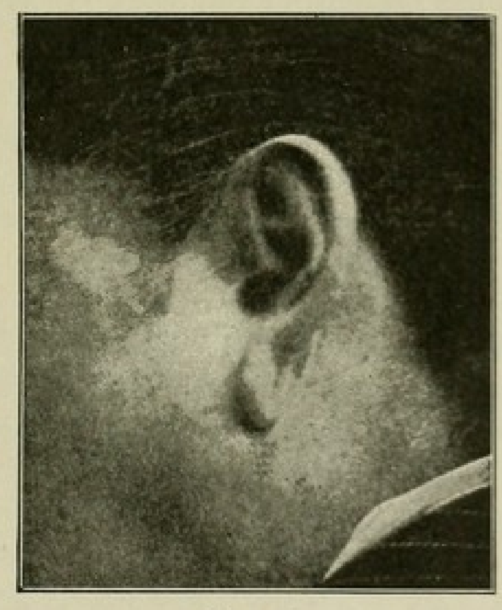

Fig. 41.
Epithlial carcinoma after operation.

The tumor in the second case (compare fig. 39) had progressed as far as the drum membrane from whose surface growths had to be removed. A painless recurrence was removed with the sharp spoon a short while ago from the bony canal, as far as it could be reached a year after the first operation.

The most important consideration in the *prognosis* of the epithelial carcinoma is the extension of the destruction inwardly. The involvement of the cheek on the outside and the soft parts behind and below the ear are no contraindications against operative removal, since the defect can be completely covered with *Thiersch's* grafts and by the intact remainder of the auricle, as was shown in the case we operated last.

The extension of the disease inwardly is so much more important for the prognosis. The condition of the facial nerve and the hearing tests give us the most valuable information as to this point. We may without hesitation excise the tumor if the function of the facial nerve is intact and a remnant of hearing on the involved ear can beyond a doubt be established, even if the new formation has extended ever so far over the outer surface.

The cut must be made in the healthy tissue all around, about ½ centimeter away from the limits of the disease. The peripheral part of the auricle which was spared by the disease is loosened from below together with an upper bridge of the scalp, and turned upwards like a flap, as was done in the case in fig. 41. The tumor is then dissected from the bony canal and the outside of the mastoid process, when also diseased parts of the parotid gland are cut out within the healthy tissue. The bony canal and the outside of the drum membrane are scraped clean with the currette if the neoplasm extends as far as that. There were no swollen glands in our cases, otherwise they must of course be removed. The posterior margin of the flap of the auricle is then sutured to the rear rim of the wound as far down as possible. The large funnel-shaped defect in front, around the bony meatus, is covered with large *Thiersch's* skin grafts the position of which may be secured by sutures all along the periphery.

The success of this operation is usually favorable beyond expectation as to lasting recovery and as to cosmetic effect. The defect is so completely masked by the use of the flap of the auricle, that it can not be noticed except on close inspection, as was the case in the large sarcoma just described and also in the two cases of carcinoma.

LECTURE XII.

Diseases of the External Meatus.

Gentlemen:—The diseases of the external ear amount to 22 to 23 per cent of all diseases of the ear according to my statistical compilations. In this number are included the diseases of the auricle which, as we saw, are relatively rare, and the independent disease of the drum membrane, which occur only sporadically.

This number diminished some during the later years in my statistics, as in those of other authors. The cause of this fact must be found in the greater accuracy of our diagnosis, by which the number of cases of otitis externa diffusa especially was reduced. There is no doubt but what formerly a number of cases of suppurations of the middle ear were wrongly diagnosed as diseases of the external ear, because their secretions found an avenue of escape to the outside, either through a very small opening in the drum membrane, or in the wall of the canal, which we could not see at our examination. We shall enter into further particulars in speaking about otitis externa diffusa.

Congenital Atresia of the Meatus, together with Rudimentary Auricle.

This arrest of development must be dated back to an early period of embryonal life and comprises besides the meatus also the auricle and the chain of ossicles. We had better speak about it here, as in every case the meatus and the drum membrane are totally absent, while the auricle, the hammer and the anvil are present, though rudimentary only.

The *occurrence* of congenital atresia of the auditory meatus is relatively frequent. There is *one* case in about every 2,000 ear patients according to my experience. It is not very rarely found on both ears (once in about every six cases).

A small irregularly formed rudiment of cartilage which is covered with skin is seen on the outside in place of the auricle. It has no entrance to the meatus (compare fig. 42). The mastoid process starts directly behind the glenoid process of the lower jaw. I can best show you the great anatomical deviations from the normal by means of a case on which I made a post-mortem (compare fig. 43-44).

You see the glenoid process of the lower jaw together with parts of the parotid gland dissected forward from the outside of the temporal bone and from the mastoid process. The fossa mastoidea continues forward into the root of the zygomatic process without being interrupted by the aperture of the meatus.

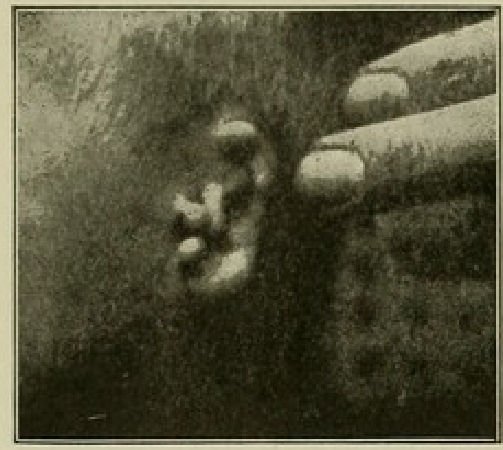

Fig. 42.

Atresia of the external meatus and rudimentary auricle. Anterior of the latter are cartilaginous appendages.

There is a cut through the drum cavity and tube (compare fig. 44). On the upper half of the cut in place of the drum membrane, you see the bony lateral wall of the drum cavity together with the rudiments of the two first ossicles. There is only the head of the hammer present with the tendon of the tensor tympani muscle, also the anvil, the long process of which terminates in a short hook-like point. The normally developed medial wall of the drum cavity appears on the other half of the cut with the promotory, the nitch of the round window and the stirrup with its tendon.

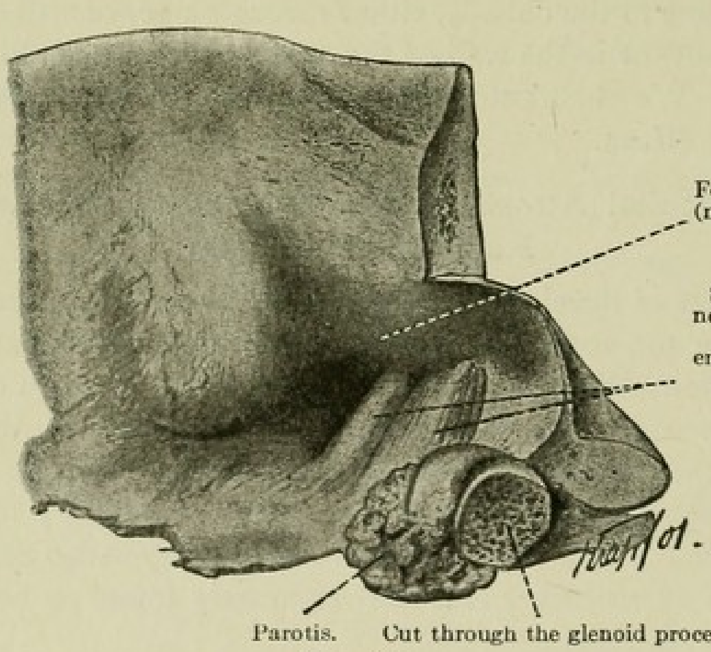

Fig. 43.

External surface of the temporal bone.

A compilation from literature which I induced *Joel* to make, of all cases of which a post-mortem had been made, established the fact that there was a complete *aplasia of the os tympanicum* and consequently also of the drum membrane, just the same as in my case. The labyrinth and its windows together with the stirrup were nearly always found intact. The latter was often less movable than normal.

There is therefore usually a considerable remnant of hearing connected with this deformity. Deafness (of course only for air conduction) is present only for the *lower* half of the normally audible sound scale, up to the one-stroked octave. The higher we ascend the scale from there, the better becomes the perception of the sounds. Hearing by bone conduction is considerably improved, as in all affections of the sound conducting apparatus.

Children are able to learn how to speak even when both ears are thus deformed. Consequently we do not find these children in deaf-mute institutions, but in public schools.

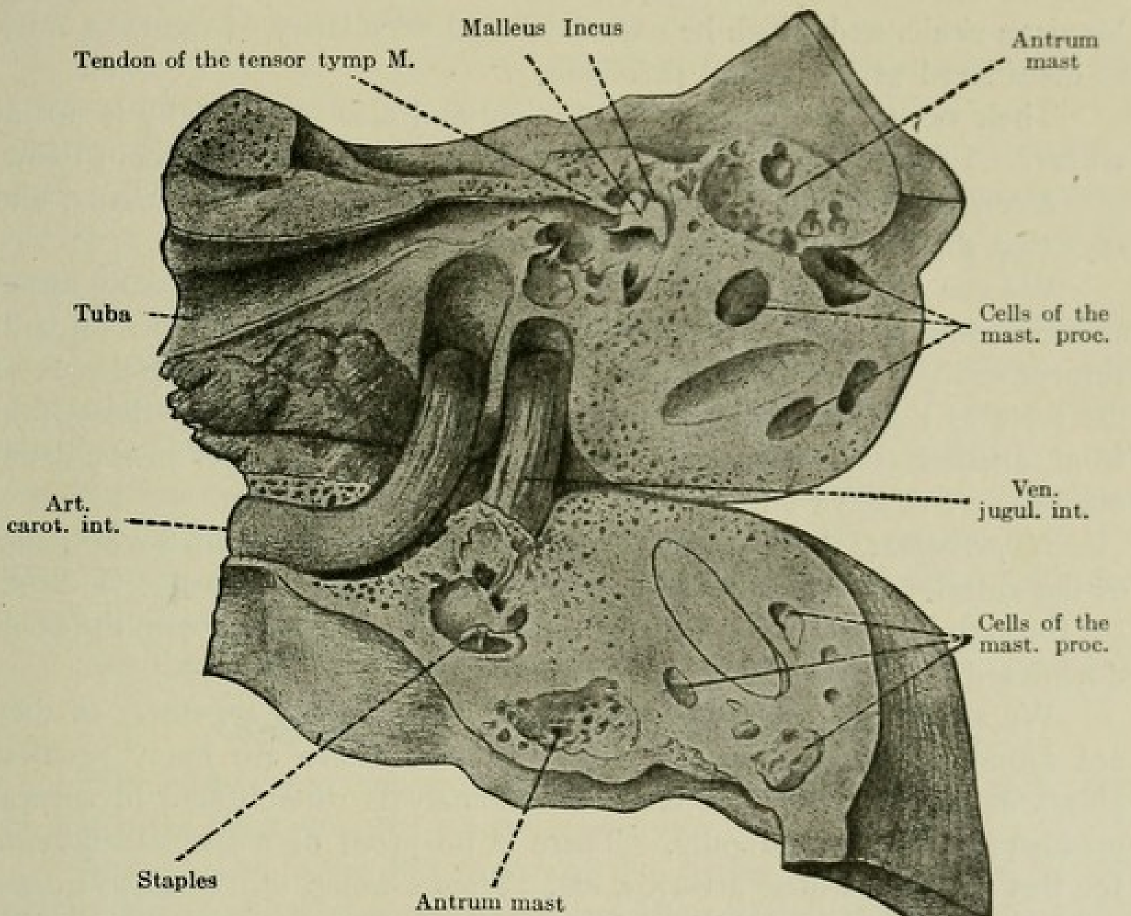

Fig. 44.

Section through the tube, drum-cavity and antrum mast.

Surgeons and otologists have tried repeatedly by operation to uncover a meatus, leading into the depth. This of course proved futile in every case on account of the nature of this anomaly.

Scheibe however tried a new operation in a case where both ears were deformed, the functions of which I had previously tested. It resulted in a considerable improvement of hearing. The antrum mastoideum is generally well developed and communicates with the drum cavity, as in our case of which pictures are given in fig. 42-43. *Scheibe* therefore opened the antrum from outside, forming a wide canal which he lined with *Thiersch's* skin grafts. The hearing distance improved from 10 centimeters to 18 centimeters as a consequence of this operation, and the power of hearing tested with the continuous series of sounds extended two more octaves downward by air conduction.

The Eustachian tube was several times found abnormally wide in cases of atresia of the auditory canal. Considering this fact, it would be worth while trying whether or not a hearing-tube, which is introduced through the nose, might improve hearing of speech in some cases.

Exostoses and Hyperostoses of the Auditory Meatus.

The exostoses in the bony meatus which *Virchow* found in many Mexican skulls and which he explained as a peculiarity of the race, must be considered as congenital deformities.

Their occurrence at the present time and also in Germany is not at all rare. I found them in 0.6 to 1 per cent of all ear patients whom I saw.

Koerner in Rostock found them in 3.8 per cent of his patients, and says that they are even more frequent in Great Britain.

We call *exostoses* small round bony growths which are usually found as little white circumscribed elevations in groups of two or more on both sutures of the deepest part of the os tympanicum to the horizontal part of the scale of the temporal bone. One protuberance is usually directly in front, another close behind the short process of the hammer in the drum membrane. A third one often protrudes between the two.

Hyperostoses present themselves more in the form of diffuse bulgings of the anterior lower, and sometimes also posterior lower wall. A cross-cut through the meatus has consequently the shape of a pear with the point downward.

We shall speak about exostoses and hyperostoses together, as they are found not infrequently in the same ear. There are many peculiar points as to their occurrence. This anomaly is often found in several members of the same family. There is no proof of a special diathesis for this disease as lues, arthritis, etc. They develop nearly always *after puberty*. In 170 cases which I observed up to 1896 there was none below 15 years. Neither did I find a single case in public schools or deaf-mute institutions.

They occur *oftener in both ears* than only in one. At times their development on the second ear can be observed later on.

The male sex is affected much more frequently than the female. My statistics show a proportion of 11 to 1, those of *Koerner* of 3.5 to 1.

Finally I was able to prove that exostoses are an affection of the well to do classes, and are almost never found in poor people. This point was also confirmed by the statistics of *Koerner*.

Continual awkward attempts at cleaning the ear with all kinds of instruments on the part of the patient seem often to cause a more rapid growth.

A complete occlusion of the meatus occurs *only very exceptionally* as a consequence of their enlargement, since even though they may touch each other, they leave an aperture with many corners. There is no serious interference with the function, except when this aperture is closed by ear-wax or epidermis which was pushed into the depth. Otherwise it is a fact established by experience that the narrowest aperture is sufficient for a nearly normal hearing.

The patients must therefore be prohibited from pouring water into the auditory canal or from diving into the water.

The removal of the swollen epidermis, etc., from between the exostoses and the drum membrane is often very difficult. It is accomplished with a straight antrum tube (compare fig. 66).

Removal of the exostoses by operation becomes necessary only exceptionally. It is indicated when one ball-shaped exostosis closes up the meatus *completely*. It may become imperative whenever secretions have gathered between the exostosis and the drum membrane, or when there are decomposed masses of epidermis or pus in cases where there is at the same time a perforative inflammation of the middle ear.

The auricle must be detached in the rear in order to remove a ball-shaped exostosis of the meatus which fills the aperture of the canal. The rear circumference of the meatus is cut at the line between the cartilaginous and bony meatus. This is done for two reasons. The first is that we may use our chisel as sparingly as possible along the rear and upper wall of the meatus, which is concave downward. The second is that a large exostosis can not be delivered through the isthmus which the cartilaginous meatus forms.

Small and multiple exostoses never need be removed by operation.

Acquired Atresia of the Auditory Canal.

The meatus may become closed from ulcerations of the soft parts in which the bone may or may not participate.

An occlusion in the deeper part of the meatus may be formed by connective tissue or by bone and will occur after serious suppurations of the middle ear. with removal of sequestra. Very rarely only a bridge may form.

Ulcerations on the entrance of the meatus may lead to occlusion by scars, as I once saw in a case of badly neglected eczema in a child.

Occlusion of the meatus was observed repeatedly after serious injuries caused by machines, tearing away the soft parts from the vertex downward in the shape of a large flap, which included the auricle together with the cartilaginous meatus. This flap is very difficult to readapt, and during recovery often moves more or less downward, so that afterwards the aperture of the torn piece is not congruent with the rest of the aperture of the canal. The dislocation is easily shown by the different height of the two auricles.

The insertion of a rubber drainage tube into the meatus down to its bony part, in order to avoid later occlusions, must never be neglected during the process of recovery after similar injuries which have severed the aperture of the meatus entirely or in part.

The suppuration, in occlusion of the meatus after the removal of a sequestrum, has generally stopped in the depth long before the sequestrum is expelled. The power of hearing is entirely lost in the greatest number of cases. (The whole labyrinth was removed as a sequestrum in a case which I observed.) There is therefore no reason to reopen the depth by operation. The reopening by radical operation will however be necessary when there are symptoms of continuation of the suppuration inside of the occlusion.

Consideration of hearing can only become an indication for operation for the reopening of the aperture in occlusions which are very far outward, and when the functional tests with tuning forks show sufficient hearing in the diseased ear (see the hearing tests in congenital atresia of the meatus, page 101).

A cross-shaped incision is sufficient when the scar is not too thick. You must not forget that an aperture can only be found in the upper part of the scar in occlusion of the canal after dislocation of the flap in injuries by machines. The cross incision may be enlarged by insertion of a stick of laminaria, which must remain there for a few hours only, on account of its rapid and considerable enlargement. It is sufficient when in this way an aperture is created large enough to insert a solid cylinder-shaped pledget of cotton, which is made by wrapping some cotton tightly around a thin probe without a probe end, slipping it off and dipping it into iodoform powder.

The aperture on the inside of the occlusion will be found completely filled with a pulp of cast-off epidermis and little hairs whenever the occlusion has lasted long enough. In one such case I found a large dry perforation of the drum membrane behind the occlusion, which existed since before the injury.

A small permanent opening which never closes entirely is sufficient for the improvement of the power of hearing. Chiseling away of the rear wall of the meatus and large plastic operation of the meatus, by the formation of flaps in order to create a large aperture, becomes necessary only exceptionally.

Foreign Bodies in the Meatus.

The removal of foreign bodies from the external meatus is a very frequent cause for treatment by a physician. *One* case of foreign body in the ear is counted to every 60 to 70 ear patients according to my statistics, in which number the number of cases of plugs of ear wax was left out of calculation.

The permanent lodging of a foreign body in the auditory meatus is in itself perfectly innocuous. It neither interferes seriously with hearing nor does it cause any other disturbance (the serious reflex neuroses which in earlier times were repeatedly recorded seem to have been wrongfully ascribed to the ear, as nobody has seen them of late). The consequences of awkward attempts at extraction, on the part of laymen and physicians, have become fateful for a great number of patients and physicians, as not a few patients have died and will die from this cause. There is hardly another domain in medical science where blind operative zeal without sufficient knowledge of anatomy and technic can cause so much damage.

Living animals find their way not very rarely into the ear, where they cause violent pain by their movements in the bony canal and on the drum membrane. Flying insects, parasites of the house, especially Blatta orientalis, (bed-bugs) are not infrequently found. I once removed even a small snail together with its shell which stuck tightly to the drum membrane. The strong jet of a syringe is sufficient without exception for their removal. You may find mentioned in all text books that larvæ of flies were found developing in the bony meatus and the open spaces of the drum cavity in fetid otorrhoea. No modern author has ever reported such an occurrence, nor did I ever observe it. It is therefore permissible to express a doubt as to the accuracy of the observation, especially as deceptions caused by quick changes of reflexes of light in the depth of the canal may occur so easily.

The great variety of foreign bodies like *seeds of different fruits, kernels, stones, pebbles, glass beads, catkins, etc.,* which children put into their own or each other's ears are much more important to us. *They can easily be removed with the syringe* as long as they do not go beyond the place where the finger of the child is able to push them. As a rule they do not advance any further into the depth than the cartilaginous meatus.

The removal of a foreign body which has slipped into the bony meatus can be facilitated by pouring some oil into the ear which makes the walls more slippery. The syringing in this case has to be done with the patient lying on his back, his head overhanging, and the auricle pulled back sufficiently to straighten the meatus. The canula of the syringe must not fill out the entrance of the canal. In this position the posterior and upper wall of the meatus become the lower wall, and, together with the drum membrane, forms a continuous inclined plane over which the foreign body can slide out. The foreign bodies in children are generally round, so that the jet of the syringe rolls them out easily.

Syringing must be avoided when the foreign body has a concavity facing outward, so that the jet may be caught in it, as happens in little bone buttons of a lead pencil, so often found in the meatus. The removal of that kind of foreign bodies is easily accomplished with a very slender knee-shaped bent forceps. Spikate blossoms (catkins, etc.,) also are difficult to remove with the syringe and are more easily dislodged by a dull curette used like a lever, under the control of the speculum.

Some kernels swell when they become wet, like peas, beans, stones of the locust bean. This may occur when the walls of the canal were injured by means of instruments in previous attempts at removal, or if water entered into the canal. The foreign body, when it is soaked, fills out the aperture of the canal completely. The outside of such highy enlarged and partly softened kernels is often found scratched by instruments, and cannot be attacked from the walls of the meatus. Their center was formerely burned with the galvanocautery and in this way reduced. This method was justly discarded because serious reaction of the surroundings was often observed.

The *removal with instruments* is indicated also when there is a *perforation of the drum membrane,* as in that case the jet of the syringe loses its power.

Adults evade incompetent interference very soon, while children usually have to undergo a number of more or less awkward attempts at removal before they are brought to the otologist.

Remembering the form of the meatus as I described it to you (page 36), you will understand how easily a foreign body by means of instruments may be pushed over the isthmus at the inner end of the cartilaginous meatus, whence it falls into the much wider bony part, from where, if pushed further, it glides along the smooth inclining walls to the drum membrane. Now it is a matter of good luck. If the foreign body is too large to pass the aperture of the deeper part of the bony canal which again becomes narrower at its end, it becomes wedged in at this place, if persecuted by further energetical attempts at removal. If however it is small enough, it will be pushed into the drum cavity through the drum membrane which tears very easily.

I will cite only one example. A hollow glass bead had to be removed from the drum cavity in many small fragments. It arrived there in the manner just described and was then broken to pieces.

The *set of instruments* for the removal of foreign bodies, which are wedged in the depth of the meatus or were pushed through the torn drum membrane into the middle ear, consists of spoons, of a number of knee-shaped bent, very slender forceps with different curves, small dull, single and double hooks, sharp ones for soaked kernels, beans, peas, etc. The steel of the shank of these instruments is handled in such a manner in hardening, that the shank allows of bending (*Brethold*). You will see in fig. 45 a set of these instruments together with the very practical handle of *Burckhardt-Merian,* also the instruments for paracentesis, for extraction of the hammer, tenotomy of the tensor tympani muscle, etc.

A deep narcosis can never be dispensed with in removing foreign bodies from the auditory meatus of children.

Surgeons often did not stop in the drum cavity in their search for foreign bodies. We find the foreign body, if it is pushed still further, either wedged in the end of the bony part of the Eustachian tube or in the aditus ad antrum. *The luxation of the stirrup* is the greatest danger in all these manipulations, according to my experience. The suppuration of the middle ear which can not be avoided in such a case, will invade the labyrinth and from there the meninges. This is the explanation for a large number of deaths which occurred after forced attempts at extraction of foreign bodies. At the post-mortem of a case which I published in the Berl. klin. Wochenschr. 1880 No. 26, I found a seed of the locust bean which had been pushed *into the tube* where it was wedged in tightly and became the cause of death.

We do not succeed in removing a foreign body through the meatus, when it is pushed that far. The bony canal joins the bony Eustachian tube in a curve (compare fig. 5 page 9). We ought therefore to be able to insert our instruments in a direction from upwards and backwards. The detachment of the auricle from the rear for this purpose is an opera-

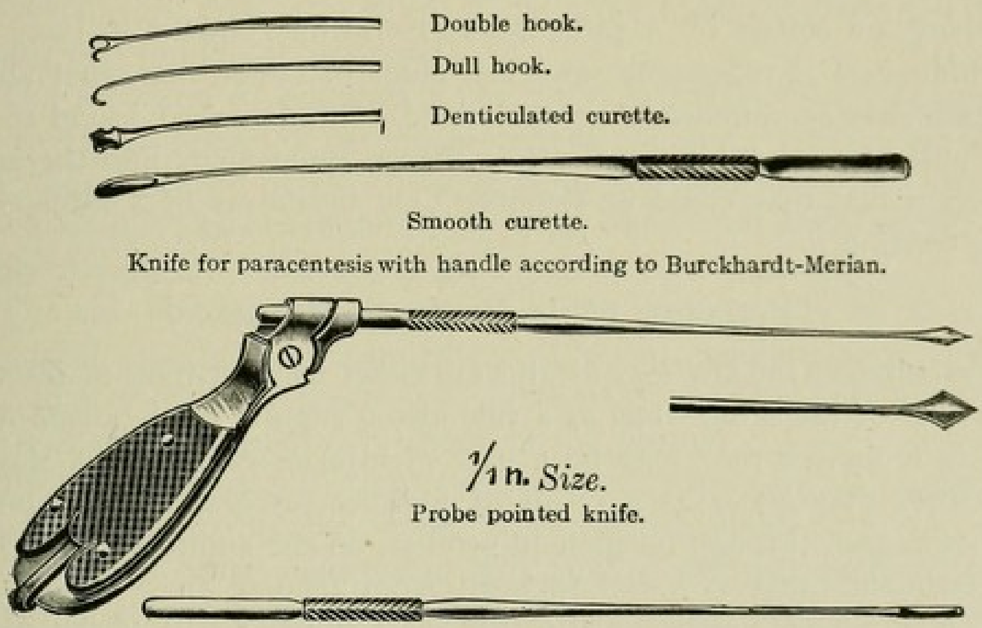

Fig. 45.

tion which was done long ago by *Paulus of Aegina.* We can get a very wide and straight avenue of access to the tube, especially in children, if we detach the posterior and upper circumference of the cartilaginous meatus from its attachment to the bony meatus. There were two instances for example only during the last year, where some doctors had pushed catkins into the tubes of two children. I removed them in the above described manner by means of slender forceps.

The detachment of the auricle however is not sufficient after the foreign body has entered into the *aditus ad antrum.* In this case, as in radical operation, we have to chisel away the whole posterior wall of the bony meatus.

Thus a cast of plaster of Paris which filled out the whole meatus had to be removed in this manner. It had been made unintentionally in the psychiatric part of the hospital while preparing a cast of the auricle, but the meatus not being sufficiently closed with cotton, the plaster filled it out entirely and there became hardened.

The atrocity of filling both ears of an intoxicated man with molten lead occurred some time ago. Such a cast is absolutely immovable in the meatus. I became convinced from experiments on a cadaver that the weight of the whole body may be lifted up by the part of the cast which fills out the concavity of the auricle without pulling the cast out of the meatus. The rear wall of the bony meatus must be chiseled away in such a case in order to remove the cast.

Plugs of cotton glided into the depth of the ear must finally be mentioned among the foreign bodies of the ear. They are not at all irrelevant in the cases where there is a perforation of the drum membrane, because, as foreign bodies, they cause and increase suppurations and decompositions. One sometimes sees fetid suppurations of the middle ear, even with serious cerebral symptoms disappear as if by magic, after removal of a plug of cotton or a piece of gauze, which found its way into the middle ear. I repeatedly saw such plugs of cotton like other abused foreign bodies surrounded by granulations. In one case I found several plugs pushed so tightly over the free margo tympanicus into the aditus ad antrum that they could be removed only by means of a forceps and strong traction.

Fractures of the Auditory Meatus.

Fractures of the auditory meatus are either continuations of fractures of the base of the skull, when as a rule also a rupture of the drum membrane is found, or they may be a part of injuries caused by a shot, or finally they may occur as a result of indirect force which acts on the lower jaw, and, through its glenoid process, on the auditory canal. The most frequent cause is a fall forward from a horse, or a horse's kick on the chin. They are confined to the anterior bony wall of the meatus and are either simple fissures or comminuted fractures. A rupture of the drum membrane is the exception, if this is the cause of the fracture.

The anterior wall of the meatus is formed, as you know, by a thin lamella of compact bone which has a larger or smaller physiological gap of ossification during the first few years of life. There is generally a hemorrhage from the ear, because the thin and tightly adherent lining of the bony canal tears. A small piece of bone sometimes becomes movable as on a hinge. One can later on recognize the line where a fissure took place from the terrace-shaped incline. I saw in a child six weeks after it received a kick on the chin from a horse's hoof, a growth which filled the whole depth of the meatus, after the removal of which, the drum membrane and the hearing distance were normal.

The therapy of fractures of the external meatus consists first in wiping away fresh blood clots with some cotton wrapped around a probe. The meatus is dusted with boric acid powder and closed with iodoform gauze. Syringing and instillations of fluids must be strictly prohibited. In complicated fractures of the meatus the lower jaw must be immobilized.

Obturation of the Meatus by Gathering of Ear Wax and Masses of Epidermis.

The occlusion of the auditory canal by ear wax, dust and cast-off epidermis belongs to the most frequent causes of deafness. In nearly 13 per cent of all ear patients whom I have seen, the disturbances of the function of hearing were caused in this simple manner.

Plugs of ear wax which close up the canal entirely are exceptions *in children.* Old people with flabby, slit-shaped entrances to the meatus are frequently affected. Complete hard casts of the bony meatus are found at this age. They may protrude into the cartilaginous meatus and interfere with hearing to such an extent that the patients are absolutely deaf for speech, especially when at the same time a certain amount of deafness due to old age is present.

The secretion of cerumen takes place in the cartilaginous meatus only, as far as there are ceruminal glands. It there forms a safeguard against the entrance of all kinds of damaging influences like the hairs in the meatus. The secretion is completely wanting in many people without any recognizable damage to the integrity of the ear.

The ear wax reaches the depth of the meatus only by unsuitable attempts at cleaning, by instillations of water, manipulations with the corner of a towel, instruments, etc. Otherwise it can not get further than the cartilaginous meatus nor gather in the depth.

Obturating *masses of epidermis* however may develop in the bony meatus where they may be found in two modifications.

Sometimes, what appeared to be a plug of ear wax syringed out of an elderly person's ear, can be unraveled into long *ribbons of epidermis* with fine crosswise folds. These peculiar ribbons, which I described years ago, lie in the bony canal rolled up like a snail, and their end is often attached to the innermost part of the upper wall of the canal. The most wonderful part of these ribbons is their length, which amounts often to *many times* that of the whole meatus. We draw the conclusions from this peculiarity of the ribbons *that the physiological production of the epidermis is a process of migration of the hornified layers which progresses slowly from the inside outward.* The largest production takes place in the region of the posterior upper wall of the meatus. We can study the same process in the gradual migration of extravasations of blood, or of dried up crusts of secretion, which, often starting from a small secreting spot of the drum membrane, may form regular ribbons which extend into the cartilaginous part of the meatus.

There is another much rarer form of gatherings of epidermis in the meatus. They are thick, white shells which are arranged in concentrical layers or irregularly crushed convolutions without any considerable amount of cerumen admixt with it. They may fill the whole bony meatus. The usually concentrical arrangement of these shells as compared with the rolled up ribbons, points to the fact that there must be some *disturbance* of the physiological growth of the lining of the meatus, because the most frequent and therefore physiological process of growth of the lining is the one which was first described. It is by gradual migration and casting off of the hornified epidermis outward, by which *automatic cleaning of the surface of the drum membrane and bony meatus is effected.* We often after the removal of these concentrical shells of cast off epidermis find a number of other changes, like excentric enlargement of the bony meatus, very pronounced cloudiness, anomalies of form of the drum membrane, sometimes with adhesions to the inner wall of the drum cavity. It must be considered highly probable that this abnormal production of epidermis emanates from old defects of the drum membrane which have healed by formation of scars. Pieces of the inner wall of the drum cavity which are also epidermized may have grown into these scars. The whole process was justly compared by some authors to the cholesteatoma of the middle ear. The center of these shell-like formations may by and by become decomposed to a putrid cheesy mass, the same condition that we observe in cholesteatoma of the middle ear.

The *removal* of plugs of cerumen and masses of epidermis is best started by instillations of some warm solution. We never know in advance whether the spaces of the middle ear are not layed open, in which case the entrance of water with germs of infection might cause suppuration. We use therefore a saturated warm solution of boric acid. The patient is instructed to let somebody fill his canal several times with the solution, and leave it there each time for 10 minutes. It is best for him to lie down on the side of the good ear and have the nurse pull back his auricle energetically (in order to enlarge the slit-shaped entrance). The patient in order to avoid unnecessary excitement must be warned that his deafness may increase considerably through enlargement of the plug when it becomes soaked, if there is a small space between the plug and the wall. A moderately strong jet of the syringe is generally sufficient to remove the masses after they have been soaked for one or two days. The canula of the syringe is pressed against the rear upper wall of the cartilaginous meatus and the jet is directed perpendicularly to the lateral plane of the face corresponding to the axis of the meatus. The removal of the concentrical masses of epidermis is sometimes more difficult, because their peripheral layers adhere tightly to their base. They must be made accessible to the jet of the syringe by repeated soakings with warm 1 to 2 per cent solutions of soda in water or salicylic acid in alcohol. The syringe must often be supported by the probe and forceps.

The meatus, after the drum membrane has become entirely clear, is carefully dried out down to the recessus meatus with a bent probe wrapped with cotton. An examination of the function of hearing is made and the canal is closed with a piece of dry cotton for one day.

LECTURE XIII.

Circumscribed Diseases of the External Meatus.

Otitis Externa Circumscripta (Furuncles, Abscesses).

Gentlemen:—The external meatus is the seat of predilection for furuncles, on account of the great number of glands and hairs, and still more on account of the many manipulations to which it is exposed.

In my statistics 3.3 per cent of all ear patients suffered from it. 89.3 per cent of them were *adults,* 10.7 per cent *children.*

The female sex is attacked by furunculosis oftener than male, contrary to what we notice in other inflammatory affections of the meatus.

I became convinced from many years' experience that furuncles develop exclusively in the *external* region of the meatus which *carries the hairs.* A number of other authors came to the same conclusion which, as we know, coincides with the pathogenesis of furuncles established by experiments. Manipulations on the part of the patients with their finger-nails instruments, etc., are as a rule the direct cause for their beginning.

Severe spontaneous pain and especially pain on pressure on the tragus and auricle is felt at the place of development of a furuncle sometime before the appearance of a slightly red local swelling. A collateral oedema often forms in a large area surrounding the ear during the development of big furuncles. Some glands in the fossa retromaxillaris may become enlarged and may be very sensitive to pressure. The oedema which shows on the mastoid process may be mistaken for a symptom of inflammatory disease in the bone, as long as the furuncle is not accurately localized. The great sensitiveness to pressure on the tragus and especially on the meatus from below indicates the starting point of the pain. Hearing which we find to be nearly normal when tested with a small ear funnel inserted into the canal in order to spread the slit between the swollen walls, excludes a disease of the middle ear.

Small furuncles may be absorbed without being opened. A pustula forms as a rule on the top of the furuncle, from which sometimes a comparatively large plug of pus is expelled. Microscopical examination shows that these plugs contain fresh leucocytes, conglomerations of more or less degenerated cells, masses or bacteria, hairs, here and there some ducts and tubules of glands, finally fibrin which surrounds the plug in dense strands and of which fine strands perforate it.

Sometimes *several* furuncles arise at the entrance of the meatus simultaneously or one soon after the other. Furunculosis was observed in 6 per cent of all cases *in both ears at the same time.*

A large amount of *fibrinous exudation* and *growths of granulation* may form on the surface of the pustule, if it is permitted to be constantly bathed in pus.

A flat spherical fluctuating *abscess* of considerable size may in rare cases develop at the entrance of the meatus.

Abscesses by gravitation emanating from furuncles of the meatus in some rare cases may appear below and also in front of the ear. The fluid discharges through the opening of the furuncle into the meatus if such abscesses are incised and rinsed out.

The *incision* of a furuncle, which is done with a sickle-shaped knife—is necessary very exceptionally only, since usually slight pressure with the ear funnel is sufficient to remove the semi-solid plug. The incision of a furuncle is very painful, and fainting of the patient is not rare. It is sustained more easily when a large abscess has formed.

The whole course of furuncles has become much more painless, since we avoid *moist* heat in treating them, nor do we see many recurrences. The formation of fibrinous exudations in the aperture of the meatus, the luxuriant growths of granulations, and the formation of abscesses by gravitation have not been observed since we avoided this form of treatment.

The *treatment* we have been using regularly for many years consists in the insertion of cylindrical plugs of very absorbent cotton (out of which the oil is completely extracted). These tampons are made by twisting the cotton tightly around a probe, dipping them into iodoform powder. They have to be renewed every day before and after incision of the furuncle.

The slight permanent compression seems to have a favorable effect on the pain. A few doses of morphine of one centigram each may sometimes become necessary during the first few days.

The principal advantage of this method of treatment seems to me to be the withholding of fluids in which, especially when moist heat is applied, exuberant development and new growth of bacteria in different spots takes place. The bacillus pyocyaneus for example has not been observed since we use these dry tampons.

The formation of secondary furuncles which occurred often in former times in connection with profuse otorrhoeas has become extemely rare since we treat otorrhoea with boric acid. They arise probably only from coarse external manipulations.

The Different Forms of Otitis Externa Diffusa.

2.4 per cent of all ear patients according to my statistics suffered from primary otitis externa diffusa. We call it primary, in that it is free from suppuration of the middle ear. Otomycosis and otitis externa crouposa, both of which will be described separately, are included in this figure. Of the above number 80.5 per cent were *adults,* 19.5 per cent *children.* In 70.5 per cent one ear, in 29.5 per cent both ears were affected.

This disease was formerly diagnosed very frequently especially by general practitioners. It became more and more rare in the statistics of otologists the more carefully the origin of the secretions, which were found in the external meatus, was investigated. A large number of suppurations of the middle ear are difficult to diagnose and may lead to such mistakes. Only a few of them may here be mentioned: Cases of otitis media purulenta acuta which soon after recovery caused a secondary otitis externa, or whose secretions still remained in the meatus. Furthermore suppurations of the middle ear in children of only a few years, in whom the drum membrane can not be completely examined, and in whom only the air douche according to *Politzer,* or movements of swallowing while syringing the ear, indicating that the fluid runs down the nose and throat, can give an intimation of the presence of a perforation of the drum membrane. Furthermore chronic suppurations of the middle ear in which the drum membrane is preserved, but has grown to the inner wall of the drum cavity in such manner that the margo tympanicus protrudes freely. Suppurations which are difficult to diagnose are especially those with defects of the membrana flaccida *Shrapnelli* which are overlooked so often and so easily, that their frequent occurrence was absolutely unknown even to otologists only three decades ago. Mistakes as to the origin of the secretions in otitis externa diffusa may finally be made when there are fistulas in the external meatus which either lead to spaces of the middle ear located very closely to the wall of the canal or from foci of suppuration in the surrounding soft tissues, abscesses by gravitation, below the mastoid process, suppurations of the parotid gland, etc.

It is well known that *secondary* otitis externa diffusa developes very frequently under the influence of a suppuration of the middle ear with perforation of the drum membrane. This occurs rather regularly if no treatment takes place and the secretions which remain in the meatus decompose. The lining epidermis of the bony meatus becomes macerated under the influence of the decomposed secretions and the surface becomes excoriated. Granulations will form if this condition lasts long enough, and if it is especially bad, that is if permanent warm applications and great uncleanliness persist, the whole surface of the meatus up into the concha may become covered with diphtheritic membranes, as seen sometimes in children who are brought in from the country. Permanent constrictions and atresia of the meatus may be the result.

All authors at present agree that *mucopurulent* secretions in the auditory canal originate in the middle ear, except in very rare cases of formation of granulations and polyps which may arise in the meatus itself, while the middle ear is intact.

The *genuine* otitis media diffusa, excluding even otomycosis and otitis externa crouposa is a disease of many different forms which probably depend upon the causes to which they owe their existence. This view was pronounced long ago by *v. Tröltsch.*

We sometimes find gatherings of very fetid masses of ear wax converted into a fluid, which from time to time reappear and fill out the depth of the meatus no matter how carefully we remove them and disinfect the whole space. In other cases we find only some serous secretions with increased new formation of epidermis. In others the walls of the meatus are so much swollen that they touch each other while not a drop of secretion may be found. Again ulcers may be seen which are always at the floor of the meatus, at its highest point, that is where the cartilaginous meatus passes over into the bony meatus. The bone in some cases is felt and seen lying bare to a large extent at the bottom of these ulcers. The ulcers are most probably provoked by continuous traumatic lesions. The patients are always very old people who repeatedly admitted having inflicted them. Sometimes serous secretions are found in the region of the external meatus where the glands are. They sometimes are purulent, as I became convinced in a case which I examined microscopically. In some of these rare cases the secretion may be seen appearing at the openings of the glandular ducts, whenever the auricle is rolled up and compressed.

Granulations in whose origin the middle ear does not participate, may form in the meatus when a foreign body with sharp corners is present, which somebody has tried to remove, or in connection with neglected furuncles.

A few very rare occurrences must here be mentioned, namely *pemphigus, condylomata lata* and other forms of luetic affections of the external meatus. *Herpes* is mainly seen on the auricle. The appearance of hemorrhagic blisters in the bony meatus proved always to be a part of an acute inflammation of the middle ear.

I saw four cases of necrosis of the os tympanicum where parts of this bone were expelled as sequestra.

The first case was that of a hereditarily syphilitic child of one year and three months. The sequestrum proved to be the whole annulus tympanicus which absolutely looked like that of a new-born. The necrosis must have taken place during the first weeks of life.

In another case I extracted a sequestrum from the meatus of a child of seven years which formed a part of the os tympanicum, and of which fig. 46 shows a front and rear view. You see clearly on its rear surface a part of the sulcus tympanicus. Nevertheless the drum membrane was found connected with the new formed bone, and whisper could be heard at a distance of three meters after the granulations which filled the meatus had disappeared.

Thermical and chemical besides mechanical influences must be named among the *causes* for the development of otitis externa diffusa, but espe-

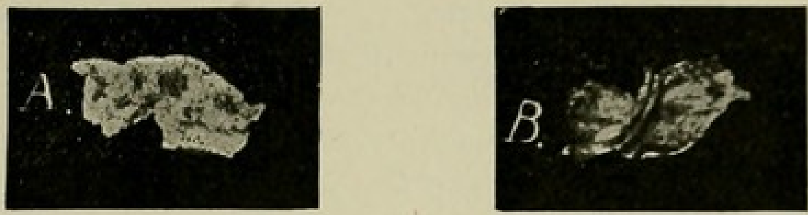

Fig. 46.

Sequestrum of the anterior wall of the meatus and a part of the tube.
a anterior surface, *b* post. surface containing the sulcus tympanicus.

cially the entrance of water into the meatus is most important, because, especially in children, it can be removed only very incompletely from the recessus. This is the reason why, in infants who are only a few weeks to a few months old, we not very rarely find an extremely fetid secretion from the ears in which the middle ear has no part whatsoever, but which is mainly caused by water and vernix caseosa which remained in the depth of the meatus. Most favorable for the development of otitis externa are: baths, local steam-baths of all kinds, warm moist applications, etc., as they all cause the epidermis to macerate.

The real causa efficiens in all different forms of this disease are micro-organisms, especially saprophytes. They play the same part in the propagation of a fetid secretion from the meatus as do the hyphomycetes in otomycosis.

The *treatment* of otitis externa diffusa is accordingly very simple. It consists in antiseptic injections, drying out the meatus very carefully down to the inner end of the recessus with a probe wrapped with cotton, and insufflation of dry boric powder, which absorbs the new formed secretions. The ulcers on the floor of the meatus are dusted with iodoform powder and the meatus is guarded against further manipulations. Luxuriant granulations are removed with the snare.

Otomycosis.

A form of otitis externa diffusa, the etiology of which has been very carefully investigated, is that form of inflammation which is caused by the development of a mould in the external meatus.

Moulds may develop under special circumstances in the caverns of a human lung, and in the organs of respiration of birds. In the same manner hyphomycetes may grow in the bony meatus and on the drum membrane, on whose surface it may spread over a large extent. Mould does not always cause inflammation as long as it is confined to the wall of the meatus. It does not cause any symptoms whatsoever in more than one-third of the cases according to my observations.

In all ear patients whom I saw during 24 years, I found the presence of mould in the bony meatus macroscopically and microscopically in no less than 0.7 per cent, including the numerous cases where there were no symptoms. Only 4 per cent of them were *children*. *Both ears* were affected in one-third of the patients.

The number of different forms of mould which grow in the meatus is pretty large. *Siebenmann* who re-examined my histories and specimens of former years found the genus aspergillus most frequently. They were aspergillus fumigatus and a. niger, less frequently a. nidulans and flavus,

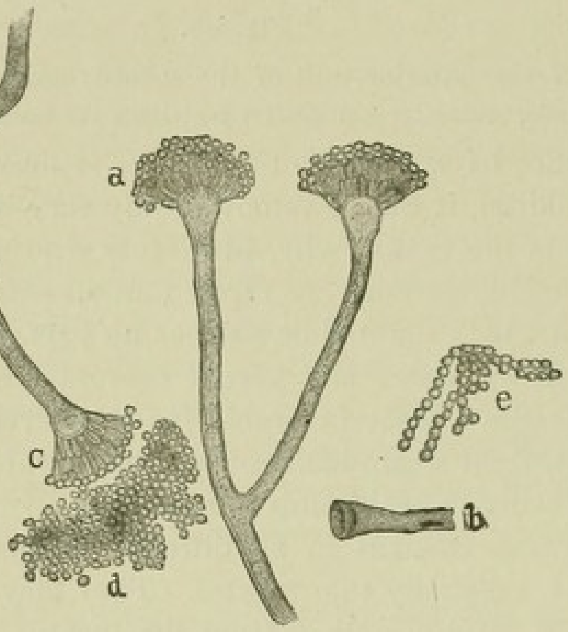

Fig. 47.
Aspergillus nidulans (according to *Siebenmann*).
a sporangiophore, *b* conidiophor with sunken top, *c* young sporangiophore, *d* and *e* free conidia.

more frequently verticillium Graphii which was pictured long ago by *Steudener* though under a different name, two cases with mucor and one case with penicillium are also mentioned.

The presence of the mould in the meatus can easily be discerned by examination with the ear speculum. Aspergillus fumigatus which is found most frequently in the meatus and usually does not cause any symptoms, forms a grayish green sod with its closely arranged little heads. Aspergillus niger and flavus have much larger black or yellow heads and form a very rich mycelium which usually fills out the bony meatus and covers the drum membrane. The verticillium is mostly enclosed in cheesy, grayish yellow masses of secretion and mucor in brownish masses.

Figures 47 to 49 give you elegant microscopical views of aspergillus, verticillium and mucor, as they are obtained from the meatus.

The meatus and the drum membrane were free from signs of inflammation in those cases which did not show any symptoms; proof enough for the fact that a dermatitis is not necessary for the growth of the fungi.

The formation of mould was never observed in cases of fresh suppurations.

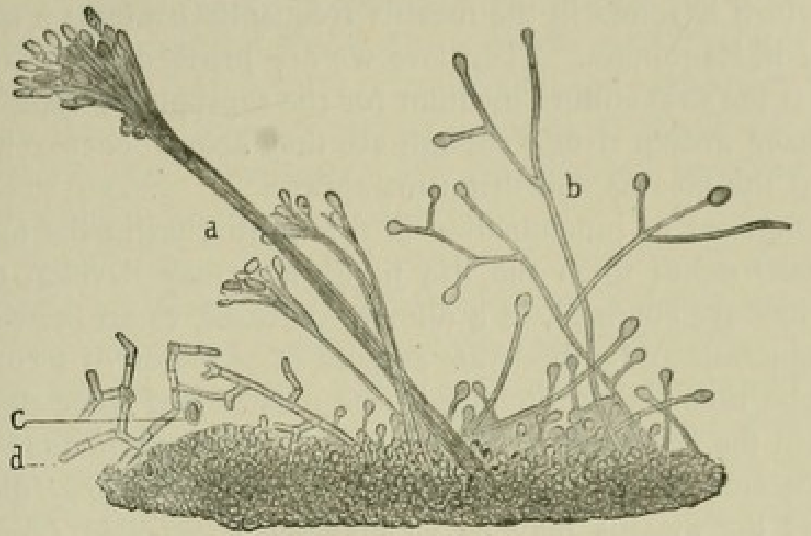

Fig. 48.

Verticillum Graphii (according to *Siebenmann*).

a formation of a trunk, *b* young conidiophore, *c* old spores, *d* old mycelia.

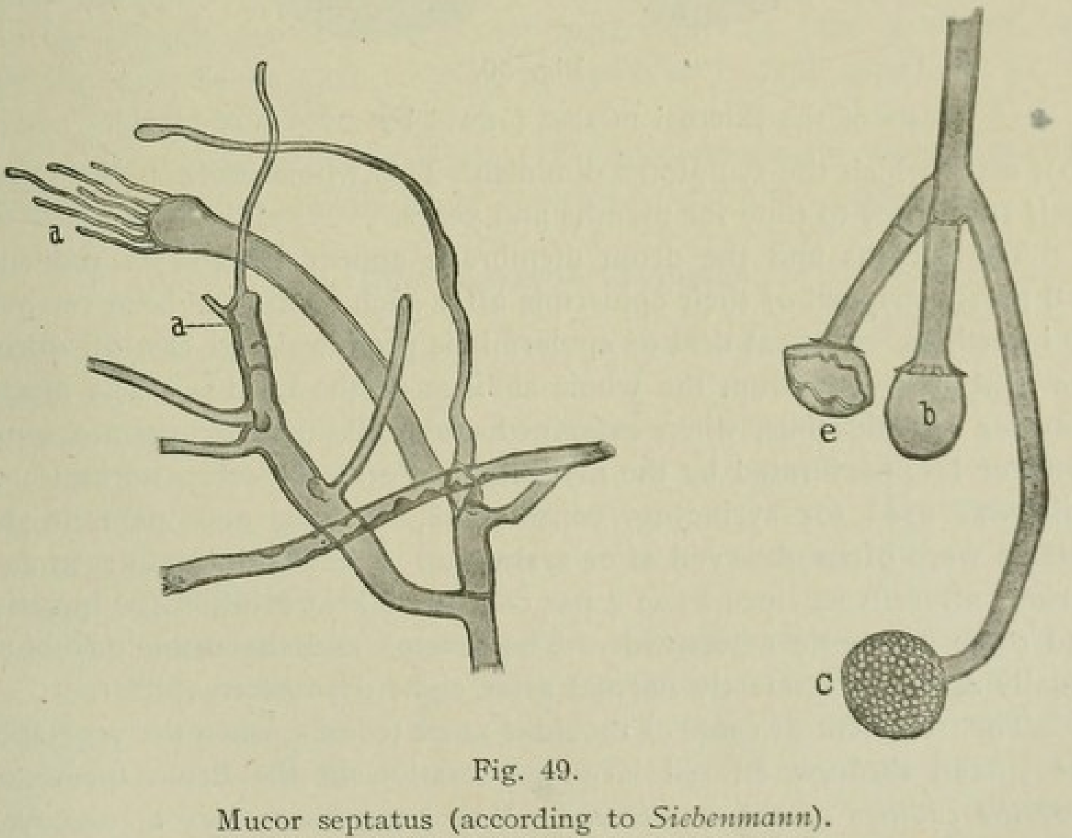

Fig. 49.

Mucor septatus (according to *Siebenmann*).

a formation of rhizoides, *b* columella, *c* sporangium, *e* open columella.

Some kind of culture medium however seems necessary for the growth of saprophytic fungi, according to my experience. Mould was found not very rarely on pieces of plants which people insert so frequently into the meatus for medicinal purposes, in other cases it located first on dry crusts. Most frequently, in *more than three-fourths of all cases which I observed, instillations of oil, glycerine or other fatty substances preceded the development of the mould.* The botanist *Harz* obtained a very luxuriant culture of aspergillus niger on lard. The mycelium which is found in the meatus frequently contains a great many drops of oil in its tubules. Therefore we are justified in the supposition that the oil is the first culture medium for the saprophytic fungi, and only after they have grown strong enough are they able to encroach upon the epidermis of the meatus and drum membrane.

The symptoms of inflammation in the meatus begin the moment the mycelium encroaches upon the life tissue and may develop to various degrees. They are confined, in a number of cases, to an increased exfoliation of epidermis and a moderate amount of secretion of serum. There is at the same time intense itching in the meatus and some deafness depending upon the occlusion of the canal. A moderate amount of pain is felt while the amount of secretions is increasing, finally large glove finger like casts of the meatus may be spontaneously expelled (compare fig.

Fig. 50.

Casts of the external meatus formed by mycelia of mould.

50), after which the symptoms diminish. This whole process may repeat itself from time to time for months and years.

The meatus and the drum membrane appear irregularly reddened and partly stripped of their epidermis after such a cast has been removed by injections. A great deal of epidermis is produced and cast off during the next few days from the whole surface of the meatus. The ejected lamellae of epidermis, when examined under the microscope, are found more or less perforated by the mycelium. Formerly, when no antiseptic fluid was used for syringing, considerable swelling and pain in the meatus were often observed after syringing. I have not again seen such serious aftereffects since I use 4 per cent boric acid solution for injection and some antiseptic afterwards. The meatus and the drum membrane usually appeared perfectly normal after eight days of treatment.

The treatment of cases of mould is more tedious, when the vegetation has spread through an old large perforation in the drum membrane *over the cavities of the middle ear.* New recurrences may appear from time to time for many months, notwithstanding the most careful continuous mechanical cleaning by means of the jet of the syringe and the use of remedies fatal to parasites. This is not surprising if we consider the secluded position and sinuosities of the infected cavities.

Not alone an otitis externa diffusa but an *acute perforative suppuration of the middle ear* was observed in some cases in which mould grew over the meatus and drum membrane. It is caused by threads of the mycelium growing into the drum membrane (*Politzer*). The mould does not seem to progress through the small perforation caused thereby in the drum membrane, on account of the profuse secretion, nor does it seem to spread into the cavities of the middle ear. Yet a profuse mucopurulent discharge may last for many weeks, and may under favorable circumstances lead to all the serious complications which are liable to develop in the disease. Fortunately all cases which I observed up to to-day recovered without further disturbance.

The *therapy* of otomycosis consists in careful mechanical removal of the mould by means of daily injections of warm 4 per cent solution of boric acid. We need furthermore the repeated action of some remedy which will kill the parasites, as the mycelium of the mould has partially penetrated into the living tissue. A 2 per cent solution of salicylic acid in alcohol has best answered the purpose. It is poured into the meatus not heated twice a day and left there for 10 minutes. At first considerable burning is felt which soon stops. In about a week recovery is usually complete, after the whole surface of the meatus has been repeatedly cast off.

Salicylated alcohol is generally well tolerated even when there is a large old perforation of the drum membrane, and the mucous membrane of the middle ear is replaced by epidermis. In case it should cause strong reaction we have to confine ourselves to daily injections of solutions of boric acid.

Otitis media purulenta acuta following otomycosis requires the same treatment as the genuine acute suppuration of the middle ear.

Otitis Externa Crouposa.

Otitis externa crouposa is a peculiar form of reaction caused by very different kinds of irritations which may act on the meatus and drum membrane. It therefore requires a summary discussion here.

It is characterized by the formation of a coagulated fibrinous exudation in the bony meatus and on the drum membrane. This process repeats itself several times in rapid succession accompanied by signs of violent local inflammation.

Thick semi-transparent membranes and often regular casts are formed in the bony meatus with accurate impressions of the tympanic membrane, accompanied by terrible pains which irradiate in the surroundings, while the walls of the canal are swollen and the temperature of the patient rises to moderate fever. This sometimes occurs in connection with other diseases of the external meatus, like furunculosis,

[1]) "Fibrinöses Exudat auf dem Trommelfell und im Gehörgang," by Bezold. Virchow's Arch. Vol. 70, 1877, and „Beobachtungen über Otitis externa crouposa," by Steinhoff Arbeiten, a. d. med klin. Instit. d. Univ. München, edited by V. Ziemsen & Bauer, Vol. II. 1. Half. 1890. (35 cases of my observation.

formation of hemorrhagic blisters in the meatus and drum membrane, otomycosis, cauterisation of the roots of polyps with argentum nitricum or liquor ferri sesquichlor. After trauma or application of dry heat, sometimes in the beginning of acute perforative or non-perforative inflammations of the middle ear, sometimes genuine, that is without any of the causes here enumerated. The formation of the pseudo-membranes repeats itself from two to five times at short intervals (usually every second day) while at the same time there is more or less discharge of serum, which, after the formation of casts has ceased, becomes purulent for a short while, when the process closes with quick recovery. The membranes and casts are very moist, semitransparent, of yellowish color and have a number of hemorrhagic red spots especially on the part which corresponded to the drum membrane. They shrink quickly and become opaque in air or in alcohol. They offer strong elastic resistance to teasing with needles, and are tough, which is contrary to what we know of epidermoid membranes. The membranes which are cast off first, when examined under the microscope, consist almost exclusively of a tender network of threads which show all the chemical reactions of coagulated fibrin. Those which are cast off later on contain more and more numerous pus corpuscles and epidermoid cells.

The removal of the membranes with the syringe or with a forceps is easy, but usually causes considerable pain for a short while. The auditory canal and epecially the surface of the drum membrane are afterwards found covered with extravasations of blood and even large hemorrhagic blisters and are partially excoriated. The removal of the membranes is sometimes followed by considerable swelling, so that the meatus becomes a narrow slit, after which the pains decrease and increase again when a new membrane is formed. The formation and casting off of a large amount of epidermis is noticed toward the end of the disease.

During the height of inflammation *hearing* is considerably diminished, also in those forms which are apparently genuine, it becomes normal when all is over. The *duration* of the disease is rarely longer than two or three weeks.

As to the frequency of its occurrence, I saw otitis externa crouposa in 0.5 per cent of all ear patients which I treated up to 1892; 85 per cent of them were *adults,* 15 per cent *children* below 15 years. The affection was noticed in both ears in 8.6 per cent. It occurs most frequently in spring like croupous pneumonia (according to v. Ziemssen).

The formation of croupous exudations in the meatus as a part of otitis is noticed much more frequently at times when there is an epidemic appearance of influenza otitis.

There is a very remarkable fact that otitis externa crouposa became successively rarer within the last decades, and I have not seen such voluminous casts within the last few years as formerly. It is possible that this is the effect of a more severe antisepsis, which was unknown in the beginning of my practice, but the gradual disappearance of the disease may as well be the expression of a change of the "genius epidemicus" since diphtheria also has accepted a milder character.

The formation of a fibrinous exudation on the surface of the meatus and drum membrane is of general nosological interest, because it is the only locality where, probably on account of its exceptional thinness and the superficial position of its blood vessels, the *cutis* is able to produce fibrin, similarly to the mucous membranes and serous membranes.

It is very probable that in the quick formation of an uninterrupted, thick layer of fibrin we can recognize a *means of protection* by enclosing infectious germs and keeping them away from the living tissues.

A few cultures were made which once showed the staphylococcus pyogenes aureus and once bacillus pyocyaneus which was also frequently found by other authors. I am doubtful, however, whether the latter is really the cause of the disease as I often saw the characteristic bluish color of the epidermis of the meatus in preantiseptic times, *without* the formation of a croupous exudation.

The therapy of otitis externa crouposa consists in careful removal of the membranes and fluid secretions by means of injections with boric acid solutions, and, after the meatus is carefully dried out, insufflations of boric acid or iodoform powder. The very violent pains and the other symptoms of inflammation at the height of the process require continuous application of the ice bag and daily doses of morphine. Air douche by means of *Politzer's* method or through the catheter are used in our clinic from the beginning, whenever there is an acute inflammation of the middle ear at the same time.

Otolithiasis.

Concretions of chalk in the external meatus are very rare. I saw them only twice.[1] The drum membrane and the meatus in my two cases were found intact, while in those few observations which are on record[2] there was at the same time a chronic inflammation of the middle ear.

In some cases there were old plugs of cotton in which hard concretions of chalk had formed; in my two cases they were found enclosed in thick layers of epidermis, the center of which was a cheesy mass. It seems probable that a special kind of bacteria plays the part of a go-between in their exceptional occurrence in the meatus on account of the presence of a great many cocci in form of zoogleamasses, as in the formation of tartar on the teeth, or concretions in the tear ducts and rhinoliths.

There was fetid secretion in the meatus in both of my cases. A cone-shaped growth had formed in the meatus of my second patient in

[1]) „Lithiasis des äusseren Gehörgangs" v. Bezold. IV. Congres internat. d'otolog. Bruxelles 1888.

[2]) Kretschmann, Verhandl. d. Deutsch. Otol. Gesellschaft in Wiesbaden 1903, page 57.

consequence of the irritation caused by the sharp corners and edges of the foreign body and of the frequent manipulations of the patient. A number of very irregular hard particles up to half a centimeter in length were removed in both of my cases, partly by means of the syringe, partly by the spoon and forceps. They looked very much like carious bone as to color and roughness, and also as to their perforated and trabeculated surface. A copious development of gas on adding muriatic acid under the microscope showed that they consisted partly of chalk.

The great similarity of the otoliths with sequestra of spongy bone might very easily cause them to be mistaken for caries necrotica of the temporal bone, especially if there is at the same time an extensive destruction of the drum membrane.

LECTURE XIV.

Diseases of the Drum Membrane.

General Part.

Gentlemen:—Only the smallest number of diseases of the drum membrane are confined exclusively to this membrane. The great majority constitute either a part of diseases of the meatus as we saw in describing the different forms of otitis externa diffusa, or, which is still more frequent, the visible changes of the tympanic membrane are simply that part of the diseases of the drum cavity and its adnexa, which is accessible to our eye.

Myringitis acuta and chronica which are usually differentiated in text-books as independent diseases, can only be separated incompletely from otitis media acuta and chronica in the way of differential diagnosis. They are represented therefore in the otological statistics in variable numbers which are mostly so small that I think it is preferable not to separate them from inflammations of the middle ear.

The so-called *acute myringitis* especially in influenza otitis often has in the beginning the characteristical appearance of a fresh inflammation of the drum membrane. Later on in the course of the disease the symptoms of a simultaneous affection of the middle ear, like deafness and secretion in the drum cavity, appear, although it is true that they are sometimes slight and pass over quickly.

Growths on the surface of the drum membrane were formerly considered.characteristical for *chronic myringitis*. They occur in the great majority of cases in connection with large perforations of the drum membrane, the margins of which, during the process of healing, have become partially adherent to the granulating surface of the promontory.

For these two reasons I prefer to desist from describing an independent myringitis acuta and chronica.

Deposits of chalk in the drum-membrane and *retractions* without considerable diminishing of the power of hearing must be ascribed to previous suppurations of the middle ear or previous affections of the Eustachian tubes respectively.

We refer to the chapter on congenital atresia of the meatus and rudimentary auricle as to congenital aplasia of the drum membrane.

Traumatic Rupture of the Drum Membrane.

Traumatic ruptures of the tympanum were found in 0.5 per cent of all ear patients whom I saw. Other authors recorded more, up to 2 per cent.

It is surprising that injuries of the membrane are not more frequent considering its delicacy, its exposed position in an open canal which is comparatively short and wide in the human, compared to that of mammals. The resistency of its unelastic fibres compared to the thinness of the membrane is considerable (*Schmiedekam*). Tears in the membrane caused by sudden changes of air pressure occur much more easily in large scars than in the normal membrane.

It is comparatively well guarded against direct injuries by the tragus, the antitragus and the antihelix which are able to ward off the thrusts of pointed objects, like branches of trees, blades of straw, etc., on the other hand by the zig-zag shaped course of the meatus itself which will divert the direction of the thrust away from the axis of the meatus and thereby away from the tympanum. The tragus especially is situated like a valve before the entrance of the meatus. Injuries are therefore seldom caused by falls or blows of the head against some pointed object, according to my experience.

Direct injuries to the drum membrane are much more frequently caused by unreasonable digging with pen-holders, matches, hair-pins, the temples of spectacles, etc. Extensive tearing of the membrane in this manner is not at all rare. It is necessary to warn the patient against using any instruments, especially in cases of *pruritus meatus,* from which so many people suffer.

The most incredible things can be seen. A patient came to see me on account of hemorrhages from the meatus. He had torn away the whole posterior half of the drum membrane from its attachment to the periphery with a temple of his spectacles the evening before. Another case is on record where a man extricated the anvil in scratching the ear with a hair pin.

Every otologist sees a certain number of ruptures of the drum membrane caused by awkward attempts at extraction of foreign bodies which had lodged in the meatus. It is fortunate if no other damage has been done in the drum cavity.

A simple thrust with a long pointed object, a hat pin, etc., into the depth of the meatus very exceptionally causes injuries in the drum cavity, tegmen tympani or oval window. The round window, as we saw, is protected by its hidden position. Abundant discharge of fluid following directly after the injury, points to the occurrence of such an accident.

The compilations of *Passow,* with which my observations concur, showed that the ruptures of the front half of the membrane occur equally as often as those of the rear half as a consequence of *direct* injuries.

Indirect ruptures of the membrane, i. e., ruptures as effects of some injurious power at a distance are much more frequent than from direct thrusts of some pointed object. A relatively moderate sudden compression or rarefaction of the air in the meatus is sufficient to burst the tympanic membrane. The greatest number of ruptures are therefore due to slaps on the ear, furthermore diving into water, hitting of trap-doors against the side of the head. Sudden rarefaction of the air in the meatus compared to that in the middle ear, caused for instance by kisses on the ear, or air-douches through the tube may cause ruptures, though only in cases of scars, which have not the same power of resistance as a normal membrane. Furthermore a number of ruptures are caused by explosions. Gun shots and cannon shots can produce ruptures only when the ear is on the side of the direction of the shot. The small mortars which are often used to fire salutes on festival occasions seem to be especially dangerous to the drum membrane, as I repeatedly saw *multiple* ruptures of *both* membranes in people who stood close by, in shooting. Ruptures were furthermore observed after strokes of lightning (*Búrkner*). There is no sufficient explanation for the rupture of the drum membrane which was often observed in people who came to death by hanging.

Indirect ruptures, according to the experience of all authors (*Passow*) are located the most frequently, in more than one-third of all cases, in the anterior lower quadrant of the drum membrane. The explanation for this fact is found in the stable position of the axis of the meatus; the anterior lower quadrant, especially the region of the triangular reflex, is the only spot on which the impact of the compressed air bounds in a *perpendicular* direction. The opening is therefore frequently in the reflex itself. The numerous exceptions to this rule are explained by the fact that pathologic membranes with extensive scars and atrophic parts in different quadrants will tear much more easily than normal membranes.

The appearance of fresh ruptures is very characteristical and can easily be differentiated from that of spontaneous perforations and destructions caused by suppurations of the middle ear. In the latter case the perforation is round or kidney-shaped, in ruptures it is irregularly torn or lancet shaped, with sharp margins which usually show several extravasations of blood, if the rupture did not take place in a scar containing very few blood vessels. The mucous membrane of the drum cavity which is seen through the rupture is yellow, like a bone, not swollen or red. Only the vessels of the handle of the mallet may be injected, the whole remainder of the membrane looks normal. A whistling, shrill noise of perforation can be heard when *Valsalva's* test is made in cases where a perforation is due to a suppuration which still may exist or have passed. A low blowing sound which can be heard with the auscultation tube only, is characteristic of a traumatic rupture.

The most important *subjective symptom* in ruptures is very violent pain which is usually felt only in direct ruptures at the moment of their formation, and must probably be ascribed to the simultaneous extensive touching of the walls of the bony canal which are very sensitive. It can be entirely absent if the latter is not touched. In indirect ruptures there is usually no pain. The patients only complain about a feeling of dullness in the ear. Permanent noise in the ear exists often, rarely however dizziness and vomiting. The subjective noises in rupture after explosions are stronger, which must probably be attributed more to the simultaneous affection of Corti's organ by the detonation than to the lesion of the sound conducting apparatus. A high singing noise may remain for a long time together with a hyperesthesia for the same sound.

Hearing for whisper is more or less diminished in the beginning. In 13 patients whose hearing became normal later on (Nother's[1]) it had been from 15 centimeters to four and one-half meters soon after the injury.

The result of the *tuning-fork tests* is very characteristic and of great physiologic interest.

More than an octave, from 12 v. d. to 32 v. d. and more, at the lower limit of the sound scale is always completely lost to hearing by air conduction, while hearing by bone conduction for this part of the scale and for all forks of higher pitch, as high as they can be used for examinations of bone conduction, is much prolonged throughout. *Rinne's* test, on account of this preponderance of bone conduction, is either very much shortened positive, or else it is negative, and in *Weber*'s test the fork is heard in the injured ear.

All these phenomena are found in all ruptures of the drum membrane including those which occurred without any large amount of violence. They disappeared again when the rupture was closed. They give us therefore the experimental proof that they, together with the simultaneous diminishing of hearing for whisper are exclusively dependent upon the disturbance of equilibrium of the sound conducting apparatus. The traction of the tensor tympani muscle overbalances its antagonists (the stapedius muscle and the circular fibres of the drum membrane) on account of the tearing apart of a number of the radiar fibres of the drum membrane, and the whole apparatus becomes one-sided and fixed. (The same functional disturbances are observed in otherwise normal ears when the tensor tympani muscle is wilfully contracted, which some people are able to do.)

Recovery from ruptures of the drum membrane, caused by compression of air in the meatus or explosion, always takes place without interfering suppuration if all damaging influences from the outside are kept away. It is usually completed within a few weeks, when the opening is

1) Zeitschrift f. Ohrenhlk. XXIII. page 19.

closed and normal hearing has been restored. Closing of the opening does not take place if the perforation is very extensive and if it occurred in very large scars.

Suppuration of the middle ear is more frequently observed in connection with direct ruptures of the membrane by means of some sharp pointed object. The germs of infection are carried into the drum cavity by the foreign body, while they are absent in indirect ruptures.

These facts, which are gained by observation, indicate our *therapy* in direct and indirect ruptures of the tympanic membrane. To keep away everything injurious which might penetrate from the outside through the opening into the drum cavity must be our exclusive object. Touching of the rent must be avoided. Extravasations of blood remain untouched around the opening and we can later on watch their excentrical migration, which corresponds to the growth of the cutis in the meatus (compare page 109) towards the periphery of the drum membrane, and from there to the wall of the meatus. A very loose ball of cotton which fills the cartilaginous meatus and is retained by the elasticity of its fibres only, affords, according to our experience, a sufficient safeguard against infection as long as the drum cavity is open. I never saw any damage arising from air douche. Nevertheless it is better to avoid it as it does not furnish any advantage, as long as the drum cavity is free from secretions. The penetration of fluids into the middle ear is absolutely harmful. The use of the syringe and instillations are to be avoided and the patients warned to be careful in washing and bathing. The treatment has to be the same as in the genuine otitis media purulenta acuta whenever suppuration has set in, as often happens in direct injuries. An injection may become directly dangerous to life when there is a flow of serum after an injury with some pointed object.

The ruptures of the drum membrane which are observed after a *trauma to the surface of the skull* like a fall or a blow on the head require separate discussion. They occur by transmission of power and are therefore counted among the indirect ruptures.

A tear in the center of the tympanic membrane may be produced by a sudden shock on the skull without any other injury. I saw a large oval opening which had freshly occurred after a fall on the occiput from a street car.

The rupture of the drum membrane is a part of the *fracture of the bones on the base of the skull* in the largest number of cases of similar injuries.

The tear is usually a continuation of a fracture of the periphery and in most cases is located on top. Lesions of the sound-conducting apparatus, like luxation in the joint between the hammer and the anvil, which I had a chance to see on the cadaver, occur sometimes in such cases. Continuations of such fractures through the tegmen tympani and the temporal bone are still more important. A fracture through the temporal bone injures also the labyrinth, since according to *Scheibe,* the line of fracture usually follows the cavities in the bone. Serious *symptoms of commotion* of the brain, like *long lasting unconsciousness, vomiting, terrible dizziness* after awakening, usually indicate the great extent of the injury. Hemorrhage may occur from the ear, or sometimes, according to the course of the fracture from the nose and mouth. Discharge of liquor cerebrospinalis is noticed in rare cases.

The result of the tests of the function will indicate whether or not the injury has extended to the sound-conducting apparatus or to the labyrinth. A very pronounced restriction of the lower limit by air conduction, together with an increase of bone conduction, inform us that the injury is confined to the drum membrane and the chain of ossicles. Bone conduction on the other hand is shortened in commotion of Corti's organ, and we find the signs of complete deafness in one ear, which will be discussed in the chapter on necrosis of the labyrinth, whenever a fissure goes through the labyrinth.

The penetration of anything which may be harmful has to be avoided much more carefully, when such serious complications are present than even in ruptures of a drum membrane. Instillations of fluid or syringing will find all doors open to produce panotitis and in connection with it fetal meningitis.

Scalding and Destruction of the Drum Membrane by Various Chemicals.

Scalding of the drum membrane occurs very easily when hot water is spilled over the side of a person's head.

There was great discrepancy in all cases of this kind which I saw, there were but few traces of scalding on the walls of the meatus, the auricle and its surroundings, while there was extensive destruction of the drum membrane. After a few days one could see but slight traces of the scalding on the first named places, while the drum membrane was nearly completely destroyed. A large perforation, the shape of a horseshoe had formed leaving nothing but some of the thicker parts, the limbus and the handle of the hammer with a small remainder at the upper part of the membrane. A yellow piece of shriveled up tissue hung from the lower end of the isolated handle of the hammer, and was expelled during the next few days.

There is a very simple physical explanation for this weak power of resistance of the drum membrane against heat. It is due partly to its being thin and partly to the nature of the medium on its inner surface, namely, the air, to which a difference of temperature cannot be transmitted as quickly as if there were some solid body as in the cutis of the meatus.

A few days after the scalding there is abundant purulent secretion from the drum cavity whose mucous membrane appears diffusely reddened or much swollen.

It seems that the cells which are further distant do not take part in the process, if treatment begins in time, under which condition the discharge stops in a few weeks. The opening in the drum membrane diminishes during the same time and becomes rounder. In one case I saw it even closed for some time. Later on, when the margins become definitely epidermized, the hole becomes a little larger again.

The disturbance of hearing which is considerable, corresponding to the swelling of the mucous membrane and the size of the opening, disappears to a great extent, and remains in accordance with the size of the opening.

Destruction of the drum membrane happened many times when bottles containing acids or alkali, like hydrochloric acid or caustic ammonia, were mistaken for ear drops and poured into the meatus.

The effect of these chemicals is not confined to the drum membrane like that of hot fluids, but extends into the cavities of the middle ear. In some cases which I saw only a long time after the mishap, suppuration had lasted for years. The drum membrane was nearly destroyed, the mucous membrane was granulating; there was great loss of the power of hearing.

Four cases of terrible destruction of the membrane or middle ear by chemicals poured into the meatus were recorded from Warsovie within the last few years (by *Jürgens*[1]). They concerned young men who poured concentrated muriatic acid into the meatus in order to make themselves unfit for military service. In all cases there was necrosis of the deeper parts of the meatus, and extensive necrotic destruction of the walls of the middle car. The wall of the carotid artery was destroyed to a great extent in three cases which caused repeated severe hemorrhage from the ear, nose and mouth. Two patients soon died from meningitis, the third one bled to death. In the last case there was paralysis of the facial nerve. There was a hemorrhage from the bulb of the jugular vein in the fourth case connected with symptoms of pyemia. The hemorrhage could be stopped in this case by means of tamponade of the meatus.

1) Monatsschr. f. Ohrh., 1902, Nos. 1 and 4, as also 1904, No. 10.

LECTURE XV.

Diseases of the Middle Ear.

General Part and Introduction.

Gentlemen:—The extensive and complicated cavities of the middle ear are the most frequent location for diseases of the organ of hearing. My otological statistics which extend over 24 years show that **66.1** per cent of all patients whom I saw during this time suffered from affections of the middle ear.

This large percentage of diseases in this region closely coïncides with all the recent otological statistics and finds its explanation on one hand in the wide port of entrance to the cavities through the tube, on the other hand in the frequent, almost regular participation of its tender linings in general infectious diseases, especially the acute exanthemata of childhood. Extensive and permanent destructions which curtail its function and even involve a constant menace to the whole organism, develop more easily and more frequently in the ear than in any other organ of the body in the course of those diseases.

There is no agreement amongst authors as to the classification and nomenclature of diseases of the middle ear.

All inflammations of the middle ear were called catarrhal in former years. Even in *v. Tröltsch's* books one finds besides an acute and a chronic suppurative catarrh, an acute and chronic otitis media.

As the lining membrane of the cavities of the middle ear is a direct continuation of the mucous membrane of the pharynx, it was also called a mucous membrane. This name is in keeping with the cartilaginous tube where the lining is thick and has many folds, is covered with several layers of ciliated epithelium, has many acinous glands and includes a direct continuation of the adenoid tissue of the naso-pharynx. The character of the lining however changes in the bony part of the tube. In the upper part of the cartilaginous tube the folds disappear and are absent in the bony part, where a fusion of the membrane with the periosteum, and a disappearance of the glands takes place. There are no glands in the drum cavity nor in any of the other cavities of the middle ear. Ciliated epithelium is found only at the floor of the drum cavity, where it is a continuation of that of the bony tube, and has one layer. On the sides it becomes lower and lower in all directions until it changes into one layer of very delicate pavement epithelium, which covers the inside of the drum membrane, the ossicles, the promontorial wall as well as all pneumatic cells of the temporal bone. The very thin and delicate lining is united everywhere with the periosteum. *Kessel,* who examined the pavement epithelium of the drum cavity, found that it has stomata which communicate with the system of lymph vessels and has an endothelial character. *Kessel* calls the lining of the drum cavity an "organ of secretion and movement" in so far as it has ciliated epithelium whose direction of movement is towards the tube, and an "organ of absorption" where it is simple pavement epithelium[1].

This way of looking at the histological findings coincides with our clinical experience. It shows that we have to ascribe a great power of absorption to the lining of the middle ear and also a great recuperative power, as we shall see later on in describing acute otitis media in the course of the exanthemata in children.

One word as to the *normal secretion* of the lining of the middle ear. It is only in the cartilaginous tube that we expect to find viscid mucus. The osseous tube, the drum cavity, and all the other cavities do not normally produce any mucus, but their walls are slightly moistened with serum.

The formation *of pathological secretions* takes a different course than in mucous membranes. A clear transudation almost without admixture of formed elements is found in the middle ear, whenever the air is shut out for some time (compare occlusion of the tubes with gathering of serum). We find on the other hand, when germs of infection are present, at first serous or sometimes sero-sanguinolent secretion which soon becomes profuse and purulent, later on, after the most acute stage has passed, muco-purulent, and exclusively mucous only towards the end. These are different, even reversed conditions from those which we find in catarrh of the mucous membranes, where the sputum crudum of the old practitioners precedes the sputum coctum.

The difference of the lining of the middle ear from a mucous membrane also becomes evident from other facts. There are numerous germs of infection constantly present in the mouth, in the entrance of the nose and in the pharynx, which become infectious as we suppose only after especially harmful influences have gained access, while the drum cavity and the other spaces of the middle ear must be considered free from germs, according to *Zaufal.* The penetration of fluid through the tube or through a perforation of the drum membrane is sufficient to cause a more or less violent exudative inflammation.

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1) Handbuch d. Ohrenheilk. V. Schwartze; Vol. I., page 75.

Finally in our post-mortem examinations of the ear we find different pathologic anatomical changes in the cartilaginous part of the tube from those in the bony part. The pharyngeal part of the tube participates in the changes of the naso-pharynx which disappear towards the isthmus, while, in inflammations of the drum cavity we find the same changes in the bony tube as in the drum cavity itself (succulency, injection, etc). The cartilaginous tube remains free. The isthmus of the tube forms in a certain measure the limit for different forms of diseases which locate on either one side or on the other. Diseases of mucous membranes are on one side; diseases which are peculiar to serous membranes are on the other.

These are the reasons why the word "catarrh" for different diseases of the spaces of the middle ear complicated matters rather than cleared them up, and I shall try therefore to give you a classification of diseases of the middle ear which avoids this expression altogether.

We shall see that just that form of disease whose symptoms even to-day are generally considered most characteristic for catarrhal affections of the middle ear, I speak of the symptoms of occlusion of the Eustachian tube, has really nothing to do with catarrh nor with inflammation. It is true that occlusion of the tube may be caused by catarrhal swelling and secretion in the cartilaginous tube, but this is only *one* cause, and, if isolated, not even a frequent cause of occlusion.

The changes of the drum membrane and of the function of hearing, etc., which are characteristic of uncomplicated occlusion of the tube pure and simple, are much more frequently caused by mechanical conditions like enlargement of the pharyngeal tonsil, of the rear ends of the turbinals, of the faucial tonsils, etc., or by scars and atresia in the tube. These changes are brought on by a physical physiological process which we can understand very well, and shall discuss later on. They may exist alone for a long time in the ear.

In classifying the diseases of the middle ear, we must therefore first set apart pure *uncomplicated occlusion of the tube,* as an independent disease which may be observed alone without any other disease being present at the same time. We prefer to avoid the expression "catarrh of the tubes," which was used up to the present, for reasons that were given above.

There are other *inflammatory processes* in the middle ear of extremely varying intensity, partly in connection with long lasting occlusion of the tubes, partly independent from it, which are all caused by immigration of germs of infection either from the outside or with the blood.

A classification of the diseases of the middle ear based on the different species of bacilli and cocci which cause them, can not be carried out, because, with the exception of the tubercle bacillus, they all may provoke symptoms of inflammation which are quite similar in quality and may vary in the same species from the mildest to the most severe.

The only remaining principle of a classification is the different clinical and pathologic anatomical appearance.

We differentiate two main groups, *otitis media simplex or non perforativa,* and *otitis media purulenta* or *suppurativa,* or *perforativa.* In the first group there is *no* perforation and discharge of secretion to the outside, in the second, the inflammatory secretions are formed in the middle ear have caused a perforation and discharge either through the drum membrane or through some other part of the walls of the middle ear.

This establishes a division which can easily be carried out for statistical purposes, and is at the same time important in the clinical picture of the diseases, our prognosis and our therapy, for with the occurrence or presence of a perforation all the spaces of the middle ear are accessible to new harmful influences from the outside.

Considering the course of the diseases we subdivide them into *otitis media simplex acuta, subacuta* and *otitis media simplex chronica;* in the same manner *otitis media purulenta acuta, and otitis media purulenta chronica.*

We designate as *residues* of otitis media purulenta with *permanent* perforation those cases in which a suppuration of the middle ear has run its course and left a dry perforation; residues with closed opening are those, where only a scar is left of a past suppuration.

There is finally a chronic disease of the sound-conducting apparatus in which *no secretion* is produced. It is characterized by a chronic process in the bony capsule of the labyrinth which leads to fixation of the plate of the stapes. This disease was formerly called "dry catarrh of the middle ear" and is now named otosclerosis.

The usefulness of these view-points will be thrown into bold relief during the special discussion of the different main groups of diseases of the middle ear which are:

(1) Occlusion of the tubes and its physiological consequences.

(2) Otitis media simplex acuta and subacuta.

(3) Otitis media simplex chronica.

(4) Otitis media purulenta acuta.

(5) Otitis media purulenta chronica.

(6) Residues of otitis media purulenta with permanent perforation.

(7) Residues of otitis media purulenta with closed perforation.

(8) Otosclerosis.

All the different sequelae as also other pathological phenomena will naturally fall into one of these eight main groups.

Occlusion of the Tubes. Its Causes in Diseases of the Nose and the Naso-Pharynx. Treatment.

There were 8.2 per cent of all ear patients who suffered from this cause of deafness which is subdivided into simple occlusion of the tubes, occlusion of the tubes with gathering of serum in the spaces of the middle ear, and occlusion of the tubes followed by atrophy of the drum membrane.

Children are not represented with nearly as high a percentage in any other disease of the middle ear, they amount to 55.7 per cent of all affections of the tubes which I observed. My statistics show that children furnish only 41.4 per cent of the patients with acute suppurations of the middle ear, which, as consequences of acute exanthemata of children, are so extremely frequent at that period of life. The frequency of affections of the tubes in children became very evident in my examination of school children; 27.8 per cent of all children who were found to be deaf, showed signs on the drum membrane which had to be ascribed to occlusion of the tubes.

Later on in life exclusive affections of the tubes become more and more rare and in very old people they are observed only exceptionally.

There is another very interesting fact established by statistics. The large majority of affections of the tubes concern *both ears* (77.0 per cent according to my statistical examination).

We make it our first task to find *the causes for occlusion* of the tubes, and why it is so frequent in the young, and why mostly in both ears.

There are children who suffer from occlusion of the tubes every time they have catarrh of the nose, or angina; still inspection of the naso-pharynx does not reveal sufficient explanation for this disposition. We may take for granted that the layer of adenoid tissue, contained abundantly in the mucous membrane of the cartilaginous tube of children, where in some cases it even has a follicular arrangement, (tubal tonsil *Gerlach*) became especially well developed. Those children are not necessarily of a scrofulous appearance, on the contrary many of them are in blooming health.

We were wrong in suspecting in the adenoid tissue a frequent location of tuberculosis. Systematic examinations of the pharyngeal and faucial tonsils showed that they comparatively rarely contained nodules.

It seems however that, besides the very frequent hereditary influences, *the acute infectious diseases* are mainly responsible for the hyperplasia of the adenoid tissue. Besides numerous swollen and reddened lymph glands on the neck, the pharyngeal ring of adenoid tissue was always found to be more or less thickened and injected in an irregular manner in all the numerous post-mortems of cases of measles and scarlet fever which had just run their course.

In the large majority of the cases we find positive evidence of a *me-*

chanical origin of the occlusion of the tubes in the surroundings of their pharyngeal ostium.

The rhinoscopia posterior and anterior and palpation of the naso-pharynx with the finger prove it.

You know we can survey the naso-pharynx with a small throat mirror bent at nearly a right angle, inserted behind the soft palate and turned upwards. It is accomplished in a similar manner to the inspection of the larynx, if we throw light on it with a reflector. Rhinoscopia posterior was introduced by *Czermak* in 1858. Cocaïn and a palate-hook have to be used whenever contractions of the muscles of the soft palate interfere with the examination.

I use a self-retaining speculum with a spring for *rhinoscopia anterior,* shown in fig. 51. It is very light and I have used it for the last 30 years.

Palpation of the naso-pharynx is accomplished through the mouth with the index finger. A metal finger guard (fig. 52) is slipped over the finger to prevent children from biting.

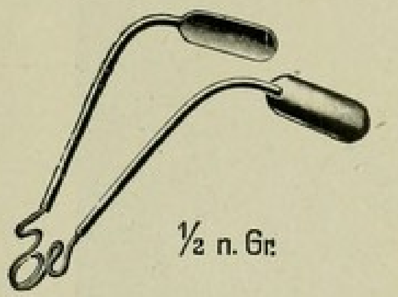

Fig. 51.

Nose-speculum.

Fig. 52.

Finger protector.

These methods of examination reveal a mechanical obstruction as by far the most frequent cause of occlusion of the tubes. The obstructions are the *hyperplasias of the adenoid tissue* in the mucous membrane of the naso-pharynx, which at the fornix forms the *pharyngeal tonsil,* but may as well extend over *Rosenmüller's fossae* and the openings of the tubes.

Wilhelm Meyer of Kopenhagen was the first to recognize to its full extent the frequent occurrence of these hyperplasias in children and their bad effect on the ear, whenever they are developed to any extent.[1] *W. Meyer* found "adenoid vegetations," as they were called by him, in 7.4 per cent of his patients, which is nearly as high a percentage as I found among my patients for all affections of the tubes (8.2 per cent). 130 patients of the 175 which *Meyer* had examined up to the time of his publication suffered at the same time from some disease of the ear, and one out of every four of the 175, from suppuration of the middle ear.

The picture which *Meyer* draws of the general appearance of the

[1] Ueber adenoide Vegetationen in der Nasenrachenhöle. Arch. f. Ohrenheilk. Vol. 7 and 8, 1873 and 74.

youthful possessors of adenoid vegetations is very characteristic. A tired, limp expression, caused by the permanent *breathing with open mouth,* develops in the face of these children, making them appear stupid. Prolonged mental exertion is really very difficult for them. *Guye* selected the expression "aprosexia" later on for this condition, which is not exactly appropriate but is now generally accepted. The best explanation for the whole condition is the restless sleep constantly interrupted by dreams, since the natural mode of breathing through the nose is interfered with more in the horizontal position and for a greater length of time. The children, after the removal of the vegetations by operation, sometimes tell us they "can understand and learn much better now."

Other consequences of constant mouth-breathing are: catarrh of the nose, provoked by the gathering of secretions in the nose which by blowing can be removed only very incompletely or not at all, furthermore catarrh of the pharynx, larynx and bronchia which must be attributed to

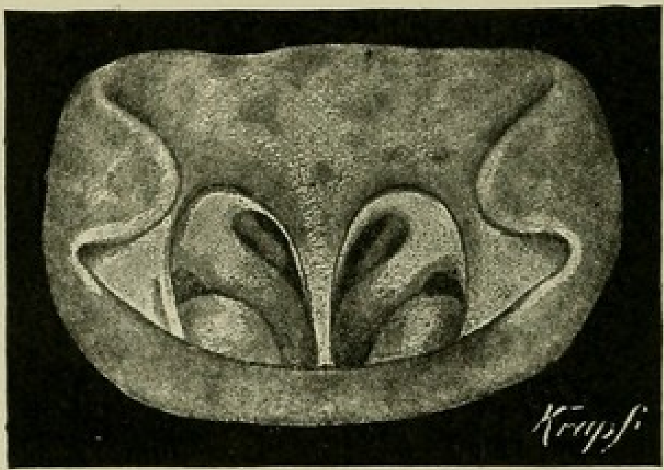

Fig. 53.
Normal naso-pharynx as seen in rhinoscopia posterior (according to Semeleder).

drying of the mucous membranes as well as incomplete cleaning, warming and moistening of the respiratory air, functions of the nose which cannot be performed because the air does not pass through it.

Speech also, like respiration, is changed in a characteristic manner. The consonants m and n sound very much like b and d. The whole speech sounds dull and has no modulation on account of the poor resounding qualities of the reduced spaces. *W. Meyer* called this "dead pronunciation."

A large majority of these children suffer also from their ears whenever adenoid vegetations are developed to any extent. Deafness caused by temporary occlusion of the tubes is *intermittent* as a rule and is therefore recognized by parents and teachers only very late, or not at all. Such children are considered distracted and inattentive. An examination of the drum membrane with the ear speculum shows how long they were misjudged.

In examining the naso-pharynx we are often surprised at the large sagittal distance between the soft palate and the rear wall of the pharynx. The faucial tonsils too are often more or less hypertrophic. Elevations and swellings of adenoid substance appear on the rear and side wall of the pharynx, especially on both sides behind the arcus pharyngo palatini. The tops of the adenoid vegetations may, in rare cases, become directly visible behind the velum.

We are able to see them to their full extent whenever rhinoscopia posterior is possible. In fig. 53 there is a picture of a normal naso-pharynx according to *Semeleder*.

Fig. 54 shows a large hyperplasia of the pharyngeal tonsil and a spreading of the adenoid vegetations to both sides over the openings of the tubes according to *W. Meyer*.

It is not at all necessary that the adenoid vegetations cover the openings of the tubes as in fig. 54, in order to effect a closing of the tubes. We even find the contrary when we make a rhinoscopic examination in cases of affection of the tubes, the opening of the tubes being in reality only very exceptionally covered by vegetations. Fig. 55 representing a

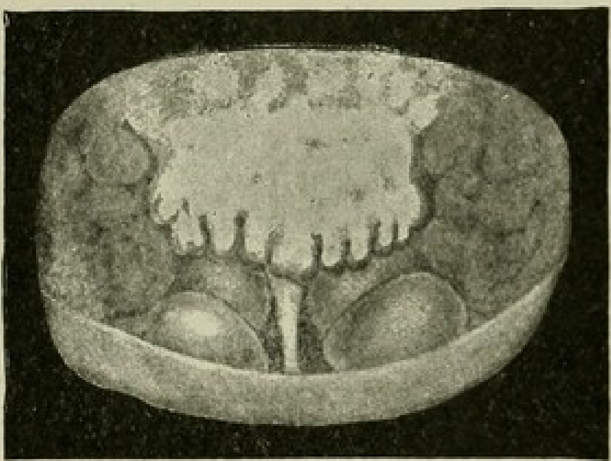

Fig. 54.

Adenoid vegetations spread over the whole naso-pharynx (according to W. Meyer).

cut through the pharyngeal tonsil and the tubes according to *Ruedinger* may enlighten you, as to how a large hyperplastic pharyngeal tonsil may close up both tubes without over-growing the pharyngeal ostia. The picture shows that an enlargement which extends over the whole width of the fornix acts like a wedge between both cartilaginous tubes compressing not so much the opening, as the aperture in the course of the tubes, thus interfering with the action of the muscles which ought to open them.

We are justified in diagnosing a real hyperplasia of the pharyngeal tonsil only in those cases in which the upper part of the nasal septum and the choanae are covered in the rhinoscopic image.

Large adenoid vegetations may sometimes be recognized through the nasal speculum by means of *rhinoscopia anterior.* A number of vertical bluish-red swellings move in different directions at each act of swallowing and reflexes of light shift from one side to the other.

In palpating through the mouth with a well disinfected finger one has the feeling of invading worms on the roof and the rear wall of the naso-pharynx. The tissue is usually very soft and brittle, so much so that each palpation causes some bleeding.

The removal of the pharyngeal tonsil becomes necessary whenever affections of the tubes either repeatedly recur, or when there is permanent breathing through the mouth. The children have to be watched by their relatives in order to ascertain whether they snore, or whether or not the mouth is open in sleeping, sometimes only to the extent of a narrow slit. A small feather must often be held between the lips in order to make sure

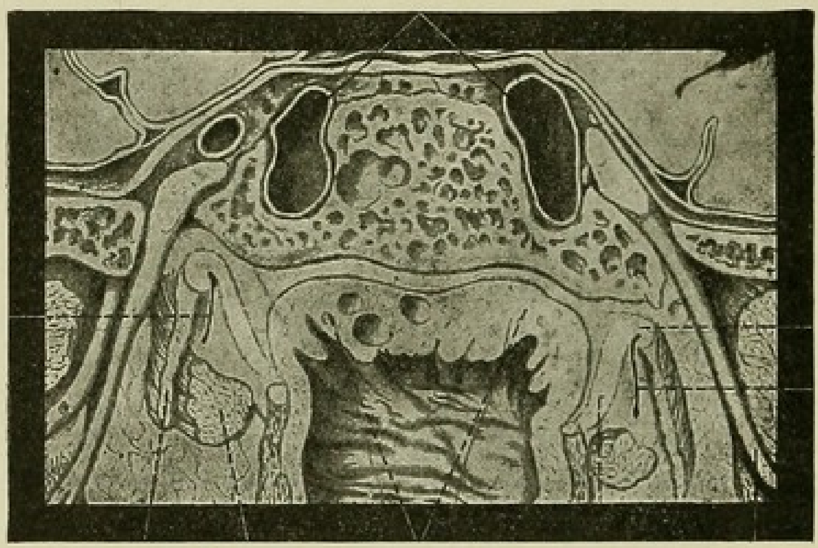

Fig. 55.

Frontal section through adenoid vegetations and both cartilaginous tubes. (according to Rüdinger).

whether there is really mouth breathing. The operation is indicated in mouth breathing even if there are no symptoms from the ear.

It is not very easy to draw the line between the normal, and a really harmful hyperplasia. I think it is one of the greatest merits of *Meyer*, that he determined the *numerical frequency of occurrence* of adenoid vegetations in his statiscal work so accurately, that the careful investigators of all countries since then obtained similar numbers. It is true that others shot beyond the mark. One ear surgeon for example asserted that of all children who consult him he operates in 95 per cent for adenoid vegetations. A number of ear surgeons, as soon as the deaf-mute institutions opened their doors to them, found there an appallingly large number of adenoid vegetations, while my own very extensive examinations showed that they are not more frequent there than in public schools.

The removal of the pharyngeal tonsil is an insignificant operation and hardly ever followed by important consequences. This fact notwithstanding, it ought never be performed unnecessarily. The size of the pharyngeal tonsil corresponds to the extension of the naso-pharnyx. Whenever the latter is large they are also developed to a considerable size. The adenoid tissue shrinks more and more after puberty, as established by *Meyer.* The complete evacuation of a naso-pharynx, which in itself is unusually large, may create a condition whose consequences are more harmful to the patient than a somewhat hypertrophic pharyngeal tonsil. I sometimes noticed the constantly repeating formation of dry crusts in noses where the turbinals had been removed by someone else. In a similar manner pharyngitis sicca having the characteristic appearance as though a coat of varnish had been applied to the walls, may result from too radical an evacuation of the naso-pharynx. This condition may secondarily extend over the openings of the tubes and in other directions.

These considerations must be a standard for us in *the removal of adenoid vegetations* and in the selection of our instruments.

Meyer devised a ring-shaped knife which he introduced through the nose and directed it with the finger inserted through the mouth. Formerly in the same manner I used a *straight snare* as fig. 56 shows, armed with elastic piano wire. It can be introduced through the narrowest nose into the naso-pharynx where the wire, owing to its elasticity, will always completely adapt itself to the masses of the tumor.

It is true the removal in this manner is very sparing, but in order to remove all that ought to be removed one has to enter the nose several times.

I have used *Gottstein's knife* with the modification of *Delstanche* exclusively ever since it was invented. It has a flat capsule with hooks for the purpose of catching the masses as they are removed. The capsule is held against the knife by means of a spring which can be removed for the purpose of cleaning. The knife is inserted through the mouth.

It is a good plan to let the palpation be immediately succeeded by the removal as a careful examination with the finger is not much more disagreeable to the patient than the operation. Palpation either alone or together with rhinoscopia will make clear the seat, the size, and the consistency of the growths. At the same time we may begin to separate the brittle masses from the rear wall of the pharynx by means of the fingernail, thus preparing them for the removal. The ring knife is then introduced behind the soft palate, and pushed up as high as possible along the rear end of the nasal septum. The handle is lowered very much in order to catch the foremost parts of the growths which are then shaved off with one sweep downward from the fornix and the rear wall of the naso-pharynx. The curve of the ring knife ought to be so that the cutting edge points nearly vertically downwards and very little backwards. The upper part in a number of recent modifications of this instrument is bent horizontally backwards. There is no question but that we are able with such instruments to extirpate the pharyngeal tonsil much more radically, directly from the fibrocartilago basilaris. That however need not be our aim, as we mentioned before, since it is sufficient to decapitate those hypertrophic parts which protrude over the level, as we do in removing the faucial tonsils. There is another disadvantage in having the

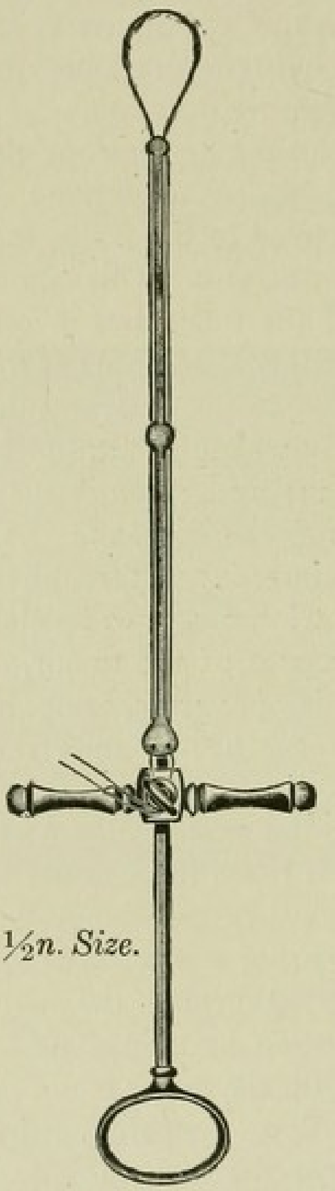

Fig. 56.

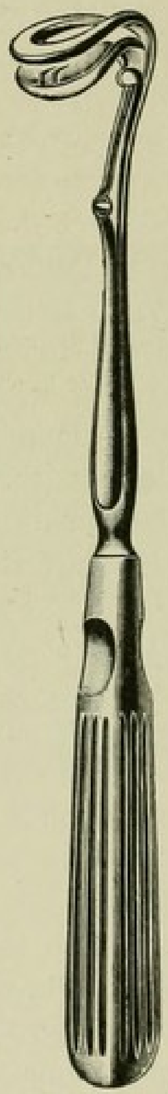

Fig. 57.

Fig. 56. Straight snare for nose and naso-pharynx.

Fig. 57. Gottstein's knife with a spring catch according to Delstanche.

position of the cutting edge more horizontally backwards,—namely it shaves the roof of the naso-pharynx very cleanly, but, instead of cutting, it scrapes along the rear wall, often getting caught or forming large flaps which hang down, and must be removed later on. This annoyance is avoided by a more vertical position of the cutting edge.

The instrument takes effect first along the middle of the rear wall.

At a second insertion from high up, down along one side and finally in the same manner on the other side, thus removing the lateral remainders which are nearest to the tubes.

Fig. 58 shows two hyperplastic pharyngeal tonsils which were removed in this manner.

The after treatment consists in gargles of concentrated solution of boric acid with some sodium chloride (20 boric acid to 3 sodium chloride to 500 water) to be used every two hours for several days. The patient lies on his back and pronounces a long "ga" in order to open the occlusion of the palate. A tablespoonful of the same warm solution is poured into the nose every two hours and the patient instructed not to blow his nose for a quarter of an hour.

The operation ought not be performed during the acute stage of an inflammation of the middle ear. Inflation of air through the tubes ought also be avoided for eight or ten days after the operation. I never saw a serious inflammatory reaction under these conditions. Hemorrhage also re-

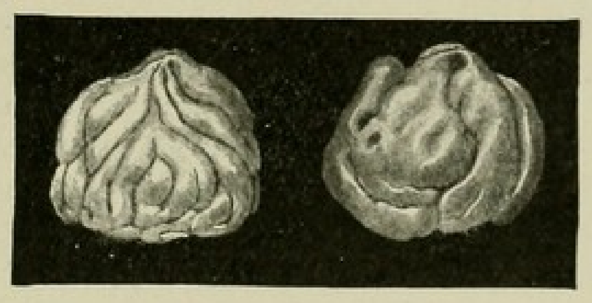

Fig. 58.

Two hypertrophic pharyngeal tonsils, removed by means of Gottstein-Delstanche's knife.

mains within moderate limits in using *Gottstein's* ring knife. I never found that narcosis was necessary.

Recurrences of occlusion of the tubes become rarer after the removal, or stay away altogether. The vegetations may enlarge again later on in a few exceptional cases, so that a second removal becomes necessary if the operation had to be done in very young children.

Other causes of constantly recurring affections of the tubes must be looked for in a small minority of cases. The *rear ends of the lower turbinals* are sometimes so much hypertrophied that their removal becomes necessary by means of a snare like the one shown in fig. 56. The enlarged *faucial tonsils* in other cases push up the floor of the pharyngeal ostium of the tube to such an extent that they must be removed either on account of the crowding of space or on account of the constantly repeating attacks of inflammation which start from them.

A number of rare causes of permanent occlusion of the tubes must be mentioned. There is the *fibrosarcoma of the naso-pharynx* occurring in youthful age, the *rhinoscleroma* and *other tumors* which either start and grow in the naso-pharynx or encroach upon it from the surroundings.

In one case of long lasting occlusion of the tubes with gathering of serum I found at the post-mortem a neuroglioma of *Gasser's* ganglion which extended along the third branch of the trigeminal nerve, compressing the tube. The poor patient whom I observed many years ago died finally of lack of nourishment on account of extreme pains. Today we would probably proceed to extirpate the trigeminal ganglion in such a case.

A most frequent cause of recurring occlusion of the tubes *in adults* is the formation of *crusts* which may extend from the nose to the ostia of the tubes. A semi-solid cast of the pharyngeal ostium some time after withdrawal is found hanging from the beak of the catheter. It is well known that such crusts are in part the consequence of rhinitis atrophicans with drying, ill-smelling secretions (ozena) in other cases they may form in different diseases of the bones of the nose especially of luetic character.

Scars after phthisical, tubercular, diphtheritic or varioloid ulcers in the naso-pharynx may produce the characteristic phenomena of a high degree of retraction of the drum membrane if previous changes in the drum cavity did not set in. The ostium pharyngeum may become distorted, or constricted, or entirely closed, and on posterier rhinoscopy it can hardly be recognized.

Luëtic processes are certainly the most frequent to leave residues in the naso-pharynx which we may see rhinoscopically. Hereditary syphilis also may produce extensive scars in these places.

It seems that such constrictions and obliterations occur only at the pharyngeal entrance to the tubes. *Real strictures in its course* similar to strictures in the urethra *do not seem ever to occur* (*Schwartze* "Pathol. anatomie"). Furthermore, I could never find them in my numerous post-mortem examinations nor in the living. In every case I became convinced of the fact that as soon as the beak of the catheter has passed the stenosis on the pharyngeal ostium, the air easily enters the drum cavity in a broad stream, provided there are no pathological changes at the other end of the tube.

I often had a chance to verify on the cadaver that the probe is quite an unreliable means to diagnose strictures within the tube, as often even on the cadaver it can be pushed only with great difficulty over the angular bend which is sometimes found on the limit between the cartilaginous and the bony part.

An occlusion by scars in the course of the tube may be brought about through injuries caused by shooting or stabbing.

As an example I mention a case of atresia of the tube from the scar of a stab with a knife which entered through the tragus.[1] A very

[1] Berl. klin. Wochenschr. 1883, No. 40.

serious hemorrhage after the injury from the mouth, the nose, and the ear suggested a small injury of the carotid artery which is close to the tube. The case obtained a great forensic interest, in that the patient was sued for perjury, because the physician, who was asked by the court to examine him, insisted that he was shamming deafness. He went free on my statement which was based on the pathognomonic findings of the drum-membrane, the hearing tests and the examination with the probe.

Congenital clefts of the soft and hard palate finally predispose greatly to affections of the tubes. The muscles of the tubes are not able to open the aperture of the tubes in a normal manner during the act of swallowing, on account of the divergence of the two halves of the soft palate. *W. Meyer* found furthermore that a considerable hypertrophy of the pharyngeal tonsil is usually combined with cleft palate. This explains why the phenomena of occlusion of the tubes with all the sequelae which we shall discuss later on, are found in the majority of patients with cleft palate.

It was generally taken for granted that a lasting impermeability of the *nose* may produce the same symptoms in the ear as occlusion of the tubes. This assumption is apparently supported by the phenomena which are produced by the so-called *Toynbee's* experiment. A movement of swallowing is made while the mouth and nose are closed, the latter with the fingers. In so doing the air from the nose, the naso-pharynx and the spaces of the middle ear is aspirated, causing a feeling of fullness in the ear which passes away only after another act of swallowing with open nose or direct inflation of air by means of *Valsalva's* test. *Toynbee's* test is still more successful if the movements of forced inspiration are made while the mouth and nose are closed. You can convince yourselves by means of the continuous tone series that the power of hearing is considerably decreased and that hearing of the lowest part of the sound scale is entirely lost by air conduction as long as the feeling of fullness lasts in the ear. The described effect of aspiration will be continually produced at each act of swallowing during every meal, if the nose is permanently obstructed. It is evident that permanent damage may easily be done to the ear.

However, normal power of hearing was repeatedly found in cases of congenital occlusion of both choanae. We are therefore forced to admit that in the normal condition of the tube an act of balancing of the difference of air pressure takes place by means of an action of its muscles which is independent of the act of swallowing. This action does not permit permanent harm to be done to the ear. Consequently we are not justified in regarding the impermeability of the nose as a physical cause for the development of deafness.

LECTURE XVI.

Simple Occlusion of the Tubes and Its Physiological Consequences.

Gentlemen:—The effects of occlusion of the tubes upon the sound conducting apparatus and consequently upon the function of hearing have a great physiological interest.

The extensive pneumatic spaces of the middle ear are lined with a very delicate membrane containing a system of blood vessels which are extended over a large surface. They act similarly to the alveoli of the lungs. The oxygen of the air which they contain becomes absorbed by the blood vessels and carbonic acid is secreted which has a smaller volume. We notice changes of form of the drum membrane which *prove a rarefaction of the air* in the middle ear, as soon as the ventilation of the spaces of the middle ear, effected normally by each act of swallowing, etc., is interfered with by the permanent occlusion of the tubes, which are the only avenues for admission of air. The drum membrane, the membrane of the round window and the lig. annulare of the oval window are the only flexible parts of the middle ear, all other walls are bone The drum membrane is forced inward whenever the air in the middle ear is rarefied and overbalanced by the column of air outside. Its form is changed in a characteristic manner which shall soon be described.

We saw in the physiological discussion of the sound-conducting apparatus that it is extremely well balanced by two pairs of antagonists, namely, the two muscles in the middle ear, and on the other hand, the radial and circular layers of fibres of the drum membrane. It is therefore fit to fulfill the high requirements which the transmission of weak sound waves make upon it.

You will readily understand that a slight over-balancing of atmospheric pressure against the outer surface of the drum membrane is sufficient to interfere with the function of the whole sound-conducting apparatus. The distance at which whisper is heard may be diminished after long lasting occlusion of the tubes from more than 20 meters in the normal ear to 10 centimenters and less, i. e., one 200th part of the normal hearing distance. We are able to improve such hearing at once to the normal or nearly so, by a simple inflation of air which balances the pressure on the outside and inside of the drum membrane, provided there are no other changes in the middle ear. This is proof of the fact *that the deafness in these cases was due exclusively to the overbalancing of the apparatus.*

Thus, gentlemen, you can judge of the great diagnostic importance of changes of the form of the drum membrane produced by rarefaction of the air in the spaces of the middle ear.

They offer the following characteristics at the examination with the ear speculum (compare the plate of pictures of the drum membrane no. 2).

The mobility of the drum membrane is greatest in its center, the hammer therefore swings inward on its axis. The handle becomes more horizontal and its lower end moves somewhat backward. The lower half and the upper anterior quadrant of the drum membrane consequently appear somewhat larger to our eye, the rear upper quadrant smaller, and the *handle of the hammer more or less foreshortened.* The *short process of the hammer* which lies closely below and outside of the axis of this motion moves downward and outward. It is pressed against the drum membrane and *thereby becomes more prominent* causing several folds to form in the membrane. They start from the process and run in different directions upward into the otherwise flabby membrana *Shrapnelli* or backward and downward. The last one in the posterior and upper quadrant is the most important.

It appears as a rather long and clearly illuminated line formed by the edge of the fold which may be sharp or dull, starting from the short process and running backward and downward toward the periphery, at an acute angle with the handle of the hammer. This so-called *posterior fold*[1] may protrude so much that the handle of the hammer which is also more horizontal in these cases, may be nearly or entirely covered, and the fold may be mistaken for the handle of the hammer.

The outer edge and even the rear surface of the handle of the hammer may become visible through the membrane as whitish parts if the membrane is pushed inward against the structures in the drum cavity, and the whitish neck of the hammer appears under the same circumstances above the short process through the membrana *Shrapnelli.* The long process of the anvil can be seen quite plainly below the posterior fold.

The drum membrane as a whole appears darker, partly on account of its being pushed inward, partly on account of the hyperemia ex vacuo

[1] What we called anterior and posterior liminal strands (page 41) are called by some authors anterior and posterior fold. The posterior fold was considered identical with what *we* call posterior fold. However they are not identical, as often can be seen in children suffering from occlusion of the tubes. After a successful inflation the posterior fold can still be recognized in its sickle shape, forming an *acute angle* with the manubrium mallei, while also from the short process the posterior liminal strand runs as a white line *upward* and *backward*, in an *obtuse angle* with the manubrium. The liminal strands are strands of connective tissue indicating the limit between the membrana propria and the membrana flaccida Shrapnelli. The posterior fold is always pathologic.

in the drum cavity. It contrasts remarkably with the broad, whitish streak formed by the handle of the hammer.

The light reflexes on the drum membrane undergo a number of characteristic changes. The *triangular reflex* becomes longer and narrower, as long as the membrane retains the shape of a funnel (fig. 59c). The form of the funnel changes very easily into that of a flat pan (compare fig. 59d) on account of the exclusively one-sided pressure. Consequently the triangular reflex and the shining spot in the anterior inferior quadrant disappear, since our axis of vision at that spot is not any longer perpendicular to the membrane as is shown in fig. 59d. The form of a flat pan changes into that of a kettle if the pressure from the outside, i. e., the rarefaction on the inside, increases still more (compare fig. 59e). A part of the concavity of the membrane in the anterior lower quadrant again

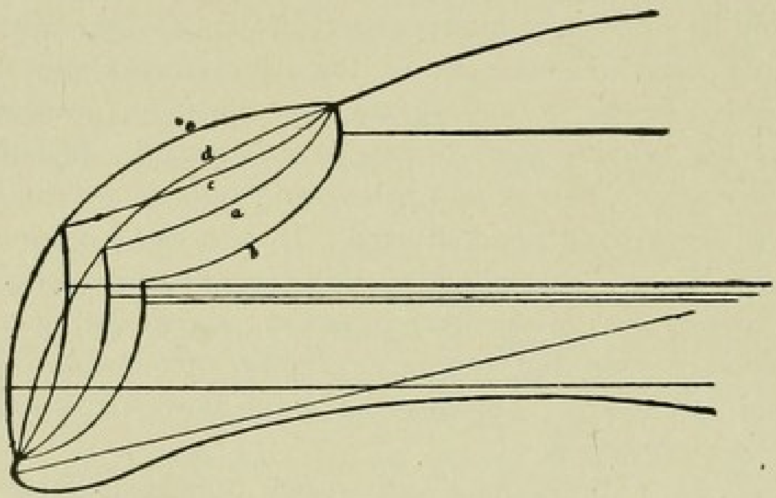

Fig. 59.

Section through the drum membrane in the axis of the meatus, cutting the triangular reflex in half.

a normal curve, *b* bulging, *c* funnel shaped (slight) retraction, *d* pan shaped (moderate) retraction, *e* kettle shaped (highest degree of retraction).

becomes perpendicular to the axis of vision and another brightly shining reflex is seen, but this reflex has no point and is more or less removed from the umbo. It forms a *real* image of the illuminated surface. The peripheral zone of the membrane is usually not subject to the high degree of retraction, but forms an edge along which an illuminated line runs in a parallel curve to the normal sulcus reflex, *called edge reflex*. The kettle-shaped retracted drum membrane has therefore three reflexes which lie close together and give it a very characteristic appearance, whenever the sulcus reflex is not covered by the protruding lower anterior wall of the meatus (compare on the plate picture no. 2).

A number of new reflexes may appear around the short process of the hammer, namely, reflexes of coves in the retracted membrana *Shrapnelli,* and in the course of the posterior fold either an *illuminated line* running backward from the short process or, less frequently, a *triangular re-*

flex of the rear upper periphery of the drum membrane whose lower limit is formed by the fold.

All these symptoms of retraction are of course rarely found combined in *one membrane*. The distinct appearance of a posterior fold, or the characteristic removal from the umbo and change of form of the normal reflex, combined with a darker color of the membrane are each alone sufficient to make the diagnosis of occlusion of the tubes, while on the other hand the preservation of the normal bend in the rear upper quadrant of the drum membrane suffices to exclude it.

The moment we *succeed in inflating air through the tube the whole picture of the drum membrane changes* under our eyes. The abnormal light reflexes disappear, the color of the drum membrane becomes clearer, the hammer and its short process do not protrude any longer. An indistinct triangular reflex appears in the umbo and a crescent-shaped reflex may even appear on top of a pronounced convexity in the posterior superior quadrant.

The drum membrane may keep this form for a shorter or longer time, according to the time it takes the excess of compressed air to flow back through the tube.

Hearing becomes more or less close to normal at the same time that the drum membrane obtains its normal convexity.

Besides deafness the subjective symptoms attending occlusion of the tubes are so insignificant, that we usually do not hear the children complain about them.

Mouth-breathing, nasal speech and especially *the change from deafness to normal hearing* caused by the temporary spontaneous opening of the tubes are characteristic for occlusion of the tubes in children. Adults complain furthermore about dullness and fullness in the head, pressure in the ear, about subjective noises and increased resounding of their own voice.

It is interesting that the noises, ringing in the ears, etc., disappear after inflation, just as suddenly and for the same length of time as the deafness. We conclude from this, that the noises do not originate in the nervous apparatus but are caused by the increased tension in the sound-conducting apparatus. Formerly it was thought that the forcing inward of the foot plate of the stapes increased the pressure on the end organs of the acoustic nerve. This theory lacks every support since, as we saw before (compare page 15) the very yielding membrane of the round window is able to move five times as far *outward* as the stapes can move inward, and because at least a slow balancing of pressure with the interior of the skull takes place through the capillary aquaeducts. On the other hand it is very plausible that noises of blood vessels and muscles which are normally inaudible are transmitted and perceived much more readily through a sound-conducting apparatus whose tension is increased on account of one-sided pressure.

This increased tension of all fibres of the sound-conducting apparatus furnishes probably the best explanation for the increased resonance of the patient's own voice. Bone conduction to the diseased ear is especially increased and prolonged in affection of the tube as is shown by its examination with the tuning fork on the vertex. Our own voice being partially heard by bone conduction acts like the tuning fork. This resonance of the voice disappears every time after inflation of air. It must not be confused with real tympanophonia which we shall become acquainted with in the chapter on "permanently open tube."

Direct Consequences of Occlusion of the Tubes.

Gentlemen:—*The gathering of serum in the spaces of the middle ear* is a consequence which hardly ever is lacking after prolonged occlusion of the tubes. A transudation takes place from the enlarged vessels of the lining of the middle ear on account of the prolonged rarefaction of air. Large quantities of an amber colored, transparent fluid are discharged if the paracentesis of the drum membrane is followed by an inflation of air. This fluid may become viscid if it stays in the middle ear for some time, but will always remain transparent as long as no inflammations intercur.

Scheibe and *Brieger* always found this fluid free from germs, which fact is of great value for the separation of affections of the tubes from inflammatory diseases of the middle ear. It is therefore not an inflammatory exudation but a simple transudation caused mechanically by rarefaction of air and consequent hyperemia ex vacuo. This fluid is not under increased but diminished air pressure; and on making a paracentesis we may often see an air bubble arising on the inside of the drum membrane from the opening of the paracentesis. The transudation is often spread in great quantities over the extensive spaces of the middle ear, and can be evacuated into the external meatus only under the condition that the paracentesis is succeeded by inflation of air.

The fluid which gathers in the tympanic cavity can *often be seen through the drum membrane* before the paracentesis. It apears as a greenish discoloration of the lower periphery or of the lower half of the membrane which is divided by sharp, dark, upward concave lines from the upper dark gray half. A posterior *and* an anterior concave line is sometimes found which meet in a point at the handle of the hammer. This picture is caused by two air bubbles, one of which adheres to the anterior, the other to the posterior superior quadrant of the drum membrane. A number of smaller air bubbles may be seen sometimes after inflation through an especially transparent drum membrane.

The *subjective symptoms* are especially characteristic. Deafness varies much more than in simple occlusion of the tubes. It changes even in a change of position of the body, becoming less while reclining, when the fluid runs back into the cells of the mastoid process. It is not very rare to have patients say that water moves to and fro in their ear, whenever they move their head. In fact in moving the head we can often see the lines of fluid, like those of a water level, moving back and forth.

The so-called *collapse of the drum membrane* must be mentioned as a *consequence* of long persisting occlusion of the tubes which *manifests itself later on.* The atmospheric pressure weighing on its outer surface causes gradual stretching and atrophy of its fibres which either may be limited to certain parts of the drum membrane, especially the posterior superior quadrant (compare the plate, picture 3 and 4) or may extend over the whole of it (picture 5).

The thin transparent membrane in the latter case clings like a wet garment to the structures in the tympanum. *The handle of the hammer, the joint between the incus and stapes, sometimes also the promontory protrude* as in relief. A number of *new reflexes* may be noticed not alone in the anterior, but also in the posterior half of the membrane around the joint between the incus and stapes and on the promontory. It sometimes seems as though the whole drum cavity lay bare and only the handle of the hammer was in its place. Only by means of *Siegle's* otoscope or inflation of air can we convince ourselves of the presence of the drum membrane.

Siegle's pneumatic ear speculum is closed at the top by an oblique glass plate or lens, and is connected on the side with a rubber tube. The movements of the drum membrane can be watched through it if the air in the tube is rarefied and compressed after the speculum is inserted hermetically into the meatus.

The structures in the tympanum disappear from view after inflation of air through the catheter or by means of *Politzer's* method and the drum membrane bulges into the meatus forming folds similar to the flower of convolvulus (compare on the plate figure 4).

The pronounced forms of collapse of the drum membrane develop only after occlusion of the tubes has existed for many years or recurs persistently. Therefore they are found just as frequently in adults as in children. They may continue for decades without further consequences, although exceptionally.

Atrophy is often confined to some spots on the rear upper quadrant of the drum membrane, which are deeply retracted over the joint between the incus and stapes and over the tendon of the stapedius muscle, all protruding in relief. It is very remarkable that in these cases the long process of the incus is often missing, and the head of the stapes together with its tendon are there alone (compare on the plate fig. 5). The reason for this finding is the fact that sometimes the incus is luxated backward on account of the horizontal position of the hammer, occurring, as we saw, not infrequently in retraction of the membrane; at other times it is lost or destroyed by preceding intercurrent inflammations. The posterior upper quadrant protrudes like an irregular blister over the drum membrane after inflation (compare the plate fig. 4). This picture may also be seen when the patient, by blowing his nose shortly before the examination, succeeded in forcing air into the middle ear.

The changes of form in collapse of the drum membrane, whenever they are well developed, will persist even after occlusion of the tubes has ceased and they have become quite patulous.

The power of hearing in the cases of uncomplicated occlusion of the tubes and in those with gathering of serum can usually be restored to its full extent by treatment, while in those with pronounced collapse more or less of it is generally lost. It may become very close to normal, when the tube has become patulous again. Such cases show *that the diminution of hearing does not depend upon the change of the form of the drum membrane in the first place, but upon the one-sided over-balancing of pressure.*

The great number of different sequelae which may occur in the ear, besides the two which were described here as consequences of occlusion of the tubes, are of inflammatory nature and will be discussed in later chapters. We shall see there more clearly how important a very careful study and knowledge of the clinical picture of pure occlusion of the tubes, as I have given it here, is for our comprehension of the development of the different diseases of the middle ear and for our whole diagnosis.

Treatment of Occlusion of the Tubes and of Its Consequences.

The first requirement in treating occlusion of the tubes and its sequelae is to make the tubes patulous and keep them patulous as often as occlusion recurs. *Politzer's* method generally accomplishes this in children. It consists as you know of inflating air through a canula inserted into the entrance of the nose, while at the same time both openings of the nose are hermetically closed over it with thumb and index finger, and the mouth is shut off from the naso-pharnyx by the raising of the soft palate through the act of swallowing or crying.

Politzer uses for inflation a simple pear-shaped rubber bulb. We prefer *Lucae's* double bulb for performing *Politzer's* method and catheterization, since it produces a longer lasting current of compressed air. A wide dull glass tube (compare fig. 15 page 30) is used to connect the rubber tube with the nose.

Small children, who cannot be induced to swallow when ordered to do so, are layed on their back and a teaspoonful of water is poured into their mouth the moment everything is ready for the inflation.

The success of *Politzer's* method is recognized by the distinctively visible changes of the drum-membrane and by comparing the hearing before and after inflation.

Too much pressure must not be used if some spots or the whole drum membrane show the symptoms of collapse, or if there is a thin scar, since a thin part may rupture through too high pressure.

A valve-like occlusion of the pharyngeal ostium of the tube which cannot be overcome by means of *Politzer's* method seems to occur in some patients, children as well as adults. In such cases we have to *use the catheter* for inflation, even in children. The insertion even at that age does not offer any difficulties to any one who is used to it. The air enters into the middle ear with a strikingly uneven, rugged noise as soon as the catheter has passed the obstruction which is usually at the pharyngeal ostium of the tube.

It is sufficient to repeat the inflations every 2 to 3 days, even if the hearing distance should recede earlier than this period.

We use inflation first in the cases in which serum has gathered. The transudation may stop and absorption may begin by establishing normal pressure in the middle ear. It is well, in order to evacuate fluid which is present in the middle ear, to have the head in catheterizing in such a position that the tube points perpendicularly downward, that is the head of the patient must be inclined towards the good ear, downward and forward.

The serum must be evacuated through a paracentesis in *the drum membrane* whenever a large amount has gathered and the occlusion of the tubes has lasted for some time. The small operation is in these cases little or not at all painful.

In order to do it antiseptically the meatus is injected with a warm three per cent solution of carbolic acid, afterwards the meatus and the drum membrane are cleaned and dried with a probe wrapped with cotton. The paracentesis is made with a lance-shaped knife 1 to 2 millimeters in width (compare fig. 45 page 107) in the rear lower quadrant of the drum membrane and parallel with the handle of the hammer.

It must not be forgotten that the bulb of the jugular vein sometimes lies bare at the floor of the tympanic cavity or even protrudes into it. A number of injuries to it have been reported in literature; one of which terminated fatally because pyemia had set in. The carotid artery also may be found lying bare on the anterior wall of the tympanic cavity in exceptional cases. For these reasons sickle knives ought not be used for paracentesis.

An air bubble as before stated frequently rises on the inside of the drum membrane the moment the lance penetrates into it, proof of the existing rarefaction of air, which also prevents a spontaneous discharge of the fluid outward.

An astonishingly large quantity of amber colored fluid can sometimes be forced into the external canal by means of *Politzer's* method. It seems to be more expedient to drain it in the reversed manner through the tube. We give the head the above-described position for this purpose, the tube directed vertically downward, then, by compressing the double bulb whose canula has been hermetically inserted into the *meatus,* we force the air through the opening in the drum membrane during the act of swallowing.

A deep bubbling noise originates in the naso-pharynx caused by the fluttering to and fro of the membranous walls of the tubes and on inspection the drum cavity is found empty. Pressure must not be too high in this external inflation of air, as considerable dizziness may result, probably from intense commotion of the membrane of the round window. Infection from germs thrown into the middle ear from the naso-pharynx can safely be avoided by external inflation.

I usually inflate some boric acid powder against the drum membrane after removal of the serum, partly as a protection from infection from the outside, partly in order to remove the last remnants of serum by the capillary attraction of the little flat crystals of boric acid. We find the powder usually colored yellow like honey the next day.

The opening in the drum membrane is usually healed after 2 to 3 days in uncomplicated cases when also normal hearing is obtained which remains if the occlusion of the tubes itself is amenable to treatment.

The opening in an atrophic membrane may remain open for a longer period of time.

Paracentesis or better even cutting a large hole in the drum membrane are often the only means to improve hearing at least temporarily in atresia of the tube by scars or by tumors which cannot be removed. Hearing may remain improved for weeks after a simple paracentesis as the membrane is usually atrophic under such conditions.

It is very difficult to make a permanent opening in the drum membrane on account of its great faculty of regeneration.

Paracentesis in gathering of serum may be recommended to the patients without hesitation *as I never saw it followed by suppuration* if the precautions which I have described are taken. This fact which was established by many years of observation is important to us for two other reasons.

Firstly, it furnishes a new proof for the fact that the serum which has gathered on account of occlusion of the tube is always free from germs as bacteriological examinations have shown before.

Secondly, *it shows that under normal conditions germs of infection cannot be transmitted to the middle ear through the tube in perforations of the drum membrane.* Suppuration never occurred after paracentesis even when *Politzer's* method through the nose instead of external inflation was used. We shall return to this subject in speaking about acute inflammations of the middle ear, and shall see of what importance the results of the above mentioned observations are for our judgment of these pathological processes.

We have finally to say a few words concerning the therapy of diseases of the surroundings which may lead to occlusion of the tubes. We have already discussed the operative removal of adenoid vegetations, and, wherever it appears necessary, of the faucial tonsils, also of the posterior ends of the lower turbinated bodies. Our attention must be given to the removal of crusts and tenacious masses of secretions which gather in the nose and naso-pharynx, often obstructing the entrance of the tubes or occasioning its agglutination.

The crusts in ozena may be removed from the nose by three different methods.

The best known method is *Weber's* nasal douche which most general practioners use. A considerable quantity of fluid is conducted into one nostril by means of a siphon or an irrigator and is drained through the other nostril. It is not so well known however that this manipulation, which was intended to remove damaging obstacles from the surroundings of the ear, may do great harm to the ear itself if carelessly applied. The otologist has occasion often enough to see inflammations of the ear after nasal douches or simple pouring of water into the nostrils on account of the general application of this mode of cleaning the nose even by laymen. Profuse suppurations with perforation of the drum membrane and a number of further deleterious sequelae are not infrequent. The beginning of the disease of the ear is usually distinctly attributed to the nasal douche by the patients. They felt the fluid suddenly entering the ear while washing, and from this moment their trouble began, first a feeling of fullness, later on pain in the ear and increasing deafness.

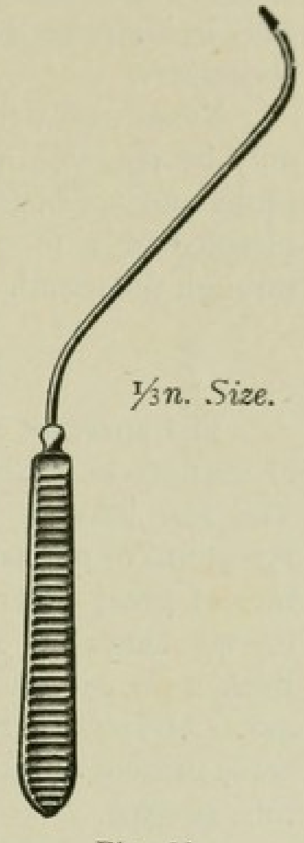

Fig. 60.
Probe for the naso pharynx.

The connection can well be understood. The tube is closed in repose. The moment it is opened by an action of the muscles of the palate and tubes during the douche the fluid enters into the spaces of the middle ear and carries there all the germs of decomposition which it gathered on the road.

This danger to the ear can be avoided if the patient does not swallow or speak during application of the douche. A half liter (about one pint) of luke warm solution of boric acid or a weak salt solution is used. The irrigator must not be raised more than 80 centimeters (about 2½ feet). The canula must be inserted horizontally into the nostril which is least open. The patient must be warned not to close the other nostril with his finger. The fluid must then be expelled by exhaling forcibly, keeping the nose open, and for a quarter of an hour blowing the nose with the handkerchief ought to be avoided.

Atomizers with long straight tubes or bent tubes with holes on the side for the pharynx are less dangerous than *Weber's* nasal douche.

Gottstein described a very suitable method for removing crusts from the nose. A large pledget of cotton is inserted high up into the middle nasal duct. The cotton is wrapped around a straight probe about the thickness of a match, for a distance of 4 to 5 centimeters. After insertion the probe is pulled out, while the cotton is retained with two fingers. The cotton irritates the nose like a foreign body, and the walls produce sufficient fluid secretions to loosen the hard crusts, which are usually blown out together with the cotton when we see the patient again the next day. In case some pieces still remain adherent they can be removed by means of *Weber's* douche or the atomizer. Ozena can be influenced symptomatically by *Gottstein's* tamponade at least to such an extent that the bad smell disappears.

Tenacious, tightly adherent and dry masses in the *naso-pharynx* can only be removed mechanically by means of a thick bent probe without probe end (compare fig. 60) which is tightly wrapped with cotton for a distance of 2 to 3 centimeters, and is inserted behind the soft palate through the mouth.

Perpetual Opening of the Tube.

The aperture of the tube may permanently remain open on account of changes in its surroundings. This is a comparatively rare occurrence. The few patients whom I examined while showing the characteristic symptoms of permanently open tube, presented, without exception, the picture of great general emaciation produced in a short time by phthisis in the last stages or other serious general diseases or senile marasmus. A thick layer of fat surrounds the cartilaginous tube, according to *Rüdinger.* Atrophy of this layer causes the external membranous wall to become detached from the inner cartilaginous wall and the aperture of the tube to gape.

An extremely disagreeable resounding of their own voice forces the patients to consult the otolgist. The "tympanophonia" which thus arises is much greater than resonance caused by increase of bone conduction which we mentioned in connection with occlusion of the tubes. It is produced when sounds formed in the mouth and pharynx enter directly into the tympanic cavity through the open tube. Whoever like myself, is able to open his tube at will and keep it open can easily convince himself of the change and increase in strength of his voice. It appears indistinct in spite of the powerful rumbling noise accompanied by over tones of highest pitch, and we experience a disagreeable sensation of trembling of the drum membrane. Even simple inspirations and expirations sound like loud noises. I was often able to observe changes of the reflexes on the tympanic membrane which occurred with each inspiration and expiration during forced respiration in patients with open tubes.

Hearing itself is not materially diminished in patients with open tubes.

The above-described clinical picture gives us an insight into the usefulness of the normal mechanism of the tubes and its faculty of momentary opening. There is another reason why I mentioned it here, namely, because we have a very simple procedure to give patients at least temporary relief from their annoying affliction. I use an insufflation through the catheter of salicylic and boric acid powder one part in four for this purpose. Tympanophonia disappears instantly and often stays away for a number of days on account of the irritation of the mucous membranes and the increased secretion.

Injuries and foreign bodies in the tubes are such rare occurrences that I can refer you to the monograph of *Passow* on "Injuries of the organ of hearing."

LECTURE XVII.

Acute Inflammations of the Middle Ear.

Etiology.

Gentlemen:—The affections of the tubes which have so far been discussed have purely mechanical issues. The inflammatory processes in the middle ear which we now have to consider are of different character. The presence of organized germs of infection has been established with such regularity that we can not doubt of their causative importance as to the pathogenesis of all inflammations of the middle ear. The numerous bacteriological examinations made since *Zaufal's* initiative showed that germs were never absent in the slight cases which do not perforate, as well as in the serious perforating forms of inflammations.

Zaufal and later investigators only exceptionally succeeded in raising cultures of some few germs from the normal drum-cavity. We are justified in the supposition that so small a quantity of germs are powerless against the living cells of the normal lining of the middle ear. We also found the transudations formed ex vacuo in the middle ear after prolonged occlusion of the tubes, to be free of germs. The exudations which form while symptoms of inflammation are present and which always contain more or less cells, on the contrary are regularly impregnated with one or more forms of pathogenic micro-organisms.

Diplococcus pneumoniae and streptococcus pyogenes are found the most frequently. The different forms of staphylococcus pyogenes usually appear secondarily after a suppuration has lasted for a while, although sometimes they seemed to be the primary infection. A number of other micro-organisms were found in some few cases. Even the germs which usually cause some general acute infectious disease like influenza, typhoid, diphtheria bacillus and meningococcus intracellularis were found in the purulent secretions of the middle ear.

We might expect in each inflammation of the middle ear occurring in the course of some general infectious disease, to find simply the specific organism in the secretions. Conditions are however not so simple. There were on the contrary only few cases in which the specific germs of the general infection were shown also in the middle ear, and even then very rarely in pure cultures. The general pyogenic organisms, strepto, diplo, and staphylococci were found either exclusively or in by far the greater number.

Von Troeltsch established the fact that inflammatory changes with gathering of secretion in the middle ear are found in nearly every post-mortem examination of infants of the first few years. It seems therefore that the middle ear at that age becomes affected in nearly every general disease. *Preysing* published a very careful investigation of 100 post-mortem examinations of children less than 3 years old. He found pathologic changes in the middle ear in 81 per cent, and of all positive bacteriologic findings pneumococcus was shown in 92 per cent.

Streptococci were found by far the most frequently in the secretions of otitis complicating acute infectious diseases like scarlet fever, measles, etc. They were also found in nearly every case where serious complications implicating the blood vessels or the brain developed after an otitis. The presence of streptococci became evident in every case of thrombophlebitis which was examined in my ambulatory clinic. Pneumococci were found on the other hand in genuine uncomplicated otitis, in empyema of the mastoid process and in the local extensions to its surroundings.

The impression may be gained from this rudimentary synopsis of the bacteriological findings in the middle ear to which we have to confine ourselves, that the kind of bacteria which develop, as well as the mode of their propagation and spreading, are dependent to a certain degree upon the *soil* on which they grow. The adult organism considered in opposition to the infantile organism, as well as general infectious diseases, produce changes in this soil which favor the growth of certain bacteria.

It would be shortsighted to consider an occurrence like this which repeats itself in all diseases of the first few years and in the most frequent acute infectious diseases like measles, scarlet fever, etc., with such regularity as simply abnormal and harmful to the organism.

The formation of an exudation rich in cells, formed under such circumstances in the middle ear, may possibly be compared to the abundant emigration of leucocytes which we can observe in the lymphatic ring in the pharynx, or (in examining fresh nasal polypi), through the interstitia of the ciliated cells, and which we may suppose tâkes place also in *Peyer's* and the solitary glands of the bowels. A transportation outward of toxines and products of decomposition of some, maybe partially still unknown micro-organisms of infectious diseases, may possibly take place during the increase and spreading of the normal process of emigration of leucocytes to the surface which perhaps is a necessary link in the course of healing of those infectious diseases.

The constant presence of pyogenic micro-organisms in the mouth and pharynx of healthy persons, and even the few germs that were found in the normal tympanum might find their place in the following train of thought: we might see in them or in their increase at each pathologic alteration of the walls, factors which produce irritation inducing an increased emigration of leucocytes charged with morbid matter.

I can not refrain from at least hinting at my merely hypothetical ideas concerning this dark domain. They enlighten a number of facts established by observation, which so far were entirely beyond our comprehension, from a view point that makes those facts appear suitable for the general economy of the organism.

We have become acquainted with a number of causative features for the *pathogenesis of acute and subacute inflammations of the middle ear* through our clinical experience.

It is very easy to understand that an inflammation of the tympanum may set in after *direct injuries to the drum membrane* if for example the perforation was caused accidentally by pushing in an infected instrument, or if, in an indirect rupture of the membrane, an *injection* was made through the meatus which always contains pathogenic germs.

The etiological process is the same if fluid enters the drum cavity through the *tube,* as we see it often in nasal douches.

The observation made on a conductor suffering from diabetes may be mentioned here as an instructive example. Tortured by thirst he held his mouth directly under a water pipe and felt the water as it ran through his nose into the ear which was directed downward. A serious inflammation of the middle ear, with perforation of the drum membrane and profuse suppuration lasting for weeks, developed as a direct sequence.

Suppurations of the middle ear often start *after baths.* They are produced when water which enters into the pharyngeal ostium of the tube in plunging, is afterwards forced into the middle ear by blowing. In many cases there is an old perforation of the drum membrane.

Similar experiences show how easily watery fluids may pass through the tube, which by its form however, is protected from the entrance of normal secretions from the nose into its cartilaginous part. We can easily imagine that tenacious secretions which may have gathered there are ejected from the funnel-shaped entrance to the tube by any strong current of air which strikes against it. Under no circumstances can such secretions be forced higher up than the beginning of the slit-shaped part of the cartilaginous tube, the walls of which touch during repose. The movements of the ciliated epithelium of the tube are directed towards the pharyngeal ostium and will remove small particles, pathogenic germs, etc.

Injections of fluid into the middle ear through the catheter which were formery frequently used for therapeutical purposes are fortunately being more and more abandoned, as their harmful influence was sufficiently shown by the statistics of some authors.

Acute and subacute inflammations of the middle ear from the slightest to the severest perforative types are furthermore a frequent concomitant of *acute catarrhs* of the *nose* and *pharynx* as also of *acute angina.*

The changes of the mucous membrane progress through the tube to the middle ear, just as they do to other cavities of the nose, to the larynx and bronchi.

Artificial inflammations in the nose and pharynx as they are produced for example by galvano cautery advance with comparative frequency to the middle ear.

Violent otitis was often observed after *tamponing the naso-pharynx* which is caused perhaps by the extensive harm done to the ciliated epithelium.

Prolonged and recurring *occlusions* of the *tubes,* as clinical observation shows, are an extremely frequent cause for the onset of inflammatory processes with exudations in the middle ear. We became acquainted with their primary mechanical consequences in the last chapter. We shall see that it is easy to separate the cases with pure transudations from those in which inflammatory processes have set in.

We have no clear conception and can only pronounce suppositions as to the relation between the occlusion of the tube and the immigration or quick propagation of germs in the middle ear. The latter we must admit is a condition for the development of inflammatory exudative processes. Occlusion of the tubes will hardly interfere more than the normal tube with the propagation of inflammatory processes in their continuity or with immigration of germs. This does not explain why it occurs more frequently than in the normal.

The immigration is perhaps favored by the damage done to the ciliated epithelial surface especially as acute catarrhs are very frequent when adenoid vegetations are present.

It is possible also that, in a sudden piercing of the occlusion by abnormally high pressure of air, larger particles may be hurled through the tube, (the epithelium being probably partially defective) than would be possible through a normal tube which opens easily and has intact ciliated epithelium.

May this connection be as it will, the great importance of occlusion of the tubes for the development of otitis is proven by daily experience with our patients.

It must remain an open question whether or not *"catching cold"* which is mentioned in the otological statistics as one of the most frequent etiological factors plays really so important a part among the causes of inflammations of the middle ear either with intact or occluded tube. How careful we must be in accepting this etiology which is advanced especially by patients of the better classes, is shown by the fact that deafness caused by ear wax is also attributed to catching cold just about as frequently as inflammations of the middle ear. Even in plain view of large masses of ear wax removed from the ear we often hear the question: "So I must have caught a cold anyway?" It is therefore better that we desist from giving an etiological explanation of those rather numerous cases of genuine otitis for which we can find no other cause than to base our statistics on such unreliable statements of the patients.

We shall see in the chapter on suppurations of the middle ear how often each of the *different acute exanthemata and each of the other acute infectious diseases* is complicated by inflammatory processes in the middle ear. These diseases of the ear differ as to their seriousness and in many other regards from the genuine forms. Their clinical picture is mostly that of acute *suppurative* otitis media with more or less extensive destruction of the drum membrane. Systematic examination of the ears in post-mortems after different infectious diseases showed that the participation of the ear is much more frequent than was supposed from experience on the living, and that all the different degrees occur, from the slightest exudative processes of inflammation which are absolutely latent to clinical observation, because they are too insignificant to cause a perforation of the drum membrane, up to the gravest perforative forms with the most extensive decomposition and necrosis of the walls and contents of the middle ear.

It is well for the above stated reasons to distinguish between otitis with perforation and otitis without perforation, in spite of the fact that the same micro-organisms may produce the most diverse degrees of intensity of inflammation of the middle ear and that there is a continuous transition from the slightest to the most serious forms, which can especially be established by pathologic anatomical examinations. This distinction moreover does not offer any difficulties for our statistical studies.

Acute and Subacute Simple Inflammation of the Middle Ear Without Perforation of the Drum-Membrane. Otitis Media Simplex Acuta and Subacuta.

Otitis media simplex acuta and subacuta differ from each other only in their intensity and in the duration of the clinical symptoms.

8.9 per cent of all ear patients suffered from these diseases, according to my statistics. This is nearly the same percentage as that of affections of the tubes which is 8.2 per cent.

Children are, however, represented in the latter disease by 55.7 per cent, while in acute and subacute otitis media simplex only 22.5 per cent are children.

There is also a difference in the answer to the question whether one or both ears are affected, inasmuch as 77 per cent of affections of the tubes concern both ears while only in 31.1 per cent of cases of otitis media simplex acuta and subacuta both ears were affected at the same time.

The difference in the numbers just mentioned may be taken as proof of the fact that in the development of inflammatory diseases of the middle ear other causes than a pre-existing occlusion of the tubes must be active.

Otitis media simplex acuta shows the four cardinal symptoms which are characteristic of inflammations in general, namely, tumor, rubor, calor, dolor.

The clinical picture is often blurred by some serious general disease or by other causes which I have already enumerated. Whenever this is not the case the main subjective symptom is pain in the ear which is more or less severe, often spreading over the whole side of the head, starting mostly at night in the course of a catarrh, or influenza or even in the otherwise healthy organism. These pains increase in coughing, blowing the nose, swallowing, and especially when air enters the middle ear in belching. Pulsating noises and a very disagreeable feeling of fullness and pressure are felt at the same time.

We find on examination the next morning bright red *injection of the vessels of the drum membrane* along the handle of the hammer and of the radial vessels of the periphery. The redness may also be more diffuse, locating on the rear upper quadrant or spreading over the entire drum membrane. It is not unusual, especially in influenza, to find different sized, recent extravasations of blood along the handle of the hammer or on other spots of the surface.

The *temperature* may rise in the beginning to a high degree especially in children, although this does not mean that a perforation of the drum membrane is liable to occur.

There is a *swelling* of the cutis from the formation of an exudation which makes the drum membrane appear flatter, the handle of the hammer becoming indistinct.

The infiltration and redness may extend over the limits of the drum membrane to the cutis of the posterior upper wall of the meatus which is normally somewhat thicker than the remainder. This is the reason why the limits of the membrane on this part are often effaced or have disappeared entirely. Serous, or, especially in influenza, hemorrhagic blisters may form on the surface of the drum membrane if the exudation increases and may spread over the walls of the meatus.

Hearing may be comparatively good during the first day, although the phenomena of inflammation on the drum membrane may be very pronounced. Whisper may be heard at a distance of several meters. It decreases considerably during the next few days, although the symptoms of inflammation at the membrane diminish, yet it does not sink below 10 centimeters as a rule in a formerly normal ear.

Coincident with the progress of the disease the symptoms of gathering of secretions inside the drum membrane become evident. The membrane, especially its rear upper quadrant, bulges, which may be recognized partly from the more pronounced convexity of radial blood vessels and partly from the development of a crescent-shaped indistinct reflex appearing along the rear upper periphery. The epidermis of the drum membrane in extremely acute exudations may become infiltrated and torn, when some secretions may penetrate into the meatus for a very short while, yet no perforation exists.

Bulging of the drum membrane especially of its posterior superior quadrant is never absent in the beginning of the inflammation, even when the inflammation developed on the basis of an affection of the tubes, in fact it is as a rule even more pronounced and characteristic in these cases because some of the fibres of the drum membrane have previously undergone a certain amount of stretching. Later on when the acute inflammatory symptoms have ceased the characteristic retraction of the membrane connected with occlusion of the tube gradually replaces the bulging.

The functional tests bring forth many characteristic points for otitis media acuta and also subacuta. We can consider that the peculiarities which we find here depend upon the gathering of exudate in the surroundings of the sound conducting apparatus and upon the infiltration of its soft parts.

We find the same functional phenomena in acute perforative diseases.

Disturbances of function which are characteristic for the other diseases of the sound-conducting apparatus (fixations and defects) show striking modifications in exudative processes in the tympanum. Bone conduction is prolonged even to a considerable degree. Accordingly the tuning fork placed on the vertex sounds in the diseased ear. We do not obtain such decided and unvarying statements concerning the result of *Weber's* test in any other disease of the sound-conducting apparatus. However hearing of the lower end of the sound scale by air conduction is only slightly interfered with, sometimes apparently not at all, since the patient often hears sounds as low as 16 v. d. by air conduction. *Rinne's* test also is not by any means always negative but may be positive, though shortened, in spite of a considerable diminution of hearing for whisper (down to 10 centimeters).

The explanation for this varying functional attitude of the processes of exudation compared to fixations and defects of the sound-conducting apparatus must be sought in the fact that there is no fixation present, only an increased encumbrance of this apparatus with fluid.

The prolongation of bone conduction is effected here in a different manner than in fixation of the apparatus. The chain of ossicles instead of being fixed is only overloaded. It can therefore but incompletely follow the vibrations caused throughout the head by the tuning fork on the vertex on account of its increased weight and therefore increased momentum. Greater countermovements are thus caused in the chain than is normally the case in the unbalasted chain, which acts as a mass suspended freely movable in the drum cavity.

Hearing by air conduction may be little interfered with as far as pure sounds with their regular and steady vibrations are concerned. It may even reach the lower limit of the sound scale, as we can convince our selves for example in cases where the drum membrane is balasted by extensive deposits of chalk in the intermediary zone.

We can however easily imagine that hearing is seriously interfered with by every increased balasting of the sound-conducting chain, especially for such noises as constitute the consonants of our whisper, which produce a whirl of rapidly dying away systems of sound waves.

The disproportion between the hearing of speech and hearing of low sounds which are not perceived by air conduction in the other affections of the sound-conducting apparatus, can be thus understood in exudative processes of the drum cavity.

The above-described inflammatory symptoms of otitis media simplex acuta may develop to various degrees of intensity. The injection of the blood vessels may in one case be confined to the vessels of the handle of the hammer, in another case the whole membrane may show radiar injection, while in still another the surrounding meatus also may appear diffusely red.

Pronounced injection, extravasations of blood, serous and hemorrhagic blisters are found more frequently at times when there is an epidemic of influenza and we are often surprised to see how quickly these violent forms of inflammation disappear again.

Deafness is by no means always in proportion to the outwardly visible symptoms of inflammation. It depends mainly upon the swelling and the amount of exudation in the middle-ear and may remain considerable for weeks or even increase after the injection of the drum membrane has disappeared.

Each inflation of air through the tube, as long as there is considerable swelling or gathering of secretions in the drum cavity, produces only moderate improvement, which disappears again after a short time. We hear the air striking against the drum membrane at irregular intervals sometimes for a single moment only and then with a clapping noise if we auscultate the ear by means of an auscultation tube while inflating air through the catheter.

The *duration of the disease* sometimes extends over a few days only, and rarely transgresses several weeks, if a perforation does not occur, converting thereby the simple inflammation into a suppurative one. The symptoms of the inflammation of the middle ear gradually change back into those of occlusion of the tubes if the inflammation developed on the base of a pre-existing occlusion.

We call otitis media simplex subacuta those cases which present no distinct symptoms of inflammation other than the characteristic functional disturbances. These forms of disease concern more frequently both ears and run a more prolonged course. *Luës* is sometimes found in connection with them.

The *prognosis* of acute simple otitis is favorable throughout, also concerning full recovery of hearing, as long as a perforation of the drum membrane with its consequences for the surroundings of the ear does not occur. Some deafness however often remains in otitis media simplex subacuta. This may be partially due to the incompleteness of our diagnosis, as mistakes are easily made, on account of the negative findings of the drum membrane, if no careful functional tests are made.

For treatment of otitis media simplex acuta and subacuta considerable importance was always accorded to the simultaneous treatment of the nose and naso-pharynx. There can be no doubt but that a great number of acute inflammations of the middle ear can be prevented by prophylactically removing different causes for occlusion of the tubes, like adenoid vegetations, crusts in ozena, etc.

It seems sufficient however, to keep away harmful influences like smoke, dust, etc., if an acute otitis media has set in during a simple acute catarrh of the nose, or an angina, an influenza or an acute infectious disease. The washings of the nose which are so frequently used, even where no adherent and decomposed crusts have to be removed, are certainly not as harmless to the ciliated epithelium as is often maintained. The dangers of constant reinfection from the nose through the tube are overestimated according to my experience. There are mainly the nasal douches which if awkwardly handled by the patient may cause the entrance of infected fluid through the tube into the drum cavity. Gargles in the above stated manner (page 141) with normal salt solution or boric acid are indicated whenever there is considerable secretion in the naso-pharynx.

Most authors caution against removal of the pharyngeal or faucial tonsils during the hight of an inflammation of the middle ear.

The patient ought to be kept in bed as long as he has an elevation of temperature, the bowels must be well looked after and a moderate diaphoresis ought to be induced. Physical and mental exertion as well as alcohol must be avoided. Quick improvement of the power of hearing is sometimes observed after a Roman-Irish bath, if the course is protracted, especially in subacute cases. Cold douches on the head must be avoided; it is better to cool the head by application of cold moist towels.

The local pains may call for small doses of morphine (0.01) of phenacetin (0.75 pro die). The ice bag is applied over the mastoid process if the pain persists. Leeches and painting of the mastoid process with iodine had better be avoided, as they interfere with the observation of the mastoid process which may give us important points as to the spreading of the inflammation into the cells of the mastoid process, determining our further therapeutical actions.

The inflation of air through the catheter or by means of *Politzer's* method is, from the very beginning of the inflammation, by far the most important and the most effective local remedy.

Considerable aversion against inflation of air has been current during the last few years among a large number of otologists who think they ought to warn against its use during the hight of inflammation. The aversion is based on theoretical considerations and was prevalent once before at the time of *v. Troeltsch.* I consider this anxiety absolutely unjustified after many years of experience, as do my disciples, and as to its unrestricted use, I take *v. Troeltsch's* standpoint whose words I repeat as they are valid to this day:

"According to the statements of many authors I was formerly very timid as to the use of the catheter in acute diseases of the tympanic cavity and waited until all symptoms of inflammation had disappeared for fear of causing pain or harm to my patient. Now it is generally recognized that the earlier we use the catheter and the sooner we institute a local therapy calculated to spread and remove the secretions, the more we are able to shorten the inflammatory state. The passing of the air, which is no doubt difficult, instead of increasing the pain in the ear causes the patient's head to feel lighter and the pain to diminish perceptibly, though not always immediately. In short all his sufferings take a turn for the better. . . . It is sometimes surprising how after inflation the soreness of the mastoid process which was extremely sensitive to pressure and even to touch, decreases."

We will understand the favorable effect of the entrance of air into the middle ear when we consider that even in those cases in which the acute inflammation did not develop in connection with a pre-existing chronic occlusion of the tubes, the tube is occluded for some time during the hight of inflammation by swelling and gathering of tenacious secretions, and that all the consequences which we discussed in pure occlusion of the tubes will follow, such as rarefaction of air, hyperemia ex vacuo and transudation. The inflation of air has besides the instantaneous effect, a lasting influence on the course of the whole process of inflammation by restoring normal air pressure and spreading the secretions over a larger absorbing surface. We hardly ever have to recur to anodynes if inflation of air is practiced from the first day.

Its daily use is indicated as long as hearing is considerably diminished. Later on it depends on how long the improvement of hearing lasts each time. We repeat it as often as it becomes worse.

The inflation through the catheter is preferable to *Politzer's* method for a number of reasons:

Firstly, in using the catheter we are able to hear the noises and determine with our own ear whether or not the air penetrates as far as the drum membrane.

Secondly, we confine the inflation with the catheter to the diseased ear.

Thirdly, the current of air lasts much longer and its force can be regulated much better than in *Politzer's* method, where it enters only the moment of the act of swallowing and then often with a much greater force than we intended.

We will therefore use the catheter in the adult wherever the anatomical conditions in the nose permit. *Politzer's* method is however absolutely indispensable in children; through it acute inflammations of the middle ear, also affections of the tubes first became accessible to treatment.

Paracentesis of the drum membrane may become necessary in otitis media *simplex* acuta as we can not approximately estimate the amount of secretions gathered in the middle ear, nor whether they will be absorbed or will spontaneously perforate later on. The cases in which paracentesis is followed by a suppuration lasting for days or weeks are counted among otitis media *purulenta* acuta according to our principles of classification; if no suppuration follows they are counted among otitis media simplex acuta. Paracentesis was performed in 4.4% of cases without consecutive suppuration worth mentioning among the 935 cases of simple acute otitis media of my statistical compilations. The precautions during and after paracentesis are the same which I recommended to you in gathering of serum in occlusion of the tubes.

LECTURE XVIII.

Acute Inflammation of the Middle Ear with Perforation of the Tympanic Membrane.

Otitis Media Purulenta Acuta.

Gentlemen:—We call acute suppurations of the middle ear all those cases in which a perforation develops in a previously intact drum membrane followed by a purulent discharge from the meatus. All cases in which we prevent the spontaneous perforation of the pus by a paracentesis come also under this heading upon the condition that the succeeding suppuration corroborates the accuracy of our diagnosis. An acute suppuration in the middle ear may finally perforate, not through the drum membrane, but through the bony walls at various places of these extensive cavities and extend into the surroundings, under the periosteum or the nearest soft parts. These may be the outside surface of the mastoid process, its lower surface along the bony meatus or finally on the cerebral surface of the temporal bone, raising the dura along the sinus sigmoideus, or the tegmen tympani et antri or at any other part of the dura as far as the diseased pneumatic cavities of the middle ear may extend.

Our attention is often directed toward an extension of this kind by the long peristence of the functional disturbance accompanying an acute otitis media simplex and a number of other local and general symptoms indicating the opening of the cavities of the middle ear by operation. In cases which are not accompanied by a perforation of the drum membrane, the finding on opening of pneumatic cells filled with pus puts us in a position to verify the accuracy of our diagnosis of acute suppuration of the middle ear.

We shall see how we differentiate otitis media *purulenta acuta* from otitis media purulenta chronica in describing their clinical picture and the course of recovery.

It seems superfluous to me to put subacute suppurations of the middle ear under a separate heading as some authors do, because subacute like acute suppurations usually heal with closing of the opening in the drum membrane, and no distinct line can be drawn between the two.

Otitis media purlenta *phthisica* has been classed with chronic suppurations of the middle ear, for reasons which we shall give later on.

Otitis media purulenta acuta was observed in 6.4 per cent of ear patients according to my statistics extending over 21 years.

Children are represented by *41.4* per cent, which is nearly double the number of otitis media acuta and subacuta simplex (22.5 per cent) but not as many as in simple affections of the tubes (55.7 per cent).

Acute suppuration of the middle ear attacked *both ears* in only 14.0 per cent while otitis media simplex acuta and subacuta attacked both ears in 31.1 per cent and affections of the tubes in 77.0 per cent of cases.

The latter figures are of special interest as to pathogenesis since they show that there must be local causes often confined to one side only, in the development of suppurations of the middle ear from occlusion of the tubes, and also from an increase of simple otitis media to well defined suppurations.

It must not be forgotten that the statistical figures of the ear surgeon can not approximately give an accurate idea of the real frequency of acute inflammatory processes in the middle ear, neither as to otitis media simplex acuta and subacuta nor as to otitis media purulenta acuta.

We obtain much better information as to their frequency *from systematically pursued examinations of the middle ears of cadavers.*

I have already explained to you (compare page 157) that in more than 80 per cent of all *infants* of less than six months variable quantities of partially purulent secretions were found in the middle ear.

Purulent inflammations of the middle ear from the slightest to the most serious degrees were found in *all* post-mortems after *measles,* scarlet fever and smallpox. Similar observations were made in diphtheria and the other acute infectious diseases, though not always with the same frequency and intensity (compare page 160).

The pathogenic bacteria found in infants are mostly pneumococci, while in measles and scarlet fever almost always streptococci are found, which are considered especially virulent in the middle ear.

It is therefore fair to suppose that there is hardly a human being in whose middle ear there was not pus once or several times during life.

The great majority of these inflammatory processes in the ear do not cause a perforation through the drum membrane or through any other part, and even run entirely hidden from our clinical observation. They only produce subjective and objective symptoms which draw our attention to their existence, after they have reached a certain degree of intensity.

We can draw the important and consoling conclusion from all these facts gained by observation on the cadaver and on the living, that the lining of the middle ear can get rid of a certain amount of purulent secretions and pathogenic organisms without our interference. The organ of hearing and its surroundings are in danger when the exudations and bacteria surpass a certain amount; then some therapeutical action becomes necessary.

Another fact becomes evident from the pathologic anatomical observations just described. We find all degrees of acute processes of inflammation in the middle ear which have no sharp limits, but pass in gradual transition one into the other. Still as before mentioned a separate discussion of inflammation of the middle ear with perforations of the tympanic membrane appear necessary, because with the occurrence of the perforation something new is added, modifying the course of the inflammations causing complications, making the prognosis worse and changing our therapy.

The etiology of otitis media purulenta acuta is the same as of otitis simplex acuta. It may occur just as well as a consequence of local harmful influences like *nasal douche,* traumatic *rupture of the drum membrane,* or in connection with long lasting *occlusion of the tubes,* a *catarrh of the nose,* an *angina,* as by a complication of the acute general infectious diseases, especially influenza, measles, scarlet fever, smallpox, typhoid fever. An *erysipelas* migrating over the surface of the drum membrane may sometimes cause an acute suppuration of the middle ear.

Special attention must be called to a few facts. Perforations followed by more or less profuse suppurations may arise from slight inflammatory symptoms in the ear quite often in some general infectious diseases, especially scarlet and typhoid fever, also after serious forms of measles and influenza, while the genuine cases of otitis after catarrh in an otherwise healthy organism rarely lead to perforation of the drum membrane. The difference between otitis arising under the influence of some general disease, and the genuine forms, becomes much more characteristic in their later course. Destructions, rapid enlargement of the perforation in the drum membrane, necrosis of the ossicles, necrosis of the lining of the middle ear and of its bony walls may progress under our eyes in the first class of cases, in a manner that we never see in an otherwise healthy organism. We have to admit from our observations, that the clinical picture of acute otitis media becomes very much modified in the first place by any serious infectious disease diminishing the power of resistance of the whole organism.

In attempting to study the clinical picture of pure otitis media purulenta acuta we have in the first place to exclude the different modifications caused by some serious general disease, and consider only the symptoms of the *genuine* acute suppuration of the middle ear, which occurs in an otherwise healthy organism either spontaneously or after catarrhs, etc. The acute influenza otitis does not materially differ from them as a whole.

The inflammatory symptoms are more pronounced from the beginning on an average in the cases of otitis media purulenta acuta which lead to perforation of the drum membrane, than in otitis media simplex acuta which heal without perforation. This is not true for all, maybe not even for the majority of acute suppurations of the middle ear. A perforation occurs sometimes after moderate pain which lasts for a short while, perhaps for a few hours only, and without serious local reaction, especially in cases where the drum membrane is partially very thin on account of occlusion of the tubes existing for a long time, or from old suppurative processes healed by scars.

The inflammatory reactions in case a perforation occurs in a formerly normal drum membrane, are in the beginning similar to those described in otitis media simplex, only as a rule more violent. *The temperature* especially in children may rise in the beginning of the disease up to 104° F., and may exceptionally remain high for weeks. *Cerebral symptoms* like vomiting, cramps, somnolence may usher in the disease. Temperatures of 104° F. before the perforation are however the exception in adults. The *pains and pulsating* noises are sometimes so disagreeable that colleagues for example often ask eagerly for a paracentesis, "even if the hearing be lost." *The injection of the drum membrane* is in such cases very marked and spreads diffusely over the deeper part of the bony meatus which may be concentrically narrowed on account of oedematous swelling Numerous hemorrhagic spots or serous and hemorrhagic blisters may develop on the tympanic membrane and extend far over the walls of the bony meatus especially during epidemics of influenza. An abundant fibrinous exudation sometimes forms on the excoriated surface after such a blister has burst. Its formation is always connected with exorbitant pain.

A serious infiltration of the membrane, if its surface remained visible, may be recognized by maceration of the external layers of the epidermis. They become white and crack in all directions, resembling an irrigated field of sand, which appearance they keep during the first few days after the perforation.

The sensitiveness to pressure of the mastoid process is a symptom which allows us to draw the conclusion with reasonable accuracy that there are considerable quantities of secretion in the drum cavity and in the other spaces of the middle ear. There is especially *one* spot which must be considered characteristic in this regard. It is the rear end of the antrum found by pressure with the finger in the fossa mastoidea, directly behind the line of insertion of the auricle. The point of the mastoid process also from the beginning is often sensitive to pressure. Pain extends sometimes over the whole external surface of the mastoid process and its bony surroundings.

Considerable relief is felt after the perforation of the tympanic membrane which sometimes occurs after a few hours, sometimes after a number of days and after repeated increases and decreases in the violence of all subjective symptoms. Pain and increase of temperature may persist during the following few days.

The discharge which occurs after the perforation took place is muco-purulent in the milder forms from the beginning, in the more violent ones serous during the first few days, although containing numerous leucocytes. It is more or less hemorrhagic and so profuse that for days the cotton is soaked every 5 to 10 minutes. The quantity of the secretion corresponds probably to the extension of the diseased cells, but it may be extraordinarily abundant even in infants. The secretion becomes muco-purulent after having been serous for a few days. Toward the end it becomes gradually semi-transparent, i. e., containing less cells, though it always remains more or less viscid. Discharge usually stops rather suddenly when the perforation of the membrane closes.

The opening which forms in genuine acute suppuration of the middle ear in an otherwise healthy organism and in a formerly normal drum membrane, in most cases can not be seen as such while examining with the speculum. It is always small and *does not enlarge during the course of the disease.* Its margins are so much swollen on account of the inflammatory reaction pertaining to the healthy organism, that they touch each other the next day, even though we enlarge the opening by paracentesis.

Its place, however, can easily be recognized from the constantly returning drop of fluid. In case it does not appear spontaneously the patient may either be asked to perform *Valsava's* experiment or while an assistant performs *Politizer's* method we inspect the drum membrane and see the fluid escaping from the opening at the time the air is forced into the middle ear. Very extended pulsating motions can often be observed on the light reflexes forming on the fluid in the external meatus. This motion is transmitted to the fluid by the highly injected blood vessels of the middle ear.

A noise of perforation is sometimes not heard at all, sometimes only if considerable air pressure is produced on account of swelling of the walls of the tube and of the tympanic cavity. Corresponding to the narrow opening more or less obstructed by tenacious mucous a shrill sound is produced and can be heard at a great distance.

Many wrong ideas are prevalent as to the *position of the perforation in the drum membrane.* A number of text-books say that it is usually in the inferior anterior quadrant, and some authors believe that they saw an acute perforation in the membrana flaccida *Shrapnelli.* Mistakes as to the position are easily possible, because the limits between the membrane and the meatus, owing to swelling and redness, have more or less disappeared, and on the other hand, because a large part of the membrane is often covered from our view, by the bulging and later on granulating upper part of the membrane which comes very close to the anterior inferior wall of the meatus.

The real seat of the perforation in such cases can only be located after long continued observation and careful sponging with a probe wrapped with cotton.

Careful observation of many years especially directed to this point taught me that a perforation in genuine acute suppurations of the middle ear is only exceptionally located in the anterior inferior quadrant and never in *Shrapnell's membrane.* In the vast majority of cases I saw it in the *rear* half of the membrane and most frequently in the posterior upper quadrant, less frequently in the posterior inferior quadrant or below the umbo. It is always in the thinnest intermediary zone of the membrane.

All these details are important for the prognosis. A perforation which is clearly visible as a black hole points to deficient reaction of the margins. This may be due to the fact that it occurred in an old atrophic scar of the tympanic membrane or that the reaction is wanting on account of some serious general disease. A more or less pronounced tendency to spreading of the destruction of the membrane is even characteristic for suppurations of the middle ear which develop as a complication of some general disease. The position of the perforation in these cases also differs frequently. We find a hole in the anterior inferior quadrant especially in tuberculosis, where it appears to be small because we can only partially see the anterior inferior quadrant. In other cases of tuberculosis it is in the periphery and enlarges under our eyes, or multiple perforations develop. All these occurrences simply do not happen in a healthy organism and in an otherwise normal membrane. The condition of the perforation is therefore to a certain extent a gauge for the seriousness of the constitutional changes during some general disease. A fresh perforation sometimes becomes larger in old people, and also in septicopyemia, whether of otitic origin or not.

It is often impossible to decide whether the yellow spot of pus on the top of the prominence corresponding to the perforation is in the rear upper quadrant or in *Shrapnell's* membrane if the margin of the membrane is effaced by swelling and redness. Continued observation may later on convince us that the perforation is not above but below the rear liminal strands of the membrane. Even the pictures of so keen sighted an observer as *Politzer* could not convince me in this regard. Fibrinous exudations on the tympanic membrane and formation of protuberances in the rear upper quadrant, etc., may easily mislead us.

We shall see later on in speaking about chronic suppurations of the middle ear with formation of cholesteatoma how perforations of *Shrapnell's* membrane really occur.

The opening in the tympanic membrane may temporarily close when, in the course of the inflammation, the secretion decreases. It sometimes gathers anew and bursts through the scar.

Considerable swelling of the margins of the perforation sometimes causes the formation of a large *conical prominence.* A red button-like growth is seen on its top through which the pus discharges. Cone-shaped perforations are found especially when profuse discharge has existed for a long time; or in the first few days of violent inflammations, especially in influenza-otitis. This growth, if removed with a snare, shows a long perforating central canal similar to a fistula.

The *power of hearing* decreases even more in the course of an acute suppuration of the middle ear than in otitis media simplex. Whisper is however always understood at a distance of several centimeters by an ear which was normal before; an a′ tuning fork can also be perceived for some time by air conduction, if the labyrinth is not implicated in the inflammation to any great extent.

The examination of the lower limit, *Schwabach's* and *Rinne's* tests give similar results as in otitis media simplex acuta (compare page 162). A considerable loss of hearing of the highest sounds is often found down to the mark 3 of *Galton's* whistle (18,000 v. d.).

The suppuration may have run its course in a few days, but it may also last several weeks or months with or without interruptions. I have seen it last even longer than a year in some cases, and yet it healed, the perforation closing and the normal function returning.

I have *never*, in an otherwise healthy organism, seen a *genuine* suppuration of the middle ear become chronic nor develop a persisting or enlarging perforation.

The clinical picture of the numerous *acute suppurations of the middle ear* occurring in connection with *different acute general infectious diseases* varies greatly in many regards.

A large perforation may, though exceptionally, form in more violent forms of influenza otitis together with extensive extravasations of blood and blisters which were mentioned as characteristic. Large perforations are more frequent in otitis in connection with measles and typhoid fever. I saw 48 cases equal to 4 per cent, of acute suppurations of the middle ear in 1,243 cases of typhoid fever, most of which had large perforations in the membrane. In comparison to other diseases the ear suffers rarely in diphtheria but in some epidemics of scarlet fever *Burkhardt-Merian* found even 33.3 per cent of such complications. These cases do not only show the most extensive destructions but they even most frequently involve both ears. The ossicles may be expelled after a few weeks. More or less complete deafness may result from implication of the labyrinth. Among 233 acquired deaf-mutes I established scarlatina as the cause of this affliction in 42, equal to 18 per cent.

The clinical picture in the ear differs totally from the very beginning from that in genuine suppuration of the middle ear. I saw for example discolored fetid secretions in the meatus of an ear in which an extensive perforation had taken place during the previous night. Fetid secretions in acute genuine suppuration of the middle ear occur very late and only as a consequence of gross neglect.

I saw another case where within six days the whole tympanic membrane was destroyed and the handle of the hammer became necrotic at the hight of scarlet fever. The prognosis as to the general disease in the face of such a rapid destruction is with great certainty fatal.

Paralysis of the facial nerve, an extreme rarity in genuine forms, is often seen here.

The glands are usually more swollen than in genuine otitis, and may suppurate, which never happens in genuine otitis.

We shall see later on what a large number of chronic suppurations with all their consequences have to be attributed to scarlatina.

We will now discuss *the treatment* of uncomplicated cases of otitis media purulenta acuta.

Inflation of air into the middle ear is the remedy which at the very beginning of the inflammation, when it may still be doubtful whether we have to deal with a simple or suppurative form, often soothes the subjective symptoms to such an extent that we can avoid the use of anodynes. It ventilates the spaces of the middle ear and aids absorption of the secretions by spreading them over a larger surface. We apply an ice bag to the mastoid process at the same time and keep the patient in bed whenever possible. A paracentesis with the described precautions (compare page 152) is indicated if serious symptoms of inflammation, especially sensitiveness to pressure of the mastoid process, persist until the next day or if the hearing distance decreases and the bulging of the membrane increases.

Some colleagues try to avoid this small operation in many cases. I can not support this standpoint as I became convinced from many years of experience that early paracentesis affords speedy relief and shortens and ameliorates the course of the process.

The paracentesis is succeeded by inflation of air in order to evacuate the secretions from the drum cavity. We perform the inflation through the meatus especially when otitis occurs in the course of some general infectious disease and in ozena, as we are able to disinfect the meatus, but never the complicated cavities of the nose and naso-pharynx. We do not need to be afraid of *Politzer's* method later on, after the nose and naso-pharynx have become free, it then forms an essential part of each cleaning of the middle ear. Irrigations of the tympanic cavity through a catheter in the tube which were formerly so frequently used, are now generally recognized as harmful and have therefore been abandoned.

To give you an idea of how frequently paracentesis is indicated I might say that it was performed 454 times, equal to 27.1 per cent, in 1,677 cases of otitis media purulenta acuta observed from 1887 to 1901.[1])

In 1879 shortly after *Lister* established the antiseptic properties of boric acid which came into his hands as a secret remedy from Sweden, I reported its favorable influence in powder form, in acute and chronic suppurations of the middle ear.[2] This was at a time when the bacterial origin of these processes was unknown, as is evident from the expression "acute and chronic purulent *catarrh*" which was then used. Antiseptic

[1] Dölger, Die Mittelohreiterung, auf Grundlagen der statist. Berichte *Bezolds* 1869—1896. Münch. 1903. Lehmanns publ. (Table IV).

[2] "Zur antiseptischen Behandlung der Mittelohreiterungen". Arch. f. Ohrenhlk. vol. XV. 1880.

remedies were then only used in fetid otorrhoea, namely, solutions of permanganate of potash and carbolic acid which are very injurious to the lining of the middle ear.

The treatment of acute and chronic suppurations of the middle ear by means of boric acid prevailed during the next few years until *Schwartze* cautioned against the use of the powder on account of retention of secretions in small perforations situated high up in the membrane. This complaint was repeated over and over again by some colleagues, although a number of older authors who became well acquainted with treatment by means of boric acid, called the scruples of *Schwartze* exaggerated.

All the manifold dangers of acute suppurations of the middle ear became apparent only since then, when also their real connection with the local focus of the disease was carefully studied.

Very careful histories were kept in my statistical records, extending over 28 years, of all fatal and non-fatal complications of suppurations of the middle ear. My conviction that there is not one case in which boric acid treatment can be kept responsible for the dangerous occurrence is based on this large material.

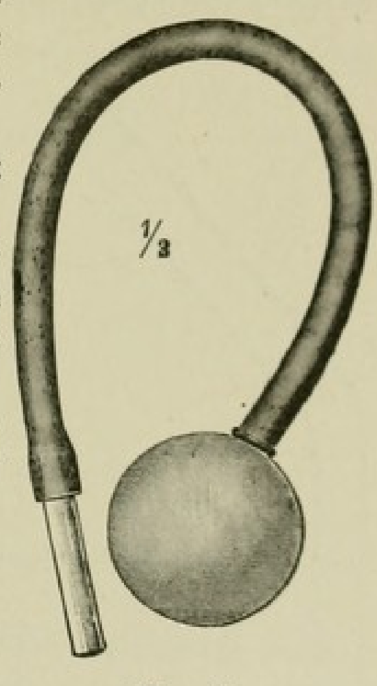

Fig. 61.
Simple powder blower.

We are able by means of boric acid treatment to avoid reinfections from the meatus through the opening in the drum membrane in acute suppurations of the middle ear, even though its influence is not quite so evident there as in chronic cases containing putrid decomposed secretions.

Secondary otitis externa, excoriations, formation of granulations and furuncles in the walls of the meatus, formerly so frequently seen as consequences of large quantities of pus constantly passing through the meatus, have nearly entirely disappeared since boric acid treatment was introduced.

The insertion of a strip of gauze down to the tympanic membrane and tamponade of the meatus so much used during the last few years can only safely be performed by the hand of a physician, and is a poor substitute for boric acid powder, since it rests on the membrane and absorbs the secretion by capillary attraction.

There were only very few cases of idiosyncrasy against boric acid powder in patients otherwise disposed to eczema. This idiosyncrasy showed itself in eczema spreading over large areas of the face, starting from the meatus (compare page 85). We confine our treatment in such cases to washing with 4 per cent solutions.

Our procedure after performing a paracentesis is as follows:

Inflation of air through the meatus and insufflation of carefully dried boric acid powder by means of a powder blower, consisting of a rubber bulb and tube into which a glass tube is inserted, which can be changed for each patient.

The ice-bag is used for hours at a time as long as the mastoid process is at all sensitive to pressure. Patients who could not stand the ice-bag were hardly ever met with, therefore there was never any need of replacing it by warm linseed poultices.

Leeches have not been used for years, as in producing lymphangitis they often interfere with our decision, concealing those very important symptoms (sensitiveness to pressure) on the mastoid process.

An injection of 4 per cent warm boric acid solution is made not oftener than *once* a day, no matter how profuse the suppuration may be.

Inflation of air by means of *Politzer's* method follows this procedure if the naso-pharynx is free from inflammatory secretions, otherwise the inflation takes place through the meatus.

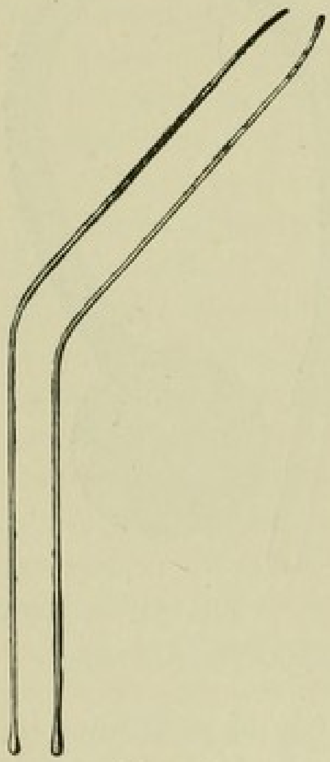

Fig. 62.

Probes for the right and left meatus.

The fluid in syringing passes only exceptionally through the narrow opening in genuine acute suppurations of the middle ear even though high pressure is used. This however occurs regularly in the larger perforations, formed in the course of otitis following acute infectious diseases. Therefore we have to be more careful in those cases. Children ought to be laid face downward during the injection, so that the fluid may run through the nose, and that they may not swallow too much of the saturated solution of boric acid.

The careful drying of the meatus is a very important point. It is accomplished by sponging with a probe without a probe-end wrapped with cotton, and curved to correspond to the axis of the meatus (compare fig. 62); in order to reach the deepest parts of the recessus.

The patient is requested to repeat *Valsalva's* experiment at short intervals when each drop showing at the perforation, is caught with the probe wrapped with cotton. This is repeated under control through the speculum till no drop shows and all secretions are removed from the tympanic cavity. The powder is then insufflated.

Here are the most important advantages of this method: Firstly, the secretions never become fetid. This only occurs very exceptionally, in acute suppurations, usually after some unsuitable treatment, like poulticing.

Secondly, the meatus remains free from inflammations and swelling during the whole duration of the treatment.

The epidermis of the external canal in patients who consult us after the perforation has existed for some time, is generally considerably thickened and macerated. It becomes smooth, the excoriations heal in a few days and the canal remains without symptoms of inflammation during the entire treatment. We are able to see the whole tympanic membrane at all times, and especially to recognize the very beginning of the ominous swelling of the rear upper bony wall of the meatus indicating a more intensive implication of the cells of the mastoid process.

Small operations on the tympanic membrane very often become necessary in the course of the suppuration.

A perforation located, as it frequently is, in the rear upper quadrant must be enlarged downward by means of a lance-shaped (not sickle-shaped) knife.

The paracentesis must often be repeated four times and more at the same place, as soon as it becomes impermeable to air during inflation and

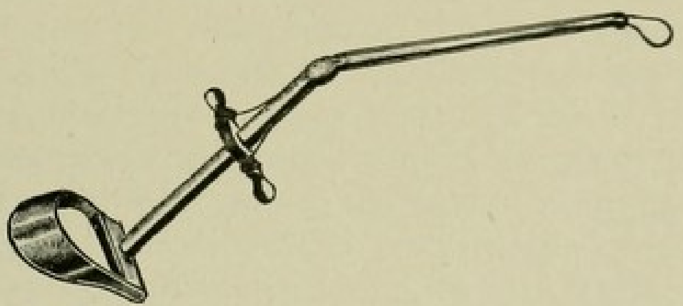

Fig. 63.

Wilde's snare.

when pus gathers again, sometimes showing through the bulging membrane.

Special attention must be paid to the button and nipple-shaped growths on the place of the perforation. They must be split downward if they are in the rear upper quadrant or a new incision in the rear lower quadrant must be made as soon as the growth interferes with the free passage of secretions or air during inflation.

They are removed by means of *Wilde's* snare (compare fig. 63), if the growths are large enough. The growth has a central aperture if we succeeded in removing it at its base. We have therefore shortened the length of the canal of perforation to the extent of the hight of the growth thereby creating better drainage. These growths especially in influenza otitis have a peculiar tendency to quickly reappear, requiring repeated removal by means of the snare.

I never destroyed the growths by means of chemicals or galvanocautery, since I do not consider indifferent the formation of a scab or inflammatory reaction at the place of perforation.

The removal of the growth by means of the cold snare and the paracentesis performed under antiseptic conditions are never followed by inflammatory reaction, and are entirely sufficient to keep the opening patulous until the suppuration in the tympanic cavity ceases.

The safest criterion for allowing the opening to close is the return of a more or less normal hearing distance of 4 to 5 meters for whisper.

After the perforation has closed it is advisable to continue the inflation of air at greater intervals, in adults by means of the catheter, in children by means of *Politzer's* method, until the patient hears no more noises while blowing the nose and hearing has become entirely normal.

Although hearing of speech has become normal the tuning fork on the vertex may still be heard in the affected ear for a comparatively long time and the highest sounds, that normally can be heard and are produced by *Galton's* whistle, can not be perceived.

LECTURE XIX.

Empyema of the Mastoid Process in Acute Inflammation of the Middle Ear.

Gentlemen:—The various diseases which may develop as consequences of acute inflammations of the middle ear are induced almost without exception by an intense and extended implication of the pneumatic cells which converge into the mastoid antrum.

The antrum and the cells probably always take part in even the slightest inflammations of the middle ear which show any clinical symptoms. Every one can easily convince himself of this fact by examining at the post-mortem table a number of organs of hearing of people who had acute exanthemata, but never showed any symptoms during life. *Topeitz* and I for example found inflammatory processes in measles and *v. Gässler* in scarlet fever regularly, even during the first few days of the general disease. The process consisted of formation of muco-purulent or clearly purulent secretions, which were not confined to the tympanic cavity but extended over the antrum and the nearest pneumatic cells, although the outside of the tympanic membrane showed no inflammatory symptoms whatsoever. Streptococci and other pathogenic organisms were always present.

The fact that an implication of the cells of the mastoid process is the rule even in the mildest forms of inflammation of the middle ear which remain absolutely latent, leaves no possible doubt that the same is true in all serious cases with perforation of the membrane. It is supported by our experience at the operating and post-mortem table.

A spontaneous evacuation of purulent secretions which may have gathered in the complicated system of cells with narrow exits through a perforation or through the tube, is impossible.

All the milder acute suppurations of the middle ear and the majority of serious ones nevertheless recover without operation if decompositions, etc., acting from the outside and in the meatus can be kept away. The supposition is therefore justified that the purulent secretion in all cases which recover spontaneously is absorbed in the cells.

The secretion perforates however in some cases through the bony walls of the cells into the soft tissues surrounding the temporal bone on the outside and the inside. The consequence of such a perforation is a gathering of pus either between the periosteum and the bone or in the interstitia of the soft tissues which is identical to an abscess.

The cause for the fact that a perforation occurs and that no absorption of pus in the cells takes place must not be sought for in the nature, nor in the quantity, nor in the virulency of the pyogenic organisms, but in special *anatomical* conditions; *superficial position of the cells, thinness and dehiscencies of their walls,* and especially single *cells of very large size.*

The superficial position of cells filled with pus often becomes evident in operation, when the first blow with the chisel evacuates pus. The importance of the *size of each single cell* for the absorption of the pus becomes evident, if you remember that the surface of a ball increases in proportion to the square of its diameter, while its contents, to the cube. The power of absorption of the walls decreases therefore with the increase of the size of the cell. The smaller the single cells are, the easier they will master the pus they contain and the number of cells that are inflamed is immaterial.

You will remember that I told you in describing the anatomy that the terminal cells are in the periphery, far away from their central confluence, the antrum, and that in some cases they form very large round cavities. An empyema, i.e., a gathering of pus which can not be spontaneously absorbed may develop wherever there are such large terminal cells in a temporal bone.

Scheibe very accurately described the histological processes occurring in such large cells filled with pus.[1]

The lining of the cells contains very many blood vessels, is 40 to 80 times as thick as in the normal and changed into a lobulated granulation tissue rich in lymphocytes. The bony inner surface of the cells is eroded all over by small dimples and in each one there is a multinuclear giant cell (osteoclasts). These erosions extend over the adjoining bony canals and cavities containing marrow, they become enlarged and contain more cells than normal. Little by little in all directions an excentrical enlargement of the cavities filled with pus is thus effected, until it reaches the dura inwardly, or most frequently the protruding wall of the sinus and outwardly the periosteum at some place of the mastoid process. Thus a fistulous perforation occurs on the latter surface, if the process is not interfered with. The formation of osteoclasts and their bone wrecking occupation comes to a standstill as soon as the pus is evacuated, and a layer of cells containing *one* large nucleus takes their place on the walls of the diseased spaces. They are the osteoblasts which at once form os-

1) Aetiol. und Pathol. des Empyems im Verlaufe der akut. Mittelohreiterg. Zeitschr. f. O. Vol. 48, 1904.

teoide substance and this later on becomes ossified all around and in the focus. At a greater distance from the focus of suppuration the occupation of the osteoblasts and the formation of osteoide tissue begins long before the evacuation of the pus.

The picture of rarefying ostitis (*Volkmann*) and its process of healing are so presented here that we can study them in rare perfection.

Much confusion was produced in the ideas of otologists by calling this process caries, and we had therefore better avoid this expression here, as the term caries is applied to a progressive process of destruction of the bone. Destruction in the formation of an empyema progresses only until the pus at some place is drained from the bony cavity. New formation of bone takes the place of destruction as soon as drainage is accomplished. It fills the defects in a short time and progresses further, with the result that the cell becomes smaller than it was before the empyema.

An admirable purpose becomes apparent from the whole sequence of these processes.

The natural opening of these cavities does not occur as the surgeon dictates it, that is exclusively toward the outside, the enlargement of the cavity takes place excentrically in *all* directions. Sometimes the bony walls of the dura and sinus are destroyed to a large extent at the same time that the outside of the mastoid process is reached. The dura itself and the walls of the sinus however show a great power of resistance, at least in the healthy organism, although not without exception. They may be bathed in pus for weeks without sustaining any damage. The openings in the outer wall of the mastoid process are usually small and are found most frequently at the very place which for anatomical reasons appears the most suitable for artificial opening, namely in the fossa mastoidea situated exactly outward from the antrum. The process of healing together with extensive restoration of bone lost either spontaneously or by operation requires, as we now know, from three to five weeks, if we attend to the drainage of the pus from the surrounding soft tissues and from the bone by sufficiently enlarging the perforation.

Suppurations of the middle ear occurring as complications of some general disease do not run their course with the same typical regularity as those developing in the healthy organism.

There is in the latter class of cases *absorption of bone* and very intense reactive inflammation of the soft parts. In the first class the soft tissues also may decompose, so that the bone becomes stripped and its nutrition more or less seriously interfered with, pieces of bone of any size may later on be cast off as sequestra. For example in some cases which had to be operated upon during the hight of scarlet fever, measles or typhoid fever all the cells were found white and stripped of all soft parts after removal of the outer plate of bone at the surface of the mastoid process. All parts that are stripped of periosteum are only exceptionally expelled as sequestrum. As a rule the bone becomes pinkish and granulations begin to form on its surface though sometimes only after two weeks.

The formation of one or several small *sequestra* on the walls of the cells is not rare in connection with acute inflammatory disease.

The diminished power of resistance and reaction is furthermore shown in those cases by a *frequent participation of the facial nerve and the extension of the suppuration to the labyrinth.*

We can not always expect a typical course of the process of recovery in the cases connected with some general disease, even if we interfere in time. In the large majority of cases however the process will take a more normal course as the general organism gradually recovers.

We shall discuss here only the perforations of acute empyema at the *outer surface* of the skull and their symtomatology.

The *inward* perforations and the intracranial complications in connection with them, have so many things in common with the sequelae of *chronic* suppurations of the middle ear, that we had better discuss them later on.

The outer surface of the mastoid process, as was before mentioned, is the most frequent location for the formation of a fistula. Perforations at the *lower* surface of the temporal bones are less frequent, but not at all rare. The cells at the *root of the zygomatic process* finally may cause a perforation in only very rare cases.

The three different locations possible of the perforation produce three characteristic clinical pictures.

1. *Perforation through the outer surface.* The sternocleido mastoid muscle, the splenius and longissimus capitis muscles are inserted at the posterior inferior part of the outer surface of the mastoid process. The most frequent case is a perforation *above* the insertion. The escaping pus can detatch the periosteum downward only as far as this line of insertion, and the point of the process as well as its surroundings remain free from swelling. The elevation of the periosteum extends below the auricle which does not insert in a simple curved line but into a broad surface of the bone (compare fig. 16 page 33). The consequence is a change of position of the auricle on the side of the head, namely, an elevation, a more or less perpendicular position and a drooping of the upper part sometimes amounting to 2 centimeters. The swelling very soon begins to fluctuate in the depth, and the subperiostal abscess extends backward, upward and forward at varying distances according to its duration. The swelling, but never the fluctuation, may extend below the insertion of the muscles down the neck, if there is not a second perforation below those insertions.

This form is most marked and most characteristically developed *in children* whose temporal bones have developed no pneumatic cells downward and inward. Although they have no cells, the empyema in children of a few years perforates on the outer surface of the process much oftener producing subperiosteal abscesses than in adults, because their antrum is comparatively very large and its rear end is very superficial. The sutura mastoideo-squamosa runs vertically through the rear end of the antrum, it often persists in this age and favors thereby a perforation at this place. A large sequestrum, shaped somewhat like a pyramid, is formed which has for its limits forward the sutura tympanica posterior, backward the fissura mastoideo-squamosa and upward the crista temporalis (compare fig. 64), if the process lasts for some time in a poorly nourished child, or after a serious general disease. The auricle as a whole moves far away from the skull, which position alone may suggest the presence of a sequestrum in the depth. The lymph glands surrounding the mastoid process may become considerably enlarged, and even, especially after scarlet fever, form an abscess, if there are general diseases or serious anomalies of constitution present.

2. *Perforation on the lower surface of the temporal bone.* Exceptionally large cells are often found in the adult and especially in later years, on the inner surface of the mastoid process, sometimes extending medial from the incisura mastoidea as far as the bulb of the jugular vein

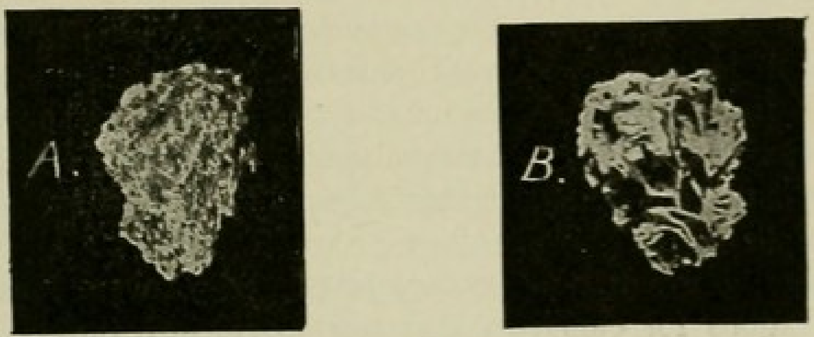

Fig. 64.

Sequestrum representing the mastoid process of a child, removed by operation.

a outer, *b* inner surface.

(compare fig. 7h). Their walls are often very thin and even have dehiscencies. Perforations in the subsequent course of acute suppurations of the middle ear at these places are therefore frequent in later years. They produce a very distinct clinical picture, differing completely from the foregoing, and in literature are often called *Bezold's* mastoiditis, because I studied its development experimentally on the cadaver.[1]

The pus escaping through these perforations cannot reach the surface, as they are below the very extended and solid insertions of those three muscles, and therefore below the deep fascia of the neck. No fluctuation can be felt. A moderately sensitive swelling develops rather suddenly in the lower surroundings of the mastoid process concealing its contours from the eyes and the palpating finger, after an otitis media purulenta acuta has lasted for weeks or months, or not rarely, even after it had ceased in the tympanic cavity, and a nearly normal hearing had returned. The suppuration spreads gradually in all directions in the interstitia of the

[1] "Ein neuer Weg für Ausbreitung eitriger Entzündung aus den Räumen des Mittelohres etc." Deutsch. med. Wochenschr. 1881, No. 28.

muscles below the deep fascia of the neck. The pus may descend along the sheaths of the large vessels and may reach the larynx and even the mediastinum if the process is not interfered with. The pus may descend by gravitation along the muscles of the vertebral column and we may be able, after opening the cells of the process, to evacuate pus from the cells by pressure on the neighborhood of the upper thoracic vertebrae.

A burrowing of pus leading to the formation of a retropharyngeal abscess was observed on the anterior surface of the vertebral column. The pus in rare cases effected an exit by boring a fistula through the floor of the meatus.

The cases which lead to these processes are not at all the most serious cases of otitis media purulenta acuta. A perforation of the tympanic membrane for example did not precede the descensions of pus in the neck in 29 per cent of the cases I observed.[1] Pneumococci were found most frequently to be the cause of the suppuration. The process of suppuration, which may pass in the main spaces of the middle ear with slight symptoms and heal in a short time, may acquire an entirely different character in the far distant large terminal cells. This form of suppuration becomes more often dangerous to life than the other forms of empyema of the mastoid process, on account of the great extension in the neck of the abscesses by gravitation and on account of the frequently very extensive connection with the walls of the sinus.

Abscesses by gravitation as were just described were found 17 times in 97 operations for empyema that were performed during the last 10 years. You see they are not at all rare occurrences.

It is very important for differential diagnosis of perforation of pus at the lower surface of the mastoid process, to remember that pneumatic cells leading to such perforations are not developed during the first years of life. A similar hard diffuse swelling at the lower periphery of the mastoid process may occur in this early age in the course of an acute suppuration of the middle ear, especially in connection with some acute infectious disease, mainly scarlet fever. Some very much swollen glands may however be felt more or less distinctly by palpation, while superficial fluctuation, which never occurs in perforation of pus through the floor of the mastoid process, must be attributed to the breaking down of some of the glands. A collateral oedema and redness of the whole auricle, which was never observed in deep perforation, occurs in these cases of lymphadenitis which apparently start from an inter current otitis externa.

3. *Perforation at the root of the zygomatic process.* The third form is observed rarely and leads to elevation of the periosteum under the temporal muscle and to pronounced raising from the head of especially the *upper* half of the auricle. Sometimes the pus may descend below the arcus zygomaticus.

Two of the described forms may occur together.

An extradural abscess secondary to disease of the ear may finally find

[1] Leimer statistische Zusammenstellungen etc. Zeitschr. für Ohren. Vol. 43 page 273.

an avenue outward along an emissary vein, thereby leading to a subperiosteal abscess on some part of the outer surface of the skull.

Mastoid Operation in Acute Inflammation of the Middle Ear.

The manifold dangers which are involved in an acute suppuration of the middle ear justify a prophylactic interference instead of waiting for the perforation of the empyema or for dangerous general symptoms. *The operation is indicated when a profuse acute suppuration of the middle ear lasts more than 8 weeks in spite of correct treatment.* In the large majority of cases it discloses distant foci of suppuration of such dimensions that they would hardly ever have healed spontaneously. Infants suffering from acute genuine suppuration of the middle ear must be excepted from this rule. A suppuration lasting for 8 weeks is not so important in infants as it is in adults, because the cells of the mastoid are not yet developed and the sigmoid sinus has not yet dug a groove in the temporal bone deep enough to come close to the antrum. A perforation of pus at this age, occurs much more readily toward the outside than inwardly towards the cavity of the skull, thereby informing us in time of the necessity of operative interference.

There are some local symptoms which may indicate an extensive implication of the mastoid cells much earlier, thereby justifying an operation; for example lasting sensitiveness to pressure of some parts of the mastoid process, spontaneous pains irradiating towards the skull and interfering with sleep, pronounced swelling of the posterior superior bony wall of the meatus, and, combined with profuse suppuration, button-shaped growths on the tympanic membrane which reappear after removal.

Other indications for opening the cells are, swelling on the outside of the mastoid portion which soon begins to fluctuate, or the characteristic hard swelling below the mastoid process, even though no perforation of the tympanic membrane has occurred, also if fistulas have formed anywhere else in the vicinity.

An operation is scarcely ever indicated before the end of the first 8 to 14 days.

Symptoms pointing to a *threatened invasion of the labyrinth* are of utmost importance. They are sudden pronounced disturbances of equilibrium combined with nausea, furthermore sudden and considerable decrease of the power of hearing to such an extent that whisper is heard indistinctly close to the ear, the highest sounds are not heard as far down as the mark 4 or 5 of the *Galton* whistle. An a^1 tuning fork is heard only for a short time by air conduction. To relieve the pressure in the middle-ear by freely opening the cells is our urgent duty, if one or several of these symptoms are present, in order to prevent an invasion of the cavities of the labyrinth. A fatal meningitis can not be stopped in the majority of cases if a perforation and a consequent panotitis occurs, as is often seen in weak individuals and in old people.

Another indication for mastoid operation in acute otitis is the appearance of facial paralysis. This is very rare.

Intracranial complications and their symptoms calling for operative interference will be discussed later.

Technic for Opening the Antrum—Schwartze's Operation.

The necessity for the performance of a mastoid operation appears so frequently and sometimes so suddenly that every general practitioner ought to be acquainted with its technic. Injuries can easily be avoided if we are acquainted with the anatomy of this region and its frequent variations.

The operation ought to be previously practiced on the cadaver.

The cut is made as a vertical tangent to the posterior insertion of the auricle from the crista temporalis to the point of the mastoid process, through the skin and periosteum.

Wilde's incision which was used years ago was confined to incision through the soft tissues. It is insufficient because the suppuration always begins in large cells in the bone which therefore have to be drained.

The periosteum is pushed forward and backward by means of a dull periosteum elevator. Thus the whole outer surface of the mastoid process is laid bare, from the crista temporalis and forward to the rear limit of the entrance to the meatus. The spina supra meatum appears directly behind and above the meatus and can always be found there, at least in the adult.

This ridge has generally been accepted as the safest mark for finding the antrum, since I proved that its position as compared to the antrum is always the same.

It is advisable to chisel away the whole outer plate of the mastoid process from its point to the crista temporalis and to the spina supra meatum, since usually a number of cells, especially far distant ones, take part in the suppuration. We obtain the smoothest field of operation by using a gouge about 15 millimeters wide with a convex cutting edge. We find the rear end of the antrum by penetrating to a depth of 10 to 12 millimeters in the angle between the crista temporalis and the spina supra meatum. We use the gouge flatly and from the rear for removing the outer plate; in the fossa mastoidea horizontally in order to avoid the sigmoid sinus which is sometimes so superficial and so far forward that it may be uncovered with the first stroke of the hammer. For the same reason we remove the cover of the point by chiseling from the point upward. It is sometimes necessary to remove the lateral part of the rear wall of the bony meatus when the sinus comes very far forward.

Large cells filled with pus are most frequently found in the point of the process and on the rear margin of the pars mastoidea in the prolongation of the incisura mastoidea upward and backward.

The absorption of the bony walls of the cells, especially if the cells were large before they became diseased, may progress so fast that a few weeks after the beginning of an acute purulent otitis media the bony covering of the sinus has disappeared and the wall of the sinus forms to a large extent the wall of the empyema cavity. Utmost care must therefore be taken when the granulations are scraped away by means of a sharp spoon.

In cases of perforation through the floor of the temporal bone into the neck we often find the cell containing the empyema, medial of the whole mastoid process. In such cases it becomes necessary to chisel away the entire point of the process, regardless of the insertion of the muscles attached to it, whereupon we often find an unexpectedly large cavity filled with pus, extending along the sinus toward the bulb of the jugular vein which it sometimes reaches. Special care must be taken here also in removing granulations from such deep cavities in order to avoid injuries to the sinus and bulb.

The whole territory is converted into one cavity by removing all the bony septa which divide it.

Contra incisions, according to the rules of surgery, must be made on the neck if there are abscesses by gravitation. In these cases the pus comes close enough to the surface to be reached only after long duration of the process and sometimes in very distant locations. The removal of the mastoid process and of the lower wall of the cells medial of it, is sufficient in the large majority of cases in order to drain the pus gathered in the interstitia of the muscles.

I saw perforations through the floor of the temporal bone only in adults.

Diabetes is no contraindication against the opening of the mastoid process as was formerly thought. Experience has shown that recovery in diabetics does not take a materially different course than in the normal organism.

We must remember that in *children in the first years of life* only the antrum has to be opened, which lies very superficial at its rear end. Nevertheless these operations occasionally offer considerable difficulties on account of the swelling of the soft tissues, sometimes amounting to 2 centimeters and more, combined with the smallness of the field for operation; and also because both, the crista temporalis and the spina supra meatum may be absent in that period of life. A number of injuries to the dura followed by fatal meningitis are reported in literature caused by the difficulty of the anatomy together with the thinness and softening of the bone owing to rickets.

It is fortunate however that in infants a fistula leading into the antrum often shows us the way, and we only have to enlarge it by means of a chisel 5 to 6 millimeters in width. There are either no cells at all or only in the direct neighborhood of the antrum.

The wound is dusted with iodoform powder and lightly packed with iodoform gauze. The external meatus is carefully dried and some boric acid powder insufflated. The wound and the ear are covered with a large tuft of cotton over which a gauze bandage is run in circles around the head leaving the other ear uncovered. We avoid if possible to run the bandage under the chin as it feels uncomfortable to the patient. A starched bandage helps to keep the dressing in place, which may remain for six days provided the secretions were not fetid and no pains or fever ensue. Later on the dressings have to be changed every 2 or 3 days, often every day.

The secretion from the meatus stops during the next few days and the perforation of the tympanic membrane closes, if no further complications arise. The wound fills with granulations and newly formed bone on an average after 3 to 5 weeks and heals without leaving any deformity.

The reports of ear clinics give an entirely wrong idea as to *how frequently* the opening of the antrum and mastoid cells becomes necessary in acute purulent otitis media, as the cases needing operation gather there from great distances. Counting only the cases of otitis media purulenta acuta which remained in our care from their beginning, their number amounts to little more than 1 per cent.

LECTURE XX.

Chronic Suppurative Inflammation of the Middle Ear.

Otitis Media Purulenta Chronica.

Gentlemen:—*All inflammations of the middle ear which have a lasting perforation or one that closes only after years, and which show a continual or temporarily recurring suppuration, are called otitis media purulenta chronica.*

Of all the patients whom I observed during the last 21 years **16.9** per cent suffered from chronic suppuration of the middle ear. "Residues with persistent or closed perforation" are not included as they form a class for themselves.

29.5 per cent were *children.*

In 22.5 per cent *both ears* were affected.

The large majority of patients suffering from suppuration of the middle ear ask the aid of an otologist only after years and scores of years of illness.

This is one of the reasons why the study of *pathogenesis* is so very difficult. It is true that in the course of some *acute infectious* diseases as well as in consumptives we may witness the formation of large perforations in the tympanic membrane, or the perforation enlarges to such an extent that it can not close spontaneously. It is however the minority of cases of chronic suppuration of the middle ear which can be traced back to some acute infectious disease or phthisis.

Scarlet fever can by far the most frequently be accurately ascertained as the cause, namely in 13.8% of all the cases according to my statistics; measles only 1.6% and the remainder of *the acute infectious diseases* in still smaller figures.

All *genuine* acute suppurations of the middle ear which came under our observation, and nearly all of the numerous cases of *influenza* otitis recovered in a comparatively short time, the perforation closing. Recurrences are rare except in the cases which are due to acute recurrences of affection of the tubes.

The origin of the large majority of chronic suppurations of the middle ear with persistent perforation remain therefore unexplained.

We shall see later on that a large number of decidedly characteristical forms with perforations of *Shrapnell's* membrane and the cholesteatomata, must be attributed to long lasting occlusion of the tubes and are a consequence of partial relaxation and atrophy of the tympanic membrane.

The perforations of the tympanic membrane in otitis media purulenta chronica are of the greatest variety as to form, size and position.

Two kinds of perforations must be distinguished in regard to their origin and to the character and prognosis of the changes in the middle ear. Firstly the *central perforations* showing a remnant of the drum membrane at least along the whole upper part of the periphery which may be ever so narrow; secondly the marginal perforations, embracing all cases with total destruction of the membrane; furthermore, all small perforations reaching to the rear upper or anterior upper part of the periphery, and finally all perforations of *Shrapnell's* membrane which always extend to the upper margin.[1]

Perforations produced by the loss of the limbus of the drum membrane together with a part of the bony frame of the tympanic membrane are also called marginal perforations.

1. Central Perforations.

The large majority of perforations develop more or less distant from the limbus. The only exception to this rule are perforations occurring in the course of tuberculosis. But perforations occurring in genuine otitis media, or in the course of acute infectious diseases are in the very beginning removed from the limbus. In scarlet fever and typhoid fever I often had an opportunity to watch the progress of large perforations from their very beginning. The destruction can progress to the margin within the first few days only in the severest forms of scarlet fever. The conclusions drawn from the majority of these cases have however no bearing on the pathogenesis of chronic suppurations of the middle ear, because as before mentioned, the general disease soon terminates fatally in these rapid cases. New perforations do not usually reach that size, they remain in the intermediary zone of the tympanic membrane, become round, oval, kidney or horseshoe shaped, surrounding the handle of the hammer from below. The majority does not surpass two-thirds of the membrane. Sometimes we see two perforations in the beginning, one in front, the other in the rear, the handle of the hammer forming a bridge between them which may remain or later on disappear causing the two to become one.

These are the usual forms of central perforations which we see after years in chronic suppurations, leaving a peripheral zone of the membrane. Their size is somewhat larger than in the beginning, partly on account of further destructions by temporary granulations of the margins, partly on

[1] Other small perforations reaching the rim of the tympanic membrane *at any other place* of the circumference are observed with some degree of frequency only in otitis media purulenta phthisica and will be discussed there.

account of retraction and shortening of the tendon of the tensor tympani muscle drawing the handle of the hammer inward to a more or less horizontal position, and together with it, the whole remnant of the tympanic membrane. For the sake of convenience we call those perforations "central" which apparently extend to the anterior inferior or posterior inferior margin of the tympanic membrane, as long as the whole superior peripheral zone together with the enclosed handle of the hammer or its upper remnant remain in situ. It is easy to ascertain this at our examination by means of the speculum. The lower end of the handle of the hammer is not infrequently adherent to the promontory.

The forms of central perforations thus defined can frequently be traced back to acute infectious diseases.

2. Marginal Perforations.

Perforations reaching the *upper* periphery of the tympanic membrane or extending partly into its bony frame, and therefore also included in marginal perforation are much more varied.

We know very little as to their pathogenesis since the anamnesis is very seldom clear. Of the 578 cases of otorrhoea caused by scarlet fever which I saw during 12 years there were only 16 perforations of *Shrapnell's* membrane and 17 cholesteatoma. Perforations of *Shrapnell's* membrane and cholesteatoma are however the very forms of disease which always show perforations reaching to the margin of the membrane or extending into it.

Total perforations are most frequently due to some serious general disease, especially scarlet fever.

It is very difficult however to trace the origin of the following forms of perforation: the frequent *small* marginal perforations generally confined to the rear upper quadrant, those less frequent perforations reaching the periphery in the anterior superior quadrant, but especially the numerous defects in *Shrapnell's* membrane and finally a combination of the three forms. In spite of special effort I could never observe the acute development of a perforation in *Shrapnell's* membrane although I looked for it ever so carefully for decades.

Perforations of *Shrapnell's* membrane have many characteristical points in common. Consumptives are however excepted from this rule as in their suppurations, destructions may begin in any part of the tympanic membrane, therefore also in the upper periphery.

An inexperienced person will often have great difficulty in detecting perforations in *Shrapnell's* membrane because the background frequently appears white, dry and lustreless, exactly like the surface of the tympanic membrane. From this condition of the medial wall of the tympanic cavity we may easily recognize macroscopically that its lining has changed, it has become like epidermis.

Often none of the margins of the perforation are distinctly visible except the margo tympanicus, which protrudes, is often irregular, and usually covered with epidermis. The other margins of the perforation may be more or less absent because the tympanic membrane together with the handle of the hammer have become more or less adherent to the medial wall. The tympanic membrane may in this way pass over to the promontory. The communication between the external meatus and the middle ear can only be recognized by a crescent-shaped shadow of the margo tympanicus thrown on the inner wall and becoming larger or smaller according to the motions of our eyes to and fro. Parts of the inner surface of the cavity appear and disappear below the margin, according to the position of our axis of vision, as for example the head of the stapes often lying bare in the rear upper quadrant, a number of different light reflexes, lumps of epidermis or red granulations protruding from the slit.

Perforations of *Shrapnell's* membrane situated above the short process and the two upper liminal strands of the tympanic membrane show very similar conditions. We can recognize the presence of the perforation only at the protruding upper bony margin, if the neck and head of the hammer are in situ, as the neck of the hammer appears like a continuation of the grayish white surface of the tympanic membrane (compare fig. 9 on the plate).

According to the variable size of *Rivini's* notch the opening may vary greatly in extent. In the majority of cases we find the bony rim, which on the anatomical specimen has a sharp edge, more or less eaten away, and the opening thus secondarily enlarged. It may extend into the anterior and posterior superior quadrant of the tympanic membrane by destroying the anterior and posterior liminal strands (compare fig. 10 on the plate). Sometimes the liminal strands are preserved and there is a perforation at the rear upper margo tympanicus, and, though rarely, also in the front and upper quadrant.

We must remember that all these perforations on the upper periphery of the tympanic membrane lead into the spaces above the membrane (cupula, *Hartmann*) which we called aditus ad antrum, since they lead directly into the antrum. Wherever the perforation is located along the upper periphery we must suppose that the disease is mainly situated in the aditus and antrum, whence also the secretions originate.

The structures in the tympanic cavity together with their pathologic changes and defects which may become visible in cases of large perforations produce such manifold pictures, that they can only be briefly mentioned.

The lining of the tympanic cavity may appear more or less diffusely red and swollen, smooth, or granulating. The upper wall in perforations at the upper periphery appears whitish epidermized, if it is not covered by depending granulations. The niche of the round window often becomes visible through perforations in the rear lower quadrant while in the rear upper quadrant the head of the stapes together with its tendon appear. The long process of the incus is comparatively rarely seen, because it is often luxated or lost by necrosis. Perforations in the anterior half may open a view into the tympanic ostium of the tube. A horizontal groove may become visible in cases where, together with the tympanic membrane, the hammer has disappeared, a frequent occurrence after scarlet fever. This groove is the end of the semicanalis pro tensore tympani in the tympanum. Parts of the tympanic cavity may be bridged over by scars. A thin membrane for example sometimes covers the tympanic ostium of the tube and bulges in *Valsalva's* experiment.

We sometimes find a formerly large perforation of the tympanic membrane entirely or partially closed by a scar which is covered by granulations. This condition has often been called myringitis chronica, but on account of its origin had better be included in otitis media purulenta chronica. A similar picture may occur if the very much swollen and granulating mucous membrane of the promontory squeezes through the opening, etc.

The secretion in different forms of chronic suppurations of the middle ear varies considerably.

Muco-purulent secretion of the same kind as in acute suppurations of the middle ear is only found in central perforations, where the lining epithelium has preserved its original character.

In cases presenting marginal perforations at the upper periphery of the tympanic membrane, the secretion contains masses of cast-off epidermis, cheesy masses consisting of different products of decomposition, such as cholesterin crystals, fat crystals, masses of saprophytes, etc., like those produced in decomposing moist epidermis. These perforations are very often combined with more or less extensive replacing of the lining of the upper part of the tympanic cavity and its surrounding spaces by epidermis.

A different character of secretion is noticed if extensive granulations or large polyps are present. In this case it becomes profuse and watery, contains little or no mucous and often appears bloody.

Purely purulent secretion is produced if naked bone is exposed.

The odor of the secretion is very important for our diagnosis, the prognosis and the therapy.

It is peculiar how long muco-purulent secretion remains without odor provided it stays free from other additions, especially decomposed epidermis. This can be noticed in acute as well as in chronic suppurations of the middle ear with central perforations. The secretions for example which are found in the external meatus and are mixed with macerated epidermis are often very fetid, while after their removal the flakes of mucous which are drawn from the tympanic cavity are absolutely free from smell. This can be frequently observed in removing strips of gauze which are still used by some, from the depth of the meatus.

The secretion furnished by large polyps is always abundant, thin, fetid and of a disagreeable sweetish odor.

The cheesy masses also produced by decomposition of epidermis which are removed from the antrum and cells always have a very bad odor. This odor is so characteristic that sponging of these spaces with a bent probe wrapped with cotton is sufficient to betray by its fetor the presence of these masses even though the meatus and the middle-ear may appear dry. The smell may become sickening if the suppuration has spread into more distant parts. This may be the case in extradural abscesses, or in abscesses of the brain, or where a perforation occurred below the periosteum, either to the outside or below the mastoid process, if the pus finds an avenue returning back through the meatus or through the fistula to the surface. Such patients are betrayed by their odor as soon as they enter a room and it has happened repeatedly that assistants hardened by years of similar work became nauseated when an extensive abscess of that kind was opened and the pus mixed with gas bubbles was evacuated.

Similar abscesses are betrayed at a distance by these same peculiarities and may give you an idea of the serious toxic effects produced by the gases which are developed by them, and by the diffusion of their fluids into the surrounding tissues, the meninges, the brain and the large blood vessels.

We have to say a few words about the bacteriologic *findings in chronic suppurations of the middle ear.* The same pyogenous organisms are found as in acute inflammations. They are in pure cultures in fresh acute recurrences with muco-purulent secretions that have no odor. As the fetor becomes noticeable different kinds of saprophytic organisms appear and after the secretion has lasted for a while they increase to immense quantities of innumerable different kinds. Only some of them can be raised and then only unsatisfactorily, as many are anacrobic and their conditions of life are only partly known. The pyogenous organisms may entirely disappear from the secretion and only one or a few kinds of saprophytes may remain according to investigations of *Stern,* if the secretion in the meatus decreases, partially dries up and forms crusts. Many chronic suppurations of the middle ear seem to heal spontaneously in this way under uncomplicated conditions. Pyogenous organisms may however persist and even thrive in putrid foci of the surroundings which lie deeper and can not dry up. Abundant streptococci are for example always present in septic thrombosis of the sinus, in the walls of the sinus and in the thrombus masses even though they may be decomposed.

Two occurrences are noticed in chronic suppurations of the middle ear with such regularity that it does not seem justifiable to call them complications as has often been done. They must be considered as belonging to the clinical picture, and are firstly, the formation of granulations and polyps, secondly, the formation of sclerosed bone in the surroundings of the diseased spaces.

The formation of granulations and polyps can be traced as to their pathogenesis directly to the lining of the bony meatus.

Hardly ever does a suppuration of the middle ear, that has been neglected for some time, come under our treatment which does not show excoriations and even granulations; in other words, an otitis externa in the depth of the external bony meatus, caused by the constant exposure to the secretions. Some cases coming from the country and treated by unsuitable methods, like warm applications, etc., show the whole meatus covered with white diphtheritic membranes which leave an irregular granulating surface after they are cast off. The wall of the tympanic cavity has the same appearance as far as it can be seen.

The granulations develop especially well and become independent on the free margin of the perforation of the tympanic membrane and in marginal perforations on the free bony rim, where it is mostly exposed to the passage of pus. On account of their own weight they may cause a strangulation of the blood vessels and thereby enlargement of the veins. They may quickly increase in size and take all possible forms, club-shaped, lobulated, raspberry-shaped, and soon become lined with epithelium which may be ciliated on the inside and epidermised on the outside. Young polyps consist of granulation tissue, older ones may become fibromatous, sometimes containing myxomatous parts and even, though rarely, bone. They sometimes become unusually large after years of existence and protrude from the external meatus with a club-shaped end which may grow as large as a cherry. This end has a lining of dry epidermis and protrudes from the external meatus. The pedicle becomes very thin and reaches in the depth to the circumference of the tympanic membrane. The root of such large polyps is usually directly inside of the rear upper limit of the sulcus tympanicus. Smaller polyps very often develop in marginal perforations of the upper periphery and project downward from the slit leading to the upper spaces of the middle ear like a theatre curtain. The removal by means of the curette shows that they usually originate from the protruding margo tympanicus, from the lateral wall of the aditus or from remnants of the ossicles.

Moos expressed the view that the majority of polyps originate from the inner wall of the tympanic cavity. It was widely propagated but does not at all coincide with my experience. Granulations arising from a broad base on the promontory, quickly recurring after removal, are comparatively rare. They usually correspond to a fistula in the bone or indicate extensive necrosis of the wall of the labyrinth.

The fact that granulations and polyps develop *regularly* on bare suppurating surfaces indicates that they have a certain physiologic value for regeneration. Every loss of substance of the normal organisms is repaired by formation of granulations. Our organism has no other mechanism at its disposal for the removal of foreign bodies, sequesters, etc., than the formation of an elastic soft dam of granulations all around them. The foreign body is removed by increased pressure from the inside which pushes it gradually to the outside and finally expels it without our help.

An organism lacking this power of regeneration succumbs helplessly to the harmful influence to which it is constantly exposed. This we shall see plainly in treating the subject otitis purulenta in patients suffering from consumption and other serious diseases, who lack partially or completely this formation of luxuriant granulations which constitute an unfailing reaction of the normal organism against correspondingly strong inflammatory irritations.

The granulations become plainly pathologic however, and have to be removed as soon as their growths become independent to some degree, when they organize and keep on growing independently like tumors.

In radical operations, required in old serious suppurations of the middle ear, sclerosed bone is always found extending far into the surroundings of the antrum. The examination of a great number of temporal bones affected with slight forms of old suppurations of the middle ear, which were however accidental findings and independent of the fatal course, reveals the fact that in these cases also sclerosis of the bone is present to a greater or less extent.

The process of sclerosis of the bone consists in the formation of solid, exceedingly hard bone in place of the pneumatic spaces and cavities containing bone-marrow which surround the antrum. Only a few small cells are preserved far away from the antrum, together with a thin peripheral layer of spongy substance in the mastoid process.

Here again consumptives show an exception. I never saw sclerosed bone in these patients notwithstanding many years of serious suppuration of the middle ear. The contrary is the case, an abundance of large and small pneumatic cells is the rule in consumptives.

The casual post-mortem findings after acute suppurations of the middle ear, which had healed a number of weeks previous with closing of the perforation of the membrane, gave us the explanation for the development of the process of sclerosis of the bone. The pneumatic spaces, except the tympanic cavity and the antrum, were filled to a large extent by a tough, pale red tissue, representing evidently a later state of the process of apposition of bone studied by *Schiebe,* which finally terminates in the complete ossifying of the spaces.

This process was also considered by *Steinbrügge* in his "pathologic anatomy of the organ of hearing" as a protective measure of the organism, which tries to create more favorable conditions for the course of prolongated suppurations by diminishing the size of the spaces and simplifying their arrangements. Other authors however considered this hyperostosis as a serious complication endangering life by interfering with a perforation to the outside and thereby favoring one to the cavities in the skull. They forgot entirely that in chronic suppurations (cholesteatoma) a gradual enlargement of the external opening at the margo tympanicus, leading from the meatus into the diseased spaces, progresses step by step with the process of sclerosis of the bone. The cavity which has sclerosed walls can in the course of years acquire a sufficiently large opening towards the external meatus, so that on examination through the meatus the same picture is seen as though a radical operation had been performed. The focus of the disease healed spontaneously and remained dry in a large number of cases, which I observed, by enlarging the entrance until the whole focus formed a simple deep groove. This process of healing accomplished by nature deserves admiration, but we never dare rely upon it on account of the possible interference of incidents dangerous to life. A constant careful control of such cases is necessary.

A. Chronic Purulent Inflammation of the Middle Ear with Central Perforation of the Tympanic Membrane.

The course of otitis media purulenta chronica with a central perforation is comparatively simple in an otherwise healthy organism.

The suppuration which usually dates back to some acute infectious disease during childhood, lasts with frequent recurrences for years and tens of years if left to itself. In other cases it appears to be healed for months and even years when suddenly it begins anew as the consequence of some injurious influence reaching the middle ear. The entrance of water into the middle ear is especially harmful either through the meatus or through the tube, in diving, swimming, or if nasal douche is wrongly applied. Germs of infection may furthermore be carried into the tympanic cavity by all kinds of instruments introduced into the depth of the meatus for the purpose of cleaning. The pyogenous and saprophytic germs which are always attached to the walls of the meatus are innocuous as long as they remain dry. Serum furnished by some minute injuries produced in cleaning, furnishes the moisture necessary for their growth. Acute catarrhs of the nose are a frequent cause for constant recurrences of suppuration, as long as a permanent occlusion of the tympanic ostium of the tube has not formed. This we sometimes see after suppurations lasting for years, produced as a natural protection against these invasions. Children especially are addicted to acute nasal catarrh and its propagation through the tube, which, on account of the perforation in the tympanic cavity, opens so much more easily at each blowing of the nose. Thus the muco-purulent secretion from the lining of the middle-ear can never cease, but continues in varying quantities.

I have shown you the consequences of persistent discharge from the ears, if it is not treated. The epidermis of the tympanic membrane and meatus becomes macerated, then excoriated, later on granulations and polyps will form on the most exposed edges. Polyps may develop in simple central perforations as frequently as in marginal perforations, if they are not treated. After the removal of polyps which were so large that they protruded from the external canal I repeatedly found a simple suppuration from a central perforation which stopped definitely after a few days of rational treatment.

It is peculiar that polyps large enough to fill the whole meatus never cause symptoms of retention although they may exist for years. I saw signs of general sepsis however in rare cases where the external part became greenish discolored under the influences of saprophytes.

Simple forms of chronic otitis with central perforations hardly ever lead to necrosis of bone in an otherwise healthy organism except in cases where long lasting harmful influences create special predispositions to it, as for example a piece of cotton which became lost in the tympanic cavity causing the production and retention of fetid secretions.

We shall discuss the rare result of general sepsis in cases which *developed no sclerosis* of the bone in the surroundings of the main spaces of the middle ear in connection with other complications.

In a large number of cases where polyps were not formed the suppuration gradually ceases spontaneously. The pyogenous organisms disappear and the secretions containing only saprophytes dry up, forming crusts which adhere to the tympanic membrane. The crusts may be gradually carried outside by the mode of growth of the epidermis peculiar to the meatus (compare page 110). The perforation of the membrane may at the same time become concentrically smaller from granulations growing all around its margin, and may finally close, forming a granulating surface covered later on by a scab. One by one these scabs migrating over the surface of the membrane and the meatus form a chain like a rosary reaching as far as the cartilaginous meatus. The migration is the same as in extravasations of blood.

Large and old perforations extending over two-thirds or more of the membrane rarely close during the time we watch them. We shall see however in speaking about residues how frequently and in how extensive a measure the formation of scars takes place after a longer lapse of time.

Treatment of Otitis Media Purulenta Chronica with Central Perforations.

The favorable influence of antisepsis becomes much more apparent in the treatment of chronic suppurations of the middle ear than in acute cases. The conditions are different and simpler in many regards.

In acute suppurations there is a complicated system of cavities with a small perforation in the membrane closed by a valve-like mechanism. In chronic suppuration often nothing is left of the cavities of the middle ear but the tympanic cavity, the aditus and the antrum which are accessible to a strong jet from the syringe through a usually large opening in the membrane. In acute suppurations there are often very virulent pyogenous organisms spread in the lining and in the contents of a complicated system of cavities, with which the organism, without any possible artificial support from the outside, only with its own means of protection, has to cope. In chronic cases we have mainly saprophytes which are always accessible to that antiseptic which alone can be used in the middle-ear in sufficient quantity and concentration for any length of time, namely, boric acid in powder form. Its effect is always telling, provided the anatomic conditions permit us to reach every part of the diseased cavities. These facts are proved by the numerous cases of fetid suppuration of the middle ear lasting for years with and without interruption, which were definitely cured by one or a few careful antiseptic treatments.

The antiseptic treatment is carried out in chronic suppuration in the same manner as in the acute.

The injection of 4 per cent warm boric acid solution ought to be made with some force in a broad jet in order to reach all the walls. Care is necessary in cases of considerable deafness, especially where it developed a short time previous, on account of the possibility of destruction of the windows.

The injection is always succeeded by inflation of air by means of *Politzer's* method if the tube has not grown shut, in order to evacuate the secretion and the fluid outward. The consequent drying out with a probe wrapped with cotton must be extended over the tympanic cavity through the large opening and cannot be done too carefully or too often.

The final insufflation of boric acid powder is done as in acute suppuration but more force may be used, in order to reach the drum cavity as much as possible through the large opening.

A loose piece of cotton is inserted not deeper than the cartilaginous meatus for protection of the ear.

This treatment is repeated every day in the beginning, later on as often as secretion is present. The boric acid powder remains in the depth if the secretion has ceased.

The treatment with boric acid stopped the fetor in all cases of suppuration of the middle ear which were accessible to the jet of the syringe throughout the whole extent of the diseased cavities. It never produced irritation and I had therefore no reason to deviate from it. However, some, though insufficient experience was acquired as to the effect of other antiseptics like aqua hydrogeni hyperoxydati (peroxyd of hydrogen) 6 per cent, formaline in 1 per cent, resorcin in 4 per cent solutions; they were recommended by other authors and used the most extensively.

Solutions of 3 to 10 per cent nitrate of silver are used by *Schwartze* if the lining of the middle ear is succulent and swollen, while *Politzer* uses instillations of dilute and absolute alcohol if it is granulated.

Every circumscribed growth, be it ever so small, ought to be removed by means of the *snare*. We use *Wilde's* instrument armed with pliable flower wire (compare fig. 63, page 177). The many changes which have been made in this instrument are not improvements in my estimation. It is not necessary to cauterize the place where granulations have been removed according to my experience.

Small polyps which are unfavorably situated for removal by means of the snare are cauterized with a little pearl of nitrate of silver melted at the point of a probe. The probe end is moistened for the purpose and dipped in pulverized nitrate of silver. Sufficient powder remains on the probe to form a little pearl if it is held in the flame of an alcohol lamp for a few seconds. Granulations attached broadly to the outside of the drum membrane, often seen in cases where large perforations gradually close, are better left untouched.

The use of caustics in the middle ear whose effect reaches far into the depths, especially the galvano-cautery, must be cautioned against, as we can not always measure their effect accurately.

The galvano-cautery snare however can not always be avoided in removing very large polyps reaching to the entrance of the meatus, as they sometimes consist of very tough tissue. The removal is usually not successful at the first attack, but is accomplished piecemeal. The pedicle, usually consisting of softer tissue, can be cut with the cold snare.

I have never found a necessity for other operative interferences in chronic suppurations of the middle ear with central perforations, except in those extremely rare cases of general sepsis after acute recurrences (compare later on).

LECTURE XXI.

B. Chronic Purulent Inflammation of the Middle Ear with Marginal Perforation.

Perforation of the Membrana Shrapnelli Cholesteatoma.

Gentlemen:—The following two points lead me to the conclusion that perforations in the upper periphery have a different etiology from central perforations. The position of the perforation is in places where we never see a perforation in otitis following acute infectious diseases. Secondly, the statistical results of careful anamnesis especially carried out for decades in this direction, point equally to a different origin.

In 1879 my attention was drawn to the frequent occurrence of *perforations of Shrapnell's membrane* because of their different response to boric acid treatment. They had remained nearly unnoticed until then, and I directed my investigations especially towards their frequency of occurrence, their etiology, and their accompanying symptoms.[1]

Perforations in *Shrapnell's* membrane are found in 1.2 per cent of all diseases of the ear, and in 6 per cent of all chronic suppurations of the middle ear. Only 12 per cent were *children.* They are found rather frequently in *both ears* (16.8 per cent) or together with cholesteatoma of the other ear.

I never, as repeatedly stated, saw a perforation in *Shrapnell's* membrane form in the course of a genuine or a secondary *acute* suppuration of the middle ear.

The direct continuation of the epidermis of the tympanic membrane to the white lining of the cavity can almost always be seen, if granulations do not interfere. Large masses of epidermis can in the large majority of cases be removed from the cavity by means of direct injections.

The frequent occurrence of symptoms pointing to a simultaneous occlusion of the tubes, lasting for a long time, struck me very early. For example, retraction of the membrane is often found in *both* ears together with atrophy of the membrane, deafness which was considerably improved by inflation of air, adenoid vegetations, etc. A relation between occlusion of the tubes and a perforation of *Shrapnell's* membrane as cause and effect suggests itself. Remembering on the one hand the

[1]) Ueberschau über den gegenwärtigen Stand der Ohrenhlk. Wiebaden Bergmann, 1895, page 116.

high degree of atrophy and thinness from expansion which often take place in the tympanic membrane after years of occlusion of the tubes, and on the other the frequent recurrences of acute inflammations, we can not be surprised that the membrane yields to the outer air pressure which constantly weighs upon it, and that it tears at the very membrana flaccida, which lacks the solid support of the regularly arranged fibres of the membrana propria. Succeeding purulent inflammation and granulations on the edges, etc., result in their uniting with the wall of the small space above the membrane, thus forming the bridge over which the epidermis of the tympanic membrane and of the walls of the meatus may grow directly into the aditus and the antrum. This occurrence makes the opening a permanent one and at the same time explains the change into epidermis, which we notice in the lining of the cavity.

Similar processes may take place in *marginal perforation on the anterior and posterior part of the superior periphery of the membrane,* provided that the membrane has become very atrophic at those places. Only the small perforations showing extensive synechias of the margins with the inner wall of the tympanic cavity can be explained in this manner.

The numerous total perforations which often lead to formation of epidermis in the middle ear usually originate from former serious *acute infectious diseases.* The destruction extending to the upper part of the margo tympanicus leading to the antrum and involving it, opens the avenue for the advancing growth of epidermis into and over the cavities of the middle ear. The lining of the tympanic cavity is often found covered with granulations, or evenly swollen and red throughout its whole extent, while the epidermoidal change upward from the isthmus leading to the aditus ad antrum, is visible through the opening in the tympanic membrane. In other words the epidermisation of the aditus and antrum progresses more rapidly and earlier than in the tympanic cavity.

Holes in the upper bony wall of the meatus left after serious processes in the bone, and healed with expulsion of sequesters, may act as another avenue through which the formation of epidermis progresses into the aditus and antrum.

The epidermisation of a granulating surface, occurring as just described, in the middle ear, through formation of gaps is *a process of healing* identical with that which we observe in the repair of every loss of substance on the surface. *Schwartze* calls the continuation of the epidermis of the meatus into the tympanic cavity and the cells of the mastoid process the "surest protection against recurrence of the suppuration."

The epidermisation of the lining of the middle ear becomes dangerous often enough because its road into the cavities leads *through narrow openings and slits.* The cast-off scales of epidermis can not be absorbed by the walls as the secretions of a simple suppuration are, but as dead and retained masses cause a continual irritation of the walls, thus inciting renewed and increased production of epidermis.

This is the origin of the frequent disease of the middle ear called "cholesteatoma."

v. *Troeltsch*, by means of his post-mortems, established the great frequency of cholesteatoma of the antrum mastoideum, and this keen investigator also recognized the great danger involved (fig. 65).

Filling either the aditus alone or also the antrum throughout its whole extent, we find solid masses of epidermis. They may be decomposed towards their center from the extremity which communicated with the outside. Their periphery, which in the rear is bag-shaped, is arranged in regular superimposed layers.

An enlargement of the bone cavity in all directions and a shrinkage of the margins takes place if sufficient time is allowed for the development of large masses from the constantly repeated casting off of new scales of epidermis. Thus these masses of epidermis may break through the bone into the external meatus, or underneath the periosteum of the outer surface of the mastoid process, into the labyrinth, or through the base of the skull underneath the dura. No trace can be found of the bony septa between the cells after this enlargement has taken place. The masses of cholesteatoma arranged like the layers of an onion (compare fig. 65) are situated in a bone cavity with smooth lining and only flat excavations. The walls are sclerosed throughout.

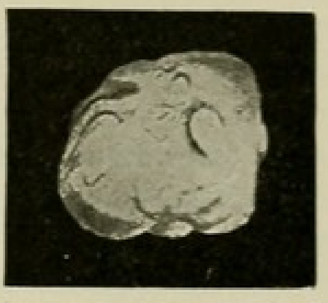

Fig. 65.

Cholesteatomatous masses removed by means of radical operation in the living, natural size.

Whenever they become moist the masses of epidermis which are accessible from the outside through the opening in the tympanic membrane, undergo a rapid putrid decomposition. They in turn act as foreign bodies, causing the formation of granulations in their vicinity, suppuration, and often caries of the bony wall and of the ossicles which they surround.

The manifold deficiencies in the bony walls caused by the excentric growths of the masses of epidermis create avenues for the spreading of the septic purulent processes to the meninges, the large blood vessels, and the brain.

Cholesteatoma amount to **2.2** per cent of all diseases of the ear; and to nearly 11 per cent of all chronic suppurations of the middle ear, if we include also the perforations of *Shrapnell's* membrane which almost without exception show gathering of epidermis in the aditus and antrum.

The youngest child whom I operated for gathering of epidermis in the antrum was three years old. The large majority of patients observed suffering from cholesteatoma are between 10 and 40 years. The beginning of the suppuration which is the cause of the whole process usually dates back to childhood.

The defects which become visible at our examination with the speculum often extend far beyond the tympanic membrane, more or less into the upper and rear bony wall of the meatus. Their size varies from a small peripheral addition to the upper pole of the perforation of the membrane, to a complete absence of the rear upper bony wall of the meatus, so that both the aditus and the antrum are open toward the meatus throughout their whole extent. There is sometimes, besides the extension of the perforation of the membrane, an isolated gap or fistula in the outer part of the meatus, and between both there is a bridge of soft tissues formed by that part of the lining of the meatus which remained intact.

The formation of granulations and polyps is found extremely frequently combined with cholesteatoma, namely in half of the cases which I saw. Their location in the region of *Shrapnell's membrane,* or protruding from the rear upper periphery, indicates the presence of cholesteatoma.

The openings in *Shrapnell's* membrane lead directly into the aditus, because the ligaments of the head of the mallet and incus, and often the heads themselves have partially or entirely disappeared from pressure. The upper spaces containing the cholesteatoma are usually separated from the tympanic cavity below, which explains why no noise of perforation can be produced by inflation of air. The tube is often closed by granulations, or it has grown shut in the region of the ostium tympanicum.

The *subjective symptoms* of cholesteatoma may remain latent for many years, as the secretion may cease temporarily or amount to so little that nothing but a dry crust is formed in the depth.

Only one-third of all cases which I compiled complained at times of *headache, dullness in the head, melancholy, etc.*

Dizziness usually occurs only during syringing. A serious attack of dizziness can be produced by sponging with the probe wrapped with cotton if the region of the horizontal semicircular canal is exposed by the perforation. The dizziness may reach such a degree that the patient is in danger of falling from the chair. We may presume that in such cases the endosteum of the semicircular canal is exposed through a perforation in the bone.

The partial *evacuation of masses of epidermis* sometimes occurs spontaneously and is then *accompanied by very great pain and swelling of the meatus. Facial paraylsis* is sometimes noticed during this process, but usually disappears after a few months.

The *chorda tympani* is comparatively frequently affected in chronic suppurations of the middle ear. The consequence is paralysis of taste in the anterior two-thirds of the same side of the tongue as the affected ear lies. The chorda is sometimes exposed in the tympanic cavity, and the patients at each touch feel a pricking, stinging sensation on their tongue, and a burning if touched with some warm object (syringo-scope). Injury to the chorda can not always be avoided in extraction of the ossicles and in radical operation. The chorda tympani, just as the facial nerve, is able to regenerate very extensively. The loss of this function is so unimportant that it is hardly ever noticed by the patient. We use four different substances for the examination of taste, sweet, sour, salt and bitter. These are applied to the half of the tongue which we wish to examine, having previously dried it.

Patients complain of *subjective noises* only very exceptionally. They are rarely observed in chronic suppuration of the middle ear.

The power of hearing varies greatly in perforations of *Shrapnell's* membrane as also in cholesteatomata originating from some other cause.

Twenty per cent of my patients with perforations in *Shrapnell's* membrane understood whisper at a distance of from 2 meters to the length of a room and more; while of those with cholesteatoma this hear-ing-distance was found only in 7 per cent. 9 per cent of the first class of cases understood whisper indistinctly close to the ear, and of the latter class 34 per cent.

Among patients who understand whisper indistinctly are classed also those who have *lost their hearing entirely,* which condition is ascer-tained by examination with the continuous series of sounds in air conduc-tion (I confined my examinations to the test of the sound a′ in the mid-dle of the series).

A rapid *disappearance of the power of hearing* during our observa-tion, combined with the appearance of *dizziness and vomiting,* indicates that the suppuration has invaded the labyrinth, which makes the prognosis very serious.

As in all diseases of the sound-conducting apparatus, prolongation of bone conduction above the normal (*Schwabach's* test) and prolonga-tion of bone conduction compared with air conduction (*Rinne's* test) ex-ists together with the loss of hearing for more or less of the lower end of the series of sounds, as long as the labyrinth is intact.

The *diagnosis* of cholesteatoma is established by means of examina-tion with the ear speculum and by removing masses of epidermis from the upper spaces of the middle ear.

As to the prognosis of these diseases, though only if they are not properly treated, the old phrase of *Wilde* is still valid in its every sense: "We are never able to tell how, when or where a suppuration from the ear will end, nor where it may lead to."

Treatment of Otitis Media Purulenta Chronica with Marginal Perforations.

The treatment of chronic suppurations with marginal perforations is more difficult than of those with central perforations, although the form of the diseased spaces is much simpler than in the second class of cases, because all pneumatic cells except the aditus and antrum have been filled by eburneous bone. One reason is the narrowness of the opening, especially in perforations of *Shrapnell's* membrane; another is the close adhesion of the scales of epidermis to the walls of the cavity, which is often excentrically enlarged.

We use special metal tubes, called antrum tubes, of different shapes and curves in order to throw the jet directly against the masses we intend to remove (compare fig. 66). They were first described by *Arthur Hartmann.* They are connected with the syringe by means of a rubber tube and are inserted under the control of the speculum into the

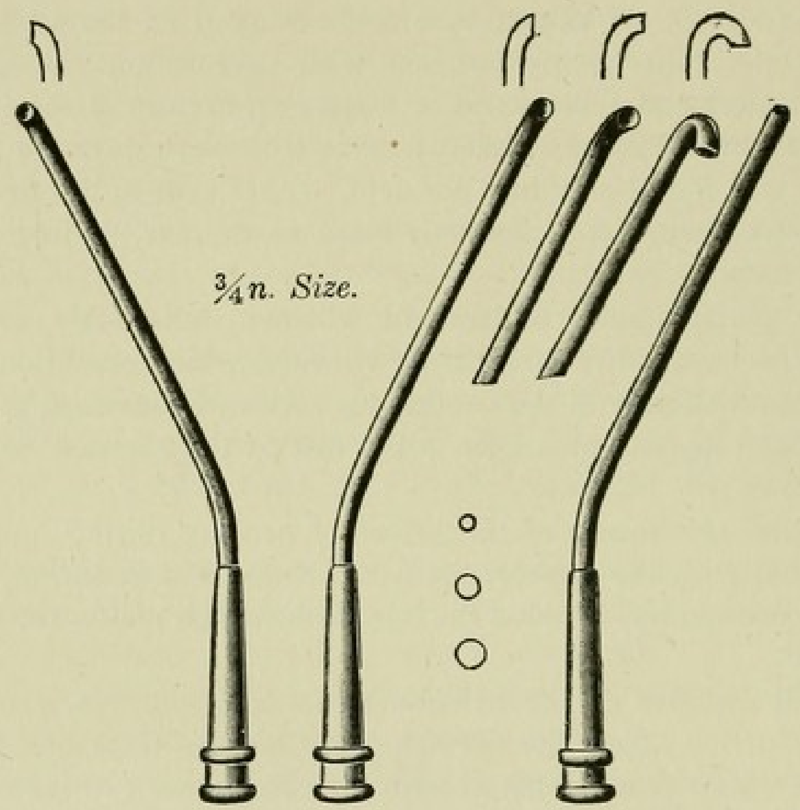

Fig. 66.
Antrum tubes of different width and different curves.

perforation in *Shrapnell's* membrane, or upward from the tympanic cavity into the slit opening into the aditus and antrum. We are sometimes able to remove, by means of these injections, surprisingly large masses of semi-solid cheesy products of decomposition, and finally thick scales of white epidermis arranged like onion peels. To reach them by an ever so strong straight jet through the meatus would have been an utter impossibility. We use 4 per cent boric acid solution of 98.6° F. for the injections in order to avoid the dizziness which they easily produce.

The solution must however be heated to 105 degrees before it is filled into the syringe in order to obtain the right temperature.

Politzer's method is applied if the tube has not grown shut.

Special care must be given to the drying of the cavity. Probes wrapped with cotton are bent to suit the case (compare fig. 67) and are repeatedly inserted far into the cavity.

The results of treatment have improved decidedly with the practice of *inflating* boric acid powder *directly* into the previously carefully dried cavity. This is accomplished through a dry antrum tube similarly to the injections of fluid. Instead of pure boric acid a mixture of salicylic acid and boric acid powder (1 to 4) may be used in order to induce a more rapid expulsion of thick peripheral layers of epidermis from the cavity. It is quite possible that during this procedure some pyogenous germs, products of decomposition and even tubercle bacilli, are dispersed into the surrounding air. It is therefore advisable for the surgeon to use some kind of a protection, either a glass diaphragm or a cloth protecting the face, as some serious experiences of my assistants taught me.

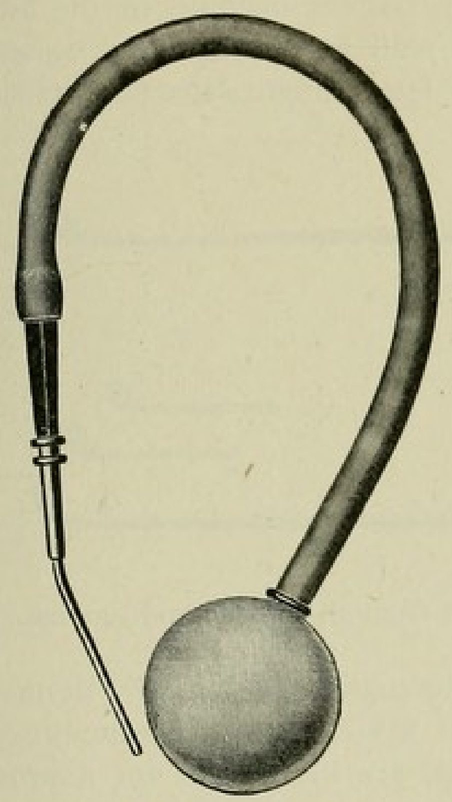

Fig. 66A.

Bulb with rubber tube in connection with the antrum tube.

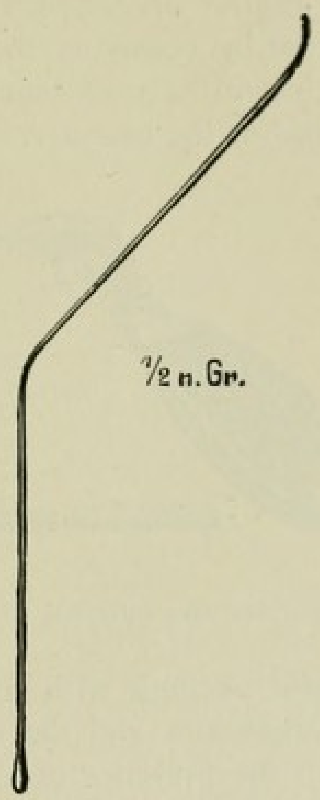

Fig. 67.

Probe used in drying out the aditus and antrum.

Very frequently we have to remove granulations and polyps in marginal perforations. They protrude downward into the slit, and curettes must often be used besides *Wilde's* snare. The curettes (compare fig. 68) are inserted beyond the free margo tympanicus, and with some gentle handling we will readily succeed. Many polyps which could not be seen may be removed from distant parts of the cavity by means of the jet from the antrum tube, thus stopping a suppuration that has lasted for a long time.

In cases where a fistula has developed in the meatus, leaving nothing of the upper bony wall of the meatus but a bridge of soft tissues, the antrum can be easily made accessible by cutting the bridge.

Sometimes the suppuration remains fetid in spite of careful treatment continued for months by means of the antrum tube and the removal of polyps. This state of affairs proves that the entrance to the cavity is inadequate, and that a part of it can not be reached by the jet of the syringe. The *indication* is therefore *to make the focus of the disease accessible by means of an operation.*

We may try to enlarge the entrance to the cavity by *removing the hammer through the meatus* (*Kessel*), if the power of hearing is already defective. I do not deem it advisable however to remove the incus also. Moreover its position places it beyond our vision, so that we can not guide the incus hook with our eye.

The *radical operation,* that is the persistent opening of the aditus and antrum by removing their external wall as *Zaufal* and *Stacke* advised it, has to be performed when the fetid suppuration persists after the removal of the hammer.

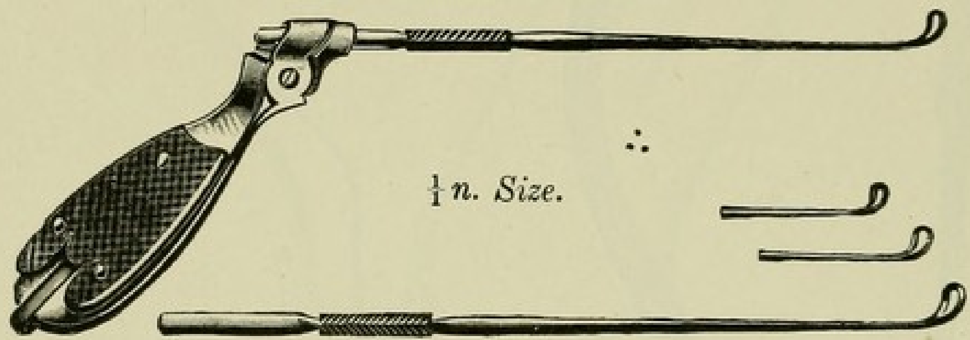

Fig. 68.

Curettes for the removal of granulations from the aditus and antrum.

Painful swelling with consecutive fluctuation of the soft tissues of the pars mastoidea and the formation of fistula in the surroundings of the ear in the presence of cholesteatoma, are indications for a prompt operation.

Plastic operations of the external meatus must be resorted to, if a very much excentrically enlarged cavity is found. Sometimes it is necessary to leave a temporary or even a permanent opening behind the auricle in order to facilitate the after-treatment and the control of the whole cavity later on.

The meatus enlarged by operation suffices however for the after-treatment if the antrum is not excentrically enlarged.

The chain of ossicles is often intact in perforation of *Shrapnell's* membrane. The operation under such circumstances must spare the ossicles and thereby preserve a good deal of the function of the ear (compare the plate of pictures of the tympanic membrane fig. 14).

The details of the technic of the extraction of the hammer, and of the radical operation, will not be described here, since both operations require the hands of a specialist.

These patients need the attention of a physician several times a year for the rest of their lives, because scales of epidermis may gather anew in some recess of the cavity, and cause formation of granulations and purulent secretion, no matter how carefully the cavity has been cleaned out either with or without operation, and despite the fact that the suppuration may have ceased for months and years.

The entrance of water into the cavity in bathing, etc., must be very scrupulously avoided.

LECTURE XXII

Suppurative Inflammation of the Middle Ear in Consumptives.

Otitis Media Purulenta Phthisica. Caries and Necrosis of the Middle Ear.

Gentlemen:—Caries can be clinically differentiated from the process of absorption of the bone as described in acute empyema of the mastoid process, and from absorption in cholesteatoma, by the following peculiarities: In caries certain parts of bone are stripped of their soft tissues and lack nutrition; the process of dying away of the bone progresses even under favorable local conditions, as for example after operative exposure of the whole focus. It terminates with the demarcation and expulsion of a sequester (necrosis).

Caries and necrosis in the temporal bone, as also cholesteatoma, present themselves in the large majority of cases not as independent diseases but as *incidents* of the *suppuration of the middle ear* taking an abnormal course.

The causes for this abnormal course are according to our experience either *serious general diseases,* considerably decreasing the power of reaction of the organism, or long lasting and serious *local disturbances in the spaces of the middle ear.*

We saw for example local necrosis of bone occurring after acute suppurations of the middle ear in the course of some serious acute exanthema.

The following disease must be considered a typical example of the influence of a cachectic general organism on the local process.

Otitis Media Purulenta of Consumptives.

This form of otitis is found in **0.7%** of all ear patients and in 4.4% of chronic suppurations of the middle ear.

Children are represented by very small numbers namely 5.5% compared to 94.5% of adults. This number is probably too small as my statistics of consumptives with suppuration of the middle ear were compiled chiefly from an infirmary which does not admit children.

They attack both ears more frequently than all other forms of suppuration of the middle ear, namely in 32.3%.

The perforation of the membrane and the suppuration may occur very acutely under our eyes. It is however characteristic for otitis media purulenta phthisica that all other objective and subjective symptoms of inflammation like redness, swelling, pain and tenderness are as a rule more or less absent. The destruction in spite of this nearly complete absence of symptoms progresses with the rapidity that we usually see only at the hight of the most serious acute infectious diseases. The perforation is large from its first appearance and frequently located in unusual places, for example in the anterior half, or in the anterior superior quadrant, or on the *margin of the membrane.* It sometimes enlarges from day to day, other perforations develop (compare the plate fig. 11) and it frequently destroys in a short time a large part or the whole of the tympanic membrane.

The findings at the post-mortem correspond with these extensive destructions observed on the living. Frequently the ossicles are partially loosened in their connections with each other and with the walls, or they are eliminated altogether. The tendons of the muscles are decomposed. The bone in many parts of the walls of the middle ear lies uncovered, and contains at an early period loose sequesters of different dimensions. The windows of the labyrinth and their bony surroundings are not rarely implicated in the destruction. The most rapid decay of all structures of the middle ear which I ever saw was at the time of the tuberculin treatment (1890) in a patient who was under the influence of a continual use of tuberculin.[1]

Occasionally after the process has lasted for a long time, large sequesters are found, extending over the whole mastoid process and beyond.

The difference between otitis media purulenta of consumptives and all other forms of acute and chronic suppurations of the middle ear becomes even more striking from the view point of pathology as evidenced in the macroscopic appearance of the tissues, than from the clinical feature of the uninterrupted rapid progress. *The tissues attacked by the disease show macroscopically almost no reaction against the destroying influences.* All processes of protection and healing with which we became acquainted in acute and chronic suppuration of the middle ear in the otherwise healthy organism are almost entirely absent here. We see instead of the big swelling which extends over the whole lining of the middle ear in acute otitis media purulenta, how this lining as also the tympanic membrane, succumbs to the disease in some places. A few

[1] Ueber das Verhalten der im Verlauf von Phthisis pulm. auftretenden Mittelohreiterungen unter dem Einfl. d. Koch'schen Behandlung. Deutsch Arch. f. klin. Med. vol. 47.

small granulations appear here and there in the immediate vicinity of places where a sequester forms. They are totally inadequate for the expulsion of the sequester.

A new formation and eburnisation of the bone filling the pneumatic cells, thereby simplifying and limiting the focus of the disease, as is seen in the healthy organism, was never observed in the surroundings of the suppuration, even in cases where the process lasted for a comparatively long time.

The advancing growth of epidermis as a final process of healing of the cavities which have lost their lining, never takes place as completely as in the normal organism.

The presence of *Koch's* bacilli alone can not be accepted as a sufficient explanation of the more or less total absence of all processes of protection and regeneration in the majority of cases of otitis media purulenta phthisica. Tubercle bacilli at least in the secretion are not found as frequently as we should expect, if that rapid decay of tissue were entirely due to them. They are even entirely absent in the secretions of some serious cases during their whole course. Another fact contradicts even more decidedly the exclusive dependence of this clinical picture upon the presence of tubercle bacilli. There are two forms of suppurations of the middle ear where the organism has not lost its normal power of reaction and where we always find a considerable number of tubercle bacilli, namely the caries and necrosis in the ear of scrofulous children, and the formation of the fibrinoid exudation. Both processes have nothing in common with the clinical picture which I just described as otitis media purulenta phthisica, except the presence of tubercle bacilli. They will be discussed separately.

In some cases the general disease in the lungs and in other organs is so slightly advanced that at the time a phthisic suppuration of the middle ear sets in, no pronounced symptoms have appeared. It may even remain stationary or heal to a certain extent. Those are the rare cases of phthisic suppuration of the middle ear which may be cured and in which a small perforation of the tympanic membrane may even close.

The *course* of the large majority of cases is however marked by the uninterrupted progress of the destruction.

A few additional points make the clinical picture more characteristic for our diagnosis. The perforation of the tympanic membrane becomes larger and other perforations appear (compare fig. 11 on the plate). The discharge is purulent and usually fetid, the tubes are wide open so that the fluid in syringing runs through them in a stream, the bone of the wall of the promontory soon becomes uncovered and rough, and finally the power of hearing decreases greatly in a very short time.

There is no other kind of suppuration of the middle ear which so frequently shows complete loss of hearing. The ossicles are loosened from their connections, the tendons of the muscles are decayed, even the membrane of the round window and the ligamentum annulare succumb to the destruction, and the suppuration progresses into the labyrinth.

Swelling, formation of granulations in the meatus, and intense pain may occur later on, when large sequesters have formed and become partially movable. It is however peculiar that in spite of the frequent panotitis the compact bony capsule of the labyrinth, or some parts of it, are never expelled *as a whole.*

A consecutive meningitis is comparatively rarely observed.

Paralysis of the facial nerve is of frequent occurrence.

Fatal hemorrhages from the carotid artery caused by luxation of a sequester comprising its bony sheath were observed most frequently in phthisic suppurations of the middle ear.

It is surprising how long the dura and the external wall of the sinus can resist the suppuration which takes place on their surface. Sinus phlebitis, suppurative leptomeningitis, and abscesses of the brain rarely cause death. The fatal issue is usually brought about not directly by the disease of the ear but by the general disease.

Mastoiditis Tuberculosa of Children.

Tuberculosis of the middle ear in children, though presenting the same characteristic progressive decay of the tympanic membrane without the formation of granulations, is observed but exceptionally, and then only in older children.

A somewhat different disease is observed in infants and small children. It begins similarly to an acute suppuration of the middle ear, but a fluctuating swelling of the mastoid process soon follows. It leads, if left alone, to fistulous perforations and progressive enlargement of the lymph glands of the neck attaining sometimes a considerable degree. The opening in the tympanic membrane in some cases remains small, in others a perforation does not even take place, or it is covered by granulations. We find in operating after the inflammation has lasted for some time, a cavity in the bone filled with flabby pale granulations surrounding several sequesters.

The processes heal like those after empyema of otitis media purulenta acuta, if the general health of the children is good. A cavity in the bone behind the ear which may be left after the removal of a large sequester, becomes lined by the advancing growth of epidermis as in a healthy organism.

The necrosis progresses irresistibly in poorly nourished atrophic children of the first few years, who suffer from other general diseases. The bare bone only partially becomes covered with granulations, facial paralysis often sets in, and the children die from their general disease which is most frequently tubercular meningitis.

Several authors assume that a tuberculosis of the bone of the mastoid process originating from the blood, is often found in very young children. This assumption seems to be justified from the histologic findings, and in view of the fact that the disease in the bone is often spread beyond the pneumatic cells.

Tubercular Fibrinoid of the Middle Ear.

The formation of fibrinous exudations on the outside of the tympanic membrane (otitis externa crouposa) is a comparatively frequent disease of the external ear. Fibrinous exudations in chronic suppurations of the middle ear through large perforations in the tympanic membrane are on the contrary rarely observed.

I noticed such exudations several times on the wall of the promontory in otherwise characteristic cases of otitis media purulenta phthisica. *Scheibe* examined them microscopically and in 1897 published six cases which showed this unusual form of inflammatory reaction in chronic suppuration of the middle ear.[1]

There were always large, usually total perforations of the tympanic membrane. Some of them showed epidermisation of the upper parts of the tympanic cavity, and obstinate odorless muco-purulent secretion. Suddenly, together with an increase of secretion, a tightly adherent thick layer of gray fibrin appeared on the wall of the promontory. It disappeared gradually after several weeks while at the same time healthy granulations formed. Particles of the fibrin and the fluid secretions contained tubercle bacilli in varying quantity during the whole time. The coagulated exudation is very similar in its microscopical and chemical condition to the fibrinoid which *Schmauss and Albrecht*[2] found in the lungs as an introductory state to cheesy degeneration of the tubercles. It does not show *Weigert's* reaction for fibrin.

All of these patients showed other symptoms of slight, usually stationary, tuberculosis.

The suppuration in the ear never manifested a destructive character, and in all cases which remained under our observation healed by means of boric acid treatment after a number of weeks. The parts of the tympanic cavity which were formerly covered with the coagulated exudation, became epidermized later on.

A large number of cases have since been observed. In no case and in no specimen were *Koch's* bacilli in pure cultures absent in the fibrinoid. The fibrinoid contained at times such an abundance of them that one might have thought there was an artificial culture under the microscope (compare fig. 69). Some bacilli showed indications of formation of pearl strings. They proved characteristically pathogenous to animals. Inoculations in the anterior chamber of guinea pigs and rabbits caused

1 Ueber leichte Fälle von Mittelohrtuberkulose und die Bildung von Fibrinoid bei denselben. Zeitsch. f. O. Vol. 30.

2 Virchow Archiv. 144 suppl. 1896.

the typical formation of a tubercle at the place of inoculation and a ring of tubercles in the vicinity.

In spite however of the abundant formation of *Koch's* bacilli in the tympanic cavity none of the patients observed during the time of the formation of the fibrinoid showed any fever or loss of weight or strength, nor did the general condition grow worse.

The great theoretical interest of this form of local tubercular disease of the ear is no doubt evident to everybody.

There is an irresistible decay of the tympanic membrane of the lining of the middle ear and of its bony walls in the common form of otitis media phthisica, while the number of *Koch's* bacilli is in *no* proportion to the extent of the destruction; often they can not be found at all

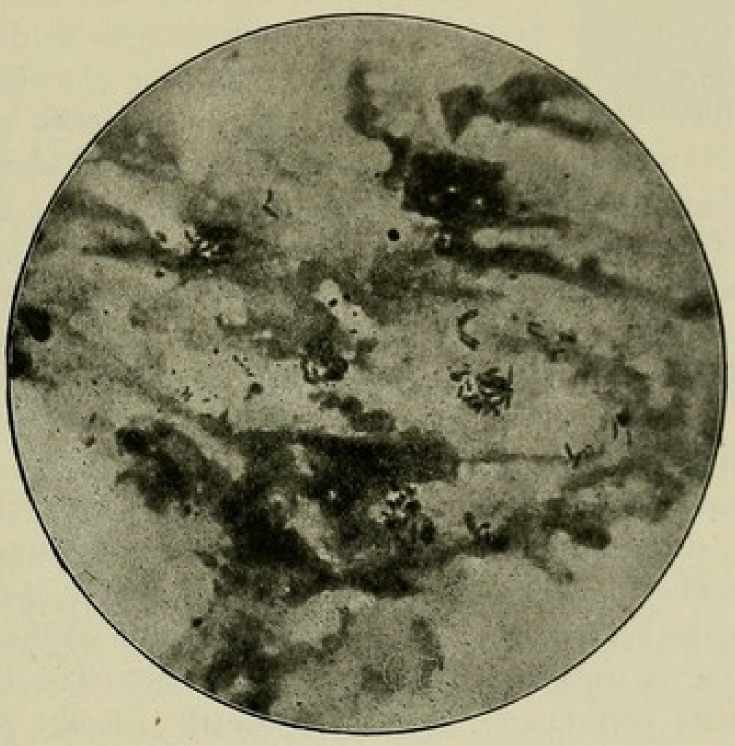

Fig. 69.

Fibrinoid with a great many tubercle bacilli.

in the secretions. On the other hand as long as the formation of the fibrinoid lasts we always find an abundance of *Koch's* bacilli, sometimes in incredible numbers in symbiosis with the human organism, which does not suffer from them in any way. They even seem to start some kind of a curative process by forming the fibrinoid.

It must however be left to the bacteriologist to follow up the importance of these clinical observations in the ear for the position of *Koch's* bacilli and for the pathogenesis of phthisis in general.

Other Forms of Caries and Necrosis of the Middle Ear.

We have mentioned that otitis media purulenta *acuta* occurring in the course of some serious acute infectious disease like scarlet fever, measles, influenza, typhoid fever, etc., may lead to uncovering of extensive parts of bone and later on to formation of sequesters.

Caries and necrosis in the course of otitis media purulenta *chronica*, besides being found in consumptives, scrofulous and atrophic children, and in those suffering from rickets, are also found in tertiary syphilis, though only exceptionally very extensively developed.

A few words must now be said about osteomyelitis in the temporal bone which however does not occur as frequently as some surgeons think.

Osteomyelitis of the bones of the skull, especially of the temporal bone, and in connection with suppuration of the middle ear, is an extremely rare disease according to a late compilation of *R. Schilling.*[1] It is peculiar that it most frequently attacks young women (which to me suggests lues congenita according to my experiences in deaf-mutes, although *Schilling* did not find any other support for this view).

The purulent inflammation does not stop in the cells of the mastoid process where it begins, but progresses irresistibly along the large *Breschet's* veins in the bone to the squama, and beyond. The formation of *corresponding* subperiostal and extradural abscesses is absolutely characteristic for osteomyelitic disease of the bone. The surface of the bone is discolored and rough. Some few foci of suppuration in the diploë are found in the earliest stages. A large number of sequesters are later on isolated. The beginning of *new formation* of bone was found only in one case, which recovered.

Three cases were examined bacteriologically; staphylococcus was found in one, streptococcus in one and pneumococcus in one; this in an infant of nine months with a rapid course of the disease, death occurring six days after the beginning of the acute suppuration of the middle ear.

The course is usually a more protracted one. The dura in these cases also resists very long. Even this bulwark is finally overcome and death ensues.

Osteomyelitis succeeding suppuration in the cells of the mastoid process is established when elevation of temperature, pain and oedema in the surroundings of the focus of the disease persist, and incessantly expand even *after* the focus has been uncovered by operation.

The whole course of osteomyelitis of the temporal bone is totally different from all our other observations in this locality. We are therefore justified in suspecting that some serious general diathesis is the instigator of this process, if it is not lues as before mentioned.

Besides the described diseases of bone there are some cases in which certainly no general disease preceded or accompanied the development of the necrosis of bone. We have to look for some *local* cause for the abnormal course in such instances.

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1) Ueber die Osteomyelitis der flachen Schädelknochen "Zeitschr. F. Ohrenhlk. Vol. 48. Ergänzungsheft, page 52.

I described one of these cases 27 years ago.[1] It may be mentioned as an example.

An otherwise absolutely healthy woman suffered from congenital cleft palate and consequently of chronic processes in both middle ears. In order to improve her hearing she introduced *Yearsley's* cotton balls (compare later) into her tympanic cavity almost daily for 14 years, so that the depth of the meatus of one ear was closed by polypoid growths. After their removal I extracted through the meatus the sequester portrayed in fig. 70. One end is the rear wall of the tympanic cavity, against which the cotton ball was pressed, the other end extends to the sigmoid sinus and represents a part of its bony wall. The remaining cavity became epidermized later on.

Fig. 70.

Bony sequestrum.

a sulcus sigmoideus, *b* posterior wall of the drum cavity.
The lower view shows the inner surface of the antrum.

Cotton balls and other foreign bodies which remained in the tympanic cavity have probably often played a similar rôle in the development of caries and necrosis.

Cholesteatomatous masses which have been allowed to gather and decompose for years consequently acting as foreign bodies, are found much more frequently than the foregoing to be the cause of more or less extended caries and necrosis of the surrounding bony walls.

Gross neglect for long periods of time and consequently far progressed putrid decomposition is found in all such cases. The surrounding soft tissues over quite an area are of a greenish color and partly decayed under the influence of the initial decomposition. Such processes are, according to my experience, absolutely excluded in an otherwise healthy organism under correct treatment. *von Troeltsch* long ago laid great stress on the importance of decomposition as a cause of destructive processes.

Treatment of Otitis Media Purulenta Phthisica, Caries and Necrosis.

The simple antiseptic treatment which was advised for suppurations with central perforations suffices as a treatment of otitis media purulenta of consumptives, as long as the suppuration keeps within moderate limits and there is no pain.

The tuberculous fibrinoid of the middle ear which we discussed before needs no other treatment than occasional use of the antrum tube.

Severe persisting pain, profuse secretion, swelling and granulations

[1] Arch. f. Ohrenheilk. Vol. XIII, page 58.

in the meatus in otitis media purulenta phthisica, indicate with great certainty *the presence of a large sequester,* which ought to be removed, no matter how far the general disease has progressed.

We were formerly more conservative as to operative interference in these cases on account of the general disease.

Experience however has gradually shown that the operative interference in extensive caries necrotica which causes considerable suppuration, swelling of the walls of the meatus, pain, etc., is of great benefit even to advanced consumptives.

The radical operation is always necessary. It is not very difficult in these cases, the bone never being sclerosed, on the contrary very thin and often extraordinarily brittle. We can not always remove everything that is diseased if for no other reason than to avoid a fatal hemorrhage from the large blood vessels. Still we are often surprised at the favorable influence which an extensive uncovering and cleaning of the focus has, not alone upon the local process, but also upon the general condition of the patient, the temperature, the increase in strength and weight.

The local reaction after the operation amounts to nothing. The formation of granulations around the exposed necrotic bone always keeps within moderate limits, so much so that often the epidermis progressing from the outside grows close to the necrotic bone, because a ring of granulations is totally absent. The suppuration can be kept within moderate limits and odorless. Necrotic pieces of bone which become demarcated and movable in the late course of the disease can easily be removed through the big opening.

Even though we are not able in far progressed cases of phthisis, to bring about a complete cure of the local process, still it remains painless, after the operation, and is not another factor to accelerate the unavoidable result.

Mastoiditis tuberculosa of children requires either *Schwartze's* or a radical operation according to the extension of the disease of the bone.

The *prognosis* of tubercular mastoiditis in children is generally favorable because tuberculosis in children is in most cases a merely local process. A complete cure however often requires considerable time. The prognosis is more unfavorable the younger the child, and the poorer its general nutrition.

The careful supervision of the general condition of the patient in all these local processes is a duty which ought never be neglected. These few remarks must however suffice, as a more careful explanation of details is beyond the scope of these lectures.

The bone in mastoid operations directly after *acute infectious diseases* is often bare to a large extent. This is however no proof that the bone is definitly dead. I saw for example in extensive operations right after an attack of scarlet fever, measles, typhoid fever, and even after a beginning tuberculosis, how all the cells were bare of their lining, the bone yellow, and yet it recovered, became gradually red, and by and by covered with granulations, though sometimes only after 10 or more days. In similar cases it is therefore sufficient to give free drainage to the pus in the middle ear, provided there are no cerebral complications present. Then we ought to wait and see, if and how much bone is going to be eliminated.

No general rules can be made as to what ought to be done if a sequester has formed or becomes more or less demarcated.

Sometimes we are able to extract a large loose sequester through the meatus or through a fistula behind the ear by means of a forceps, after the granulations have been removed; in other cases however the total removal of dead bone in connection with radical operation may extend to the dura of the middle and posterior cerebral fossa, especially in caries and necrosis of the bony walls surrounding large decomposed masses of cholesteatoma.

LECTURE XXIII.

Labyrinthian and Endocranial Complications in Acute and Chronic Suppurations of the Middle Ear.

A. Complications of the Labyrinth. Suppurations and Necrosis of the Labyrinth.

Gentlemen:—The progress of an inflammatory process from the middle ear to the inner ear, that is, the development of a panotitis, whether in the course of an acute or chronic suppuration of the middle ear must always be considered a serious complication which is directly dangerous to life.

104 out of 198 cases of suppuration of the labyrinth which *Hinsberg*[1] gathered from literature terminated fatally.

Friedrich a short while ago published a very careful monograph about "suppurations of the labyrinth of the ear" based upon the large material of the ear clinics of Halle and Kiel. He comes to the conclusion that there is about *one* case of suppuration of the labyrinth to every 100 cases of suppuration of the middle ear.

Suppurations of the middle ear occurring in the course of acute infectious diseases, particularly scarlet fever and measles, are especially prone to advance to the spaces of the labyrinth. Tuberculosis principally, but also diabetes and lues, are the chronic general diseases which are similarly responsible for this progress.

Acute suppurations of the middle ear occurring in old age are equally apt to perforate into the labyrinth.

It is however very rare that we observe this cause in an acute suppuration of the middle ear in an otherwise healthy and strong organism.

Among the *local causes* cholesteatoma, of all chronic suppurations, is oftenest complicated by invasion of pus into the labyrinth, on account of pressure atrophy and caries in its surroundings.

A number of cases of panotitis must be attributed to injuries during operations, like unintentional removal of the stapes, opening with the chisel of the horizontal semicircular canal, etc.

The usual avenues by which suppurations of the middle ear enter

[1] Zeitschr. f. Ohrenhlk. vol. 40, page 117.

into the labyrinth are the round or the oval windows, or both (the latter especially in consumptives). An acute empyema of the mastoid process may furthermore reach the labyrinth through cells surrounding the labyrinth from the inside, which are sometimes especially well developed. It may enter through the rear semicircular canal under these circumstances. In chronic suppurations these cells, except in consumptives, are filled with sclerosed bone long before such an occurrence is possible.

The characteristic *symptoms of irritation of the labyrinth* were present, at least in the beginning, in all cases that I observed of perforation of a suppuration of the middle ear into the labyrinth. These symptoms are a subjective feeling of dizziness, dizziness in rotation and lying down; objectively, irregularities in walking, horizontal nystagmus in looking towards the healthy side, and vomiting. The nystagmus is sometimes rotating and disappears sooner than dizziness.

The result of *hearing tests* furnishes reliable conclusions as to suppuration of the labyrinth, only under the condition that the power of hearing has entirely disappeared in the affected ear; that is if it shows a weak reflected image of the hearing of the other, the good ear. We shall learn in speaking about necrosis of the labyrinth how characteristic this reflected image is.

Subjective noise and violent headache are always present in the beginning, even though they are often overshadowed by other serious symptoms. There is no pronounced elevation of temperature as long as the suppuration remains confined to the labyrinth.

You will understand how easily a suppuration after having reached the spaces of the labyrinth, will spread there and how rapidly it will extend to the meninges if you consider the following facts: all spaces of the labyrinth communicate freely with each other and have open avenues (compare page 14) through the porus acusticus internus, and the aquaeductus cochleae, directly into the subarachnoidal space, and through the aquaeductus vestibuli into the saccus endolymphaticus, which lies between two leaves of the dura. Suppurations of the middle ear of consumptives form an exception, as they rarely lead to cerebral complications although they invade the labyrinth comparatively frequently.

It is probable that in a number of cases a wall of granulations is formed which checks the further spreading of the inflammation. This wall may form in the surroundings of the place of perforation, around the windows, etc., or in the porus acusticus internus and in the aquaeducts if panotitis has already developed, or later on when necrosis of the labyrinth has begun in its whole surroundings.

A large number of pathological findings in the ears of deaf-mutes who had only *partially* lost their hearing after a suppuration of the middle ear had progressed to the labyrinth, allows us to accept the first mentioned possibility.

In such cases we observe for example that the hearing of a large part at the upper end of the sound scale is lost. According to *Helmholtz's* theory this justifies the conclusion that the suppuration invaded the basal coil of the cochlea through the round or oval window. The destruction was confined to this coil or only a part of it. I draw your attention to fig. 27 which shows the diagram of hearing of a number of deaf mutes.

On the other hand we are comparatively often in a position to observe clinically the gradual expulsion of sequesters which form parts of the bony labyrinth. They could only develop after a well defined panotitis had cut off the nutrition of the bone which in turn caused such intense reaction all around, that every entrance to the interior of the skull was closed by a wall of granulations around the forming sequester, thus protecting the interior of the skull from the invasion.

The statistics of *Hinsberg*, previously mentioned, show however how numerous the cases are which succumb, because this protection does not take effect and the skull cavity remains freely accessible.

Death occurs here most frequently from leptomeningitis, and in a comparatively large number from abscesses of the cerebellum.

In 60 cases out of 104 compiled by *Hinsberg* the cause of death was meningitis alone, in 6 it was meningitis combined with abscesses of the cerebellum, 13 times abscess of the cerebellum alone, and in the other 25 cases the fatal result was brought about by "other diseases."

Empyema of the saccus endolymphaticus usually forms the connection in the development of abscesses of the cerebellum. We find a bag of pus on the rear surface of the pyramid corresponding to the slit of the aquaeductus vestibuli, or sometimes also corresponding to the posterior vertical semicircular canal, which is destroyed by caries. This bag has become broadly adherent to the surface of the cerebellum and formed the avenue for the suppuration from the labyrinth to the cerebellum. Diffuse leptomeningitis is the direct consequence if the thin leaves of the bag of the dura burst.

The question of *therapy* in cases of fresh invasion of the labyrinth is an extremely difficult one.

There can be no doubt but that theoretically an extensive operation, uncovering all the cavities in the bone containing pus might create the most favorable conditions. Accordingly a very complete opening of all spaces of the labyrinth in connection with radical operation was repeatedly tried. Many a "latent" suppuration however became "florid" after this procedure, in other words meningitis followed directly after the operation. Recent authors are therefore very reserved as to entering the labyrinth by operation. *Friedrich* classes them among "the most serious operations, which we are not justified in undertaking without vital indications," and reminds us of how easily adhesions may be separated which formed the only protection against the danger of invasion.

The heavy shock from chiseling the sclerosed bone during a radical operation must be considered dangerous in recent suppuration of the labyrinth. In the findings of a post-mortem which I made a short time after one of these operations, there was a large number of separate leptomeningitic islands with fibrinous purulent exudation all around the porus acusticus internus. The impression admits of no doubt in my mind that in this recent case these islands corresponded to small particles of pus which were scattered by the shocks of chiseling from the porus acusticus internus over a large surface of the subdural or arachnoideal space.

Since then I have made it a rule, at least in chronic suppurations of the middle ear with sclerosis of the bone and symptoms of a recent *invasion of the labyrinth* to postpone radical operation unless vital indications are present. The most important of these symptoms is sudden appearance of complete deafness.

Later on when the demarcation and the formation of a sequester of the wall of the labyrinth has taken place there is no reason for hesitation in laying bare the spaces of the middle ear, according to my own experience and to that of others..

It is of greatest importance to watch carefully for the first symptoms which may point to a *threatened* invasion of the labyrinth.

I observed them especially clearly in the course of acute suppurations of the middle ear. These symptoms are sudden appearance of dizziness and disturbances of the equilibrium, sudden loss of the power of hearing and especiall} rapidly progressing loss of hearing at the upper limit of the sound scale, which is tested by means of the *Galton* whistle. They are an urgent indication for immediate operative opening of the antrum and the cells, and in chronic suppurations with cholesteatoma or caries, for radical operation. It is preferable not to disturb the wall of the labyrinth, even if there is an old suppuration of the labyrinth, except when unmistakable signs, like a granulating fistula are found in the wall of the labyrinth, or an enlarged oval window filled with granulations. The fistula ought to be carefully enlarged with a very small chisel without scraping the granulations in the depth.

The necrotic expulsion of some parts of the labyrinth has been clinically observed in a large number of cases, also, though rarely, of the whole labyrinth, and even of sequesters representing still larger parts of the temporal bone.

As early as 1886 I gathered 46 cases from literature[1] 5 of them I reported myself. *Gerber*[2] in 1903 brought the number up to 90.

To the present time I have observed 13 cases. According to my statistics there is *one* case of necrosis of the labyrinth to every 3,000 general ear patients, and to every 500 cases of chronic suppurations of the middle ear.

Only one of those 13 cases terminated fatally, and even this one

[1] Labyrinthnekrose and Facialisparalyse Z. f. O. Vol. 16.

[2] A. f. O. vol. 60, page 16.

after the sequester was expelled. The patient suffered at the same time from necrosis of the maxilla[1]. I obtained furthermore the temporal bone of another fatal case for examination. Here the sequester, representing the cochlea, was still imbedded.

This shows that the prognosis is not so unfavorable if a demarcating formation of granulations has taken place all around the sequester.

The clinical picture of gradual elimination is so characteristic that in my last cases I could predict far in advance the appearance of a sequester of the labyrinth.

This picture offers a number of interesting points.

They were mostly patients with long neglected or unsuitably treated chronic suppurations of the middle ear. They came to us only after they had suffered from pain and continual insomnia for many months. Their general condition was therefore badly run down although there were no other general symptoms.

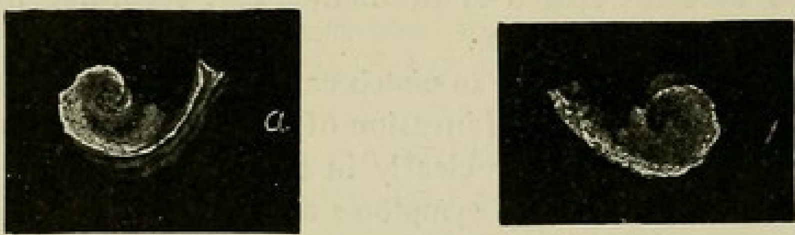


Fig. 71.

Sequestrum consisting of the whole basal coil of the cochlea.
a as seen from the outside, *b* as seen from the inside.

The beginning of the necrosis of the labyrinth could usually be determined in the anamnesis from the time when the dizziness was worst. Dizziness becomes less prominent later on.

Paralysis of the facial nerve is only exceptionally absent in the later course. It begins with a paresis which follows several months after the first attack of dizziness, and may be taken as the first sign of the fact that the sequester has become movable. The picture in the depth of the meatus becomes at the same time very characteristic. The thin fetid discharge which was there from the beginning becomes even more profuse. New granulations with a broad base on the promontory spring up very quickly as soon as they have been removed, which has to be done 2 to 3 times a week by means of the snare, in order to create free drainage for the pus. The granulation, when it is well caught at its base, is always very painful, because the sequester lying underneath is touched. The granulation is *perforated in the center,* which is a proof that it was on the opening of a fistula in the promontory. The pain, the suppuration and the formation of granulations decrease gradually later on. After several more months of scant secretion have passed, the bare bony sequester

[1] Z. f. O. vol. 30, page 11. Case Seemüller. The necrosis of the maxilla is not mentioned there in the history.

appears in the depth of the meatus and can easily be removed in the majority of cases.

In three cases I performed a radical operation on account of the especially profuse discharge and luxuriant formation of granulations. The sequester appeared however even in these cases only later on, as I do not think it is permissible to seek it forcibly for reasons which I explained before.

The sequester forms a part of the basal coil of the cochlea in the majority of cases (compare fig. 71). This fact indicates that the round or oval window formed the avenue of invasion through which the suppuration passed into the labyrinth. In one case an especially large sequester had been expelled through an opening which had formed spontaneously for that purpose behind the ear many years before I saw the

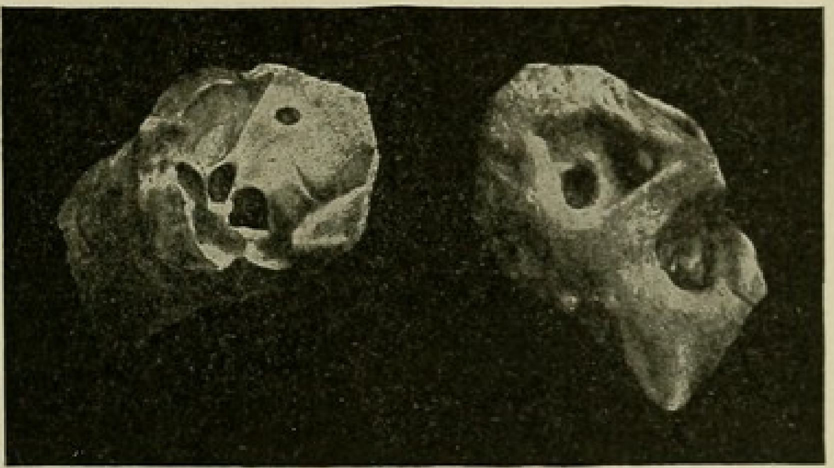


Fig. 72.

Sequestrum consisting of the whole petrous portion of the temporal bone, the labyrinth, the porus acusticus internus, the promontory, and a large part of the Fallopian canal.

a as seen from the outside, *b* as seen from the inside.

case for the first time. The sequester reached from the porus acusticus to the wall of the promontory which was eliminated with it (compare fig. 72).

Cases of necrosis of the labyrinth are also of great physiological interest, as they alone put us in a position to ascertain the *finding of the function in one-sided deafness,* the presence of which can of course not be doubted in these cases.

A number of authors thought they could show remnants of hearing after parts of the labyrinth were expelled. *Lucae-Dennert's* test however proved long ago that mistakes were made somewhere. This is no more than could be expected. This test consists in hearing tests for whisper made by alternately opening and closing the diseased ear while the other, the healthy ear, is kept tightly shut with a moist finger. The patient hears whisper or conversation just as well with the diseased ear closed as open. This remnant of hearing can not be attributed to the diseased ear but proves that we are not able to exclude hearing with the good ear, as is shown also by the considerable remnants of hearing in patients with congenital atresia of both external canals (compare page 101).

This test can be made more accurately by means of the continuous series of sounds. We test as in deaf-mutes the duration of hearing by air conduction for octaves and fifths throughout the whole extent of hearing.

The lowest part of the scale up to the octave from a to a′ is not heard on the side of the head where there is no labyrinth. Hearing increases more and more the higher we ascend in pitch from this octave (compare fig. 73). The picture of the diagram of hearing of the ear without a labyrinth, which we obtain in this way, is nothing else than a faint image of the hearing of the other, the healthy ear. This is proved most accurately in those cases which show irregularities of hearing in the better ear. We find gaps of hearing in the ear without a labyrinth which absolutely correspond to the irregularities in the better ear. Four cases of necrosis of both labyrinths showed lately that the ear without a labyrinth is absolutely deaf.

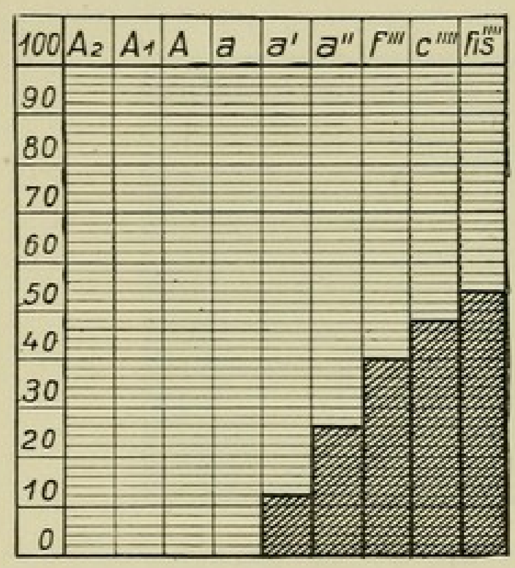


Fig. 73.

Diagram of the apparent power of hearing of the ear that has no labyrinth, while the other ear hears normally.

This diagram of hearing which we observe in each case of one-sided deafness is of utmost importance for diagnosis and treatment for you know, gentlemen, that our whole therapeutical action in a beginning invasion of the labyrinth depends principally upon the question whether or not the labyrinth is still free from pus.

The paralysis of the facial nerve disappears in most cases, especially of small sequesters of the cochlea, during the migration of the sequester or soon after. It usually remains permanent after the expulsion of large sequesters, enclosing also the vestibulum. The function of the nerve, or at least of some of its parts, may return even after years. What an incredible amount of regenerative power must be attributed to this nerve is shown by the case to which the sequester reproduced in fig. 72 belongs. You see from this picture that the sequester includes the largest part of the canalis *Fallopii*. The facial nerve must have been severed in the gradual expulsion of the sequester which occurred in early childhood. When I saw the patient as a young woman there was still the gap in the bone behind the ear through which the sequester had passed. It was filled with granulations, but there was no trace of the paralysis of the facial nerve. The patient herself was not aware that she ever had a paralysis yet we can not doubt its having been present.

The suppuration stopped in all cases after the sequester was expelled and the last granulation was removed. The patients must however be controlled from time to time during later years because cholesteatoma may gather in the cavity which becomes lined with epidermis.

B. Endocranial Complications of Acute and Chronic Suppurations of the Middle Ear.

The progress of acute and chronic suppurations of the middle ear to the meninges, the large blood vessels and the brain, may cause a large number of complications.

Extradural Gatherings of Pus.

They are the mildest and most frequent concomitant of suppurations of the middle ear, and are almost always the intermediary in the development of other more severe complications. (The empyema of the saccus endolymphaticus which we discussed before is usually an extradural gathering, as according to my experience the external leaf of the sack is very thin and perforates early, evacuating the pus between the bone and the dura). There are therefore only two complications which do not depend upon a gathering of the pus between the dura and the bone as their intermediary for endocranial complications, namely, the suppurative processes which extend through the aquaeductus cochleae and those through the porus acusticus internus. The subarachnoidal space and the space of the labyrinth are one and the same space, and do not need an intermediary for the extension of a suppuration.

We shall first discuss the *pathogenesis of the extradural gathering of pus* which is so important practically.

The first question is, which are the avenues for the pus to reach the dura from the spaces of the middle ear. Let us recall the anatomical structure of the complicated system of cells. The size of the cells varies greatly. The largest terminal cells at different places are in closest proximity to the dura. We learned that the larger the cells are, the more difficult is the absorption of an empyema which develops in them. There is furthermore a rarefying osteitis with the formation of osteoclasts in the walls, leading to a progressive excentrical enlargement of the spaces, till the pus finds some place where it perforates through the bony wall, either outwardly or inwardly. Large pneumatic cells are found especially frequently throughout the whole extent of the sulcus sigmoideus, in the hight of the antrum, and lower, in its horizontal part which is closer to the bulbus, as well as around the bulbus itself. The wall of the sulcus is often so thin that it is translucent. A large number of small blood vessels, which can clearly be demonstrated in the corrosion specimen, pass from the lining of the cells to the wall of the sinus.

All these conditions come into consideration only in *acute* suppurations of the middle ear in a highly pneumatic temporal bone. Everything is changed after the suppuration has lasted for some years. The cells are partly or entirely filled with bone and nothing but the aditus and the antrum remain. This explains the fact that extradural gatherings of pus in the sulcus sigmoideus are mainly found as complications in the course of otitis media purulenta acuta. We sometimes, in opening the cells after a few weeks' duration of an acute suppuration, find the outer wall of the mastoid process rather thick, while the inner wall of the cells is absorbed to the extent of 2 centimeters and more where the wall of the sinus throughout its entire length forms the inner limit of the empyema. The extradural gathering in other cases develops much later, sometimes several months after the perforation in the tympanic membrane has closed. There are cases which from the beginning never had a perforation.

A suppuration extends to the middle fossa of the skull less frequently than to the rear fossa. This takes place from the cupola of the tympanic cavity, from the aditus ad antrum, or from the antrum itself through dehiscences which are often found in the tegmen tympani et antri. It is favored by a sutura petroso-squamosa embracing a continuation of the dura.

The pus which gathers between the bone and the dura has no odor if the pus in the spaces of the middle ear in acute suppurations remained odorless. This can easily be accomplished by keeping away all harmful influences from the outside. Caries and necrosis play a rôle in the propagation of the pus to the dura in acute suppurations only if they occur in an organism which is weakened by some acute general infectious disease, or in diabetes, in old age, etc.

An extradural gathering of pus after an acute otitis media purulenta extends only exceptionally over a large surface between the dura and the bone, thus forming a real extradural abscess.

A spontaneous recovery is possible under favorable circumstances: the surface of the dura becomes covered with granulations which also develop all around the periphery of the focus. The pus may be evacuated backward through the middle ear and thence through the perforation in the tympanic membrane or to the outside through a fistula in the soft tissues, or it may find an avenue along an emissary vein through the bone underneath the external soft tissues which it perforates later on.

Extradural gatherings of pus occurring in *chronic* otitis media purulenta are different in many regards.

The simple form of chronic suppuration with *central* perforation of the membrane hardly ever leads to a propagation of the suppuration, according to my experience, provided it occurs in an otherwise healthy organism where the bone in the surroundings of the antrum is sclerosed.

Extradural gatherings of pus are found more frequently in chronic suppurations with *marginal* perforations and gathering of masses of *cholesteatoma,* although not as often as in acute suppurations. They are also found in *caries and necrosis* of the walls of the middle ear whether they are due to merely local causes or to the influence of some serious generai diathesis.

Cholesteatoma may lead to excentric enlargement of the cavity which surrounds it and to perforation of the inner wall of the skull the same as an acute empyema of the mastoid process. This is however a great exception. It has, as a rule, enlarged its communication with the external meatus by pressure, etc., or has perforated to the outer surface of the mastoid process long before it reaches the inner surface of the skull, provided it can develop without being interfered with.

A number of complications may however occur which put an end to their further development, and also to life, long before the cholesteatomatous masses can even partially be evacuated in this way.

We found no excessively large masses of cholesteatoma and no enlarged antrum in the vast majority of cases necessitating the uncovering by operation of an extradural focus of suppuration in connection with cholesteatoma. A small mass of decomposed epidermis, not larger than a pea, confined to the aditus ad antrum has often led not alone to an extradural abscess, but to a number of other complications which threatened directly the life of the patient.

In the surroundings of the cholesteatoma and of the extradural abscess, there are always clear evidences of decomposition, such as pronounced fetor, partial discoloration of the tissues, and putrid decay of the soft parts, besides the suppuration, and the formation of granulations. These processes defy the protection afforded by a comparatively thick inner wall of the cholesteatoma cavity. Its nutrition in part is cut off and it becomes necrotic.

There are two places in which this occurs especially frequently. The first is the rear end of the antrum, where only a comparatively thin wall separates the sinus from the antrum (compare fig. 16 page 33), the other is the thin tegmen tympani and antri.

The middle and the rear cerebral fossae seem to become affected almost equally often, which is contrary to what we see in acute suppurations of the middle ear.

The extradural gathering of pus, according to my experience, is in these cases always fetid, likewise the pus in the middle ear. The surroundings of the focus, the dura and the sinus, are usually discolored. The power of reaction of the tissues is lessened on account of the processes of decomposition. This must probably be accepted as the cause for the fact that the extradural suppuration leads here much oftener to gatherings of surprising extent, and to the *formation of real extradural abscesses.*

The dura in chronic suppurations resists the progress of the process and the perforation inward apparently even for a longer time than in acute suppurations; a similar occurrence to that which we may observe in caries of the vertebrae.

The pus may reach the outer surface of the dura, if *caries* and *necrosis* are present. The prototype of this condition is otitis media purulenta phthisica. The bone somewhere on the inner surface of the skull decays with or without the influence of saprophytes. The pus reaches the dura comparatively easily and frequently in consumptives, as sclerosis of the bone is totally absent; the pneumatic cells are usually in abundance and are even excentrically enlarged by caries of their walls, while at the same time sequesters of different sizes are formed. The power of resistance of the dura against the process of suppuration is even greater in consumptives than in acute and chronic suppurations of the middle ear. Complications like abscess of the brain, thrombophlebitis and diffuse purulent leptomeningitis are very rare in otitis media purulenta phthisica in spite of the great length of time over which these processes extend in some cases.

Clinical symptoms may be entirely absent in extradural gatherings of pus after acute or chronic suppurations of the middle ear. The most frequent symptom is one sided headache, lancinating towards the vertex. The existence of an extradural gathering of pus during a later state is sometimes betrayed by a secondary perforation of the pus into the ear, or by a perforation through an emissary vein underneath the external soft parts.

By far the largest number of extradural gatherings in acute as well as in chronic suppurations are discovered at the time of the operation. Their frequent occurrence, which was thus recognized in the living, entirely justifies the indication for operation which was given some time previous. We have to uncover the spaces of the middle ear by operation and find the focus if acute suppurations of the middle ear do not cease after careful treatment for eight weeks, and if in chronic suppurations the fetor does not cease after a treatment of several months.

You will now readily understand that the extradural gathering of pus is the process which forms the most frequent connecting link between suppurative otitis and the three complications, sinus phlebitis, abscess of the brain, and leptomeningitis, which we shall discuss in the next lectures and which usually end fatally.

LECTURE XXIV.

Sinus Phlebitis.

Gentlemen:—The proximity of the external wall of the descending part of the sinus transversus, which is usually called the sigmoid sinus, to the rear end of the antrum and to the cells of the mastoid process, furnishes the explanation why the external wall of the sinus is frequently affected in chronic suppuration of the middle ear with caries of the bony wall. This may however also occur after a very short attack of an acute suppuration of the middle ear. An extradural gathering of pus around the walls of the sinus is not even necessary.

Let me give you the findings at the post-mortem of a fresh acute suppuration of the middle ear as an example. The suppuration was caused by a foreign body in the tympanic cavity wedged into the ostium of the tube (seed of a locust bean) and by fruitless attempts at extraction. The disease terminated fatally from meningitis after 3½ weeks.[1]

It is only the finding of the sinus which interests us here.

"In the right sigmoid sinus there is an apparently fresh yellowish transparent goosegrease clot. It is adherent to the external wall, filling the otherwise empty aperture only partly. The clot can be easily lifted from the wall at both extremities above and below. It is however adherent at its center which is at the curve from the horizontal to the vertical part of the sinus. *A drop of fresh pus can be squeezed from the clot by means of a probe pressing at the place of adhesion.* The wall of the sinus is normal except at the spot where the clot adhered. After its removal a swelling the size of a lentil is seen, having a crater-shaped ulcer in its center with steep margins. *After the removal of the sinus from its bony sulcus the wall of the sinus at this place is connected with the bone by a yellow infiltrated cord.*"

I quote verbally this finding published in 1888 because I can hardly offer you a better picture of the pathogenesis of sinusphlebitis produced through the intermediary of little veins which pierce the bone (osteophle-

[1] "Fremdkörper im Ohr." Berl. kl. Wochenschr. 1888 No. 26. (The case was observed at a time when the radical operation was not known as a safe method for removing similar foreign bodies from the ear.)

bitis. *Koerner*). *There was no gathering of pus of any consequence between the wall of the sinus and the bone.*

Supposing the fresh blood clot, which adhered to the wall and shut off the pus that formed on the inner wall of the sinus, had been detached from the wall by the current of blood and no new thrombus had formed in its place, free pus and pyogenous germs would have entered directly into circulation, and that form of pyemia would have developed which *Koerner* described as characteristic for osteophlebitis. The germs after passing the lungs would have entered the circulation and caused metastases in the peripheral parts, in the joints, in the muscles, in the subcutaneous connective tissue, etc. This form developes only in acute suppurations of the middle ear according to *Koerner.*

A solid thrombus *adherent to the wall* would probably have formed around the small focus of suppuration in the sinus, if the development had lasted longer during the life of the patient. One end of this thrombus would have grown towards the heart, the other, the peripheral end, towards the horizontal part of the sinus, becoming an obstructing thrombus. Daily experience shows that this thrombus very soon reaches the *bulbus* of the jugular vein, where the conditions for its formation are especially favorable, probably on account of the slackening of the current of blood. The thrombus thence progresses down the jugular vein where it may be torn loose and carried to the *lungs.* There it is retained on account of its size and causes metastatic *infarctions* or metastatic *foci of suppuration* if it is already decaying and purulent.

We find the wall of the sinus to be yellowish transparent when we uncover it, after the thrombus in otitis media purulenta *acuta* has lasted for some time. In other cases there are either minute or large perforations, and the aperture is filled to a certain distance with fluid pus which is in direct connection with the gathering outside the walls. The pus in the sinus is shut off at both extremeties, towards the brain and towards the heart, by a solid thrombus. The outer surface of the wall of the sinus is covered with luxuriant granulations to a large extent. They may reach upward as far as the transverse part, and downward as far as the bulbus.

These foci of suppuration are usually odorless if foreign harmful influences were not allowed to take effect (poultices, tamponade of the meatus, etc.).

However *processes of decomposition* originating from decomposing masses of cholesteatoma *play an important part in the development of the thrombosis of the sinus* in otitis media purulenta *chronica.* They usually lead to circumscribed caries and necrosis of the bony wall. The gathering of generally decomposed pus is of larger extent. The wall of the sinus is discolored greenish or blackish. The granulations on the wall of the sinus also are usually discolored. A dirty looking thick layer of fibrin sometimes takes their place. Later on a large area of the external wall decays. Even the *whole* circumference of the sinus and a part of the adjoining dura may decay by necrosis and become loosened so that the pus is found in the *subdural* space (a very instructive case of this kind is described in *Koerner's* "Otitische Hirnerkrank," III edition, page 37).

The pus is always very fetid, decomposed, and sometimes contains gas bubbles. Black, crumbly massses of thrombus and decomposed pus are found in the sinus. The inner wall of the sinus is usually found to be smooth but discolored after it has been opened, and the pus and the masses of thrombus have been removed.

Thrombophlebitis in otitis media purulenta chonica usually leads to purulent metastases in the *lungs* as the emboli which become detached are generally large.

The thrombosis of the sinus may spread enormously if the patient does not die at an earlier stage.

It may creep backward through both sinus petrosi and affect not alone one but both *sinus cavernosi.* The consequences are the well known symptoms of thrombosis of these sinuses namely oedema of the eyelids, chemosis, choked disk, retrobular abscesses, etc. The torcular *Herophili* and the *transverse sinus* of the other side may be reached from the horizontal part of the transverse sinus. Thence all other sinuses and the bulbus and internal jugular vein of the opposite may be reached.

The bulbus of the diseased side succumbs to thrombosis very soon in chronic suppuration of the middle ear and the thrombosis sometimes progresses very rapidly along the jugular vein down to the vena anonyma.

Through special pathology you have become sufficiently well acquainted with the *symptoms* of thrombophlebitis with the consecutive septicopyemia and its metasases to make it unnecessary for me to discuss them in detail here. Chills are rarely absent. Enlarged spleen is found later on. The fever is pathognomonic for pyemia. It is irregular, remittent and intermittent and may vary from six to eight degrees a day.

On the other hand there are some very exceptional cases where we find a purulent decomposed thrombus at a post-mortem, while during life *no* increase in temperature, or chills were recorded.

In other cases there is a high continual fever partially due to general acute sepsis partially to leptomeningitis which started simultaneously from the original focus of the disease.

Consciousness may be retained to the very end in pure septicopyemia if other complications like abscess of the brain or meningitis did not develop simultaneously with phlebo-thrombosis. In childhood the latter very often produces a number of cerebral symptoms even where it remains isolated.

The *prognosis* of thrombophlebitis and septicopyemia in connection with chronic suppuration of the middle ear is nearly absolutely fatal, if the process is not interfered with. In *acute* suppurations of the middle ear this complication has a somewhat better prognosis, inasmuch as a few exceptional cases have even healed without an operative interference, simply by obliteration of the sinus. These few exceptions must of course not mislead us and keep us from uncovering the focus of the disease by operation as early as possible.

An attempt at operation must be made even in cases which come under observation very late and where besides the sinusphlebitis other complications, like circumscribed leptomeningitis or abscess of the brain, are present, and where metastases in different parts of the body are found. The reason for this advice is the fact that the abscess of the brain is also accessible to operation and that circumscribed meningitis and metastases may heal. I saw for example in connection with cholesteatoma and thrombophlebitis a gangrenous metastatic abscess of the lungs heal after the sinus was cleaned out, although the abscess had involved an entire lobe.

The *prognosis* of those cases which show an extension of the septic thrombosis to the other side seems to be absolutely unfavorable. At the operation of such cases severe venous hemorrhages from emissary veins were often a striking feature. In *one* case I could draw the conclusion of thrombosis of the sinus transversus of both sides from the transgression of the oedema of the external soft parts over the rear median line of the skull, to the other side. Conclusions as to thrombosis of *both* sinus cavernosi may be drawn in a similar manner from oedema of the lids of both eyes. I also repeatedly observed well pronounced choked disk in such cases.

The condition of the *temperature* decides our *therapy* in thrombophlebitis.

We are justified in immediately thinking of implication of the sinus, if the temperature rises in the later course of an acute suppuration of the middle ear, or if fever occurs in the course of a chronic suppuration of the middle ear (*Leutert*). Every rise of temperature which is not completely explained by some other disease in the organism than the ear, is to us an urgent indication to uncover the focus of suppuration in the ear and the nearest threatened parts of the wall of the sinus.

The mortality from suppurations of the middle ear will in the future no doubt decrease considerably if such cases are referred in time to the otologist by general practitioners.

A complete uncovering of the otitic focus of suppuration and of an extradural gathering, if such is present, is entirely sufficient during the first few days of such a rise in temperature in acute suppuration of the middle ear and also in some chronic suppurations.

We have however to expect an extensive thrombus in the sinus if the general disease has lasted for many days. Any brisk movement of the patient during this time, a firm pressure on the neck in examining the region of the jugular vein, the shaking during transportation, etc., may cause the detachment of an embolus and consequent metastasis.

The ear surgeon after uncovering the otitic focus in such cases has often to follow up the sinus to the bulbus of the jugular vein, slit it open and clean it out. There is furthermore a great question which he has to answer: should he ligate the vena jugularis interna either before or after opening the sinus.

Koerner compiled 314 cases of operated sinusphlebitis in the III edition of his previously mentioned book (page 118); 180 of them or 58.4 per cent, in other words more than half, had their lives saved. This figure shows how much the prognosis of this disease has improved since the operative treatment was introduced.

Koerner gives the following information as to the different *methods of operation* which were used in the 314 cases of otitic sinusphlebitis and about the results of each method.

The sinus was opened *without* ligating the jugular vein in 132 cases of which 77, or 58.3 per cent were cured. The jugular vein was ligated *before* opening the sinus in 94 cases, 56 of them or 59.6 per cent were cured. The jugular vein was ligated *after* opening the sinus in 69 cases, 38 of them or 55.9 per cent were cured.

None of these three methods has an evident advantage according to the percentage of recoveries and *Koerner* justly draws the conclusion "that it is best *to adapt the method and extent of the operation to the finding in each case. To ligate the jugular vein in all early and late operations for thromphlebitis of the sinus as a matter of principle* seems under all circumstances not justified according to the number of recoveries without litigation."

A statistical compilation of 200 operated cases of sinus thrombosis which *Toubert* published a short while ago[1] is especially valuable. It shows with sufficient accuracy that the favorable results do not depend so much upon a certain method of operation as upon an *early* interference. 120 of the 200 cases were operated *within* the first week after the appearance of endocranial symptoms. There were 25 per cent of deaths and 75 per cent of recoveries. The other 80 cases could be operated upon only *after* the first week; of these 62.5 per cent died and only 37.5 per cent recovered.

These figures show clearly that the destiny of the patients is rather in the hands of the general practitioner, and depends much more upon his accurate and timely recognition of the dangers which threaten the patient than upon the method of operation which the surgeon may apply in a given case.

There can be no doubt as to the necessity of ligating and cutting the jugular vein whenever the purulent decomposition in the sinus extends below the bulbus into the jugular vein. The advice of *Alexander* in such cases seems suitable, which is to suture the upper open end of the vein into the skin in order to create free drainage through the vein.

[1] Arch. Internat. d'otol. etc., Vol. 18, page 437.

The sinus is uncovered, starting from above down to the bulb, after the whole mastoid process has been removed. The external wall of the sinus is excised. An injury to the facial nerve in chiseling can be avoided by a man who is well versed in the anatomical conditions.

The bulbus may be carefully dried out by means of probes wrapped with cotton and bent into different curves after we have opened the sinus close enough to the bulbus. I do not think that the insertion of gauze packings in the upper or lower part of the opened sinus or bulbus is necessary or even advisable. By direct inflation of boric acid powder into the upper as well as in the lower part I often saw processes of decomposition inside the vein disappear within a few days. The aperture of the sinus and bulbus remains wide open under the dressings for weeks during the after-treatment. It fills with granulations later on after the process of suppuration has run its course.

In proceeding as described during the operation and after-treatment I never saw the necessity for splitting the soft parts beyond the bulbus, thus converting the sinus, the bulbus, and the jugular vein into one uninterrupted groove, as *Grunert* recommended in some exceptional cases.

Acute Sepsis

Develops in some rare cases as a complication of suppuration of the middle ear. The clinical picture appears more like meningitis than like pyemia.

It is peculiar that I observed this complication, which has a characteristic serious course leading rapidly to death, in a form of chronic suppuration of the middle ear[1] which otherwise almost never leads to serious consequences, namely in cases with central perforation of the tympanic membrane and a well preserved system of cells without cholesteatoma or caries necrotica.

In two cases the entrance of water in bathing was the cause for the acute recurrence of the suppuration which leads to the fatal disease. In one case there was besides the acute recurrence an angina with false membranes in the follicles, in the other two an otitis externa crouposa.

The whole surroundings of the ear become very painful when mucopurulent secretion appears in an old perforation of the tympanic membrane. A high febris continua developes. The pulse becomes rapid and small. Consciousness is considerably deranged from the first few days on. The patients sleep very much and then become comatose and delirious during the next few days.

Two of the three patients whom I observed died in a few days in spite of opening of the antrum and cells, which contained only little secretion but some fibrinous exudation and a lining that was somewhat swollen. The post-mortem showed a recent and only slightly developed phlebitis of the wall of the sinus and bulbus. The outer surface of the

[1] Zeitschr. F. Ohr. Vol. 42, page 113.

sinus was covered with a thin new layer of fibrin. Fresh embolic infarctions in the lungs were found in *one* case. The spleen was slightly enlarged corresponding to the short time the disease lasted.

On account of the great rarity of these cases it seems to me that peculiar causes are here effective.

Streptococci were found in the three cases.

The cut in one case revealed very red and swollen lymph glands in the soft tissues on the mastoid process.

The whole clinical picture suggests the idea that a *simultaneous* invasion of the lining of the middle ear *and* of the lymphatic system of the whole region takes place, which causes the wall of the sinus to become more rapidly and more easily permeable to infectious germs and toxines.

I saw a very similar acute septic course in two other cases *after* a radical operation which was performed on account of cholesteatoma. A very painful lymphangitis developed in both cases from the sutures of the wound.

Eulenstein gave this disease the rather suitable name toxinemia[1] on account of the clinical picture which is very similar to that of pure poisoning.

The *therapy* of acute sepsis, which seems to have small chance of success, can consist only in uncovering the wall of the sinus as far as it appears red and covered with a fibrinous layer.

3. Otitic Abscess of the Brain.

It often offers the greatest difficulties for *diagnosis*. It is the most frequent cause of fatal termination of suppurations of the middle ear together with thrombophlebitis and leptomeningitis. An abscess of the brain is often found by mere good fortune in tracing a focus of disease from the ear.

The number of cases of otitic abscesses of the brain which were operated upon during the last ten years is not much smaller than that of sinusthromboses. *Koerner* compiled only 55 operated abscesses of the brain in the first edition of his book (1893), while in the third edition (1901) he had 267 cases.

The number of recoveries which *Koerner* found is not much smaller than that of sinusthrombosis. It amounts to 50.5 per cent in abscesses of the cerebrum and 52.8 per cent in abscesses of the cerebellum.

The survey of that large material for observation led *Koerner* to draw the following conclusions, which are not less important for the pathogenesis than for our operative procedures.

In the large majority of cases diseased bone extends from the middle ear to the dura. The dura itself is visibly diseased in about half the cases. The diseased dura has almost always grown to the adjacent sur-

[1] "Ueber Toxinämie" Zeitschr. f. O. Vol. 40, part I.

face of the brain and a layer of a few millimeters of brain substance is as a rule between the adhesion and the brain abscess.

It is by no means only the cases of *chronic* suppurations combined with cholesteatoma and caries which lead to abscess of the brain, but the number of observations increases steadily where *acute* suppurations terminate with the formation of an abscess of the brain, sometimes even after the suppuration in the middle ear has healed.

The *place* where the suppuration transgresses from the middle ear through the meninges to the brain corresponds to the position of the abscess. In abscesses of the temporal lobe in the middle cerebral fossa the infection travels through the tegmen tympani and antri which often have dehiscencies. There are two avenues to the posterior cerebral fossa. Firstly, the superficial abscesses of the cerebellum generally form in the immediate vicinity of the sigmoid sinus, on a level with the mastoid antrum. The sinus is usually also diseased in these cases. Secondly the deep abscesses of the cerebellum develop from the inner part of the posterior surface of the pyramid from an empyema of the saccus endolymphaticus, or from a suppuration in the porus acusticus internus. The seat of an abscess in this region becomes so much more probable if a suppuration of the labyrinth can be diagnosed by means of the demonstration of one-sided deafness.

The otitic abscesses are twice as frequent in the cerebrum as in the cerebellum.

Abscesses of the brain and especially of the cerebellum are much rarer in young children than in adults. Ear patients between 11 and 30 years are in greatest danger.

The *symptoms* of abscesses of the brain are so manifold and varying that only a general sketch can be given. For further details I have to refer you to *Koerner's* book on this subject, which is indispensable to every busy practitioner.

It is sometimes very difficult to find the cause for this serious clinical picture, consisting of rapid emaciation, almost always head-ache, depression and slowness of mental activity, etc., as almost all symptoms which might allow of a diagnosis are absent. Rise of temperature can be found only in the very beginning and then only in some cases. Afterwards a long state of more or less complete latency takes place. Symptoms of brain pressure appear later on and lead our diagnosis in a distinct direction. They consist in slowness and irregularities of pulse or respiration, neuritis optica, partial simultaneous paralysis of the oculomotor and abducens nerves, caused by pressure on the base of the skull. In other cases there are more pronounced focal symptoms pointing to the locality of the abscesses, like paresis of the contralateral half of the body, sensoric aphasia, or, in abscesses of the cerebellum, cerebellar ataxia, vomiting, etc.

Often enough it is only the terminal state, namely the perforation of the abscess into a ventricle or into the subarachnoidal space which makes the diagnosis clear and thereby decides the fate of the patient.

Under such circumstances, gentlemen, you will recognize the great importance to the general practitioner of a thorough knowledge of the local symptoms which are characteristic for the serious forms of suppurations of the middle ear that threaten the general organism.

These symptoms in *acute* suppurations of the middle ear are the long duration of the suppuration and the invasion of the labyrinth, which must be diagnosed by means of the functional tests; in *chronic* suppuration principally the location of the perforation.

We need almost never think of fatal complications in chronic suppurations with central perforation, be it ever so large. Every patient however who has a marginal perforation, especially if the entrance to the cells is narrow and there is cholesteatoma present, is in constant danger of succumbing to some complication, as long as the fetor in the spaces of the middle ear can not be made to disappear completely and forever.

The *prognosis* of abscess of the brain depends upon a number of points. A large number of abscesses are combined with other complications, as sinusphlebitis and meningitis. Furthermore there are sometimes multiple abscesses. Some abscesses are inaccessible to the knife on account of their position. I found for example in a post-mortem an otitic abscess on the medial surface of the occipital lobe, brought about by thrombosis of the sinus *rectus*. The number of otitic abscesses of the brain which are cured by operation is in spite of all that satisfactorily large, as the statistics of *Koerner* show.

Gentlemen:—We can certainly expect that the number of deaths from otitic abscesses of the brain will be very much smaller in the future, when all suppurations which are not cured by conservative treatment and which suggest the possibility of complications are operated upon in time, and all avenues of suppuration followed up to the dangerous places.

The abscess of the brain must be opened from the place from which it developed. The bone must be removed, starting from the middle ear, as far as it is diseased, and to a sufficient extent for the opening of the dura. Sometimes there is already a small opening in the dura. Otherwise we may postpone the incision of the dura for a few days in order to ascertain whether the dangerous symptoms were not due to an extradural abscess which may have been present at the same time. The incision is made by means of *Preysing*'s knife bent at a right angle. It must not enter deeper than 3 centimeters, neither must the drainage tube which is inserted after the pus is evacuated. The opening in the dura must be held apart by means of an anatomical forceps, in order to facilitate the evacuation of the pus, which has often gathered in a sinuate cavity, and is mixed with necrotic pieces of brain tissue. The incision in the dura must not be made larger than is necessary for the purpose of introducing a thick drainage tube. Owing to this precaution I never saw the dangerous picture of prolapse of the brain during the after-treatment; on the contrary I have witnessed the recovery of all the abscesses of the brain which I opened.

I do not approve of exploratory incisions into the dura if it is found unchanged at the operation, unless there are reliable symptoms of the presence of an abscess in the region we are searching.

4. Otitic Lepto Meningitis.

It may, as we saw, start from an abscess of the brain which has perforated into the ventricle, or into the arachnoidal space; or it may start from any part of the thrombosed sinus, thus becoming the cause of death. Extradural abscess may lead to gangrene of the dura and infection of the pia if it lasts long enough. It originates most frequently from suppuration of the labyrinth, which finds open avenues to the arachnoidal space through the porus acusticus internus and through the aquaeductus cochleae.

Meningitis was the cause of death in a large number of cases that were operated with fatal termination.

The impression prevailed that in a large number of fresh suppurations of the labyrinth the shock of chiseling was instrumental in spreading the suppuration to the pia mater. The luxation or the unintentional extraction of the stapes during awkward attempts at extraction of foreign bodies, or during scraping of granulations from the tympanic cavity proved several times to be the cause of fatal meningitis.

Acute suppuration of the middle ear is complicated with meningitis about as frequently as is chronic suppuration.

The largest number of cases of otitic meningitis occur between the ages of ten and thirty, while children die comparatively rarely from it.

Acute suppuration of the middle ear leads much more frequently to meningitis and death in patients over 40, than does chronic suppuration (16 to 5 cases in the statistics of *Heine* from *Lucae's* clinic[1]).

The diagnosis of a *well developed diffuse lepto meningitis* is not difficult, and you are acquainted with the symptoms which it produces.

The decison is, however, impossible in many cases of *beginning circumscribed* meningitis, especially if other cerebral complications are also present.

An important differential diagnostic means is lumbar puncture. A positive finding of abundant pus corpuscles and pathogenous organisms is always present in the fluid in well pronounced diffuse meningitis. The clinical picture in these cases is however sufficient for our diagnosis and will deter us from operating.

The lumbar puncture may give a negative result in beginning circumscribed meningitis, while on the other hand micro-organisms may be

[1] Berl. klin. Wochenschr. 1900, page 769.

found in the fluid of a case of abscess of the brain which has no meningitis.

Lumbar puncture can furthermore not be regarded as a diagnostic means which is void of all danger. The number of cases in which it accelerated death, is already large enough to caution against it unless it is urgently indicated. I saw death occur at the table after only a few cubic centimeters of lumbar fluid were withdrawn. It is true though, that the patient was moribund at the time of the operation.

I need not explain furthermore what an amount of serious damage may be caused by the quick withdrawal of a large quantity of cerebrospinal fluid in a case of fresh suppuration of the labyrinth, which had no time to form a protective wall of granulations in the porus acusticus internus and aquaeductus cochleae against the overflow of pus into the arachnoidal space.

Considering finally the cases reported in literature, which were cured by operation of the fundamental disease in spite of beginning meningitis ascertained by lumbar puncture, we must not be deterred by the positive result of lumbar puncture from operating such cases. These are the reasons why, together with other authors, I consider lumbar puncture for diagnostic purposes a superfluous operation in otology.

"Meningitis serosa" is a term often used in order to explain a number of cerebral symptoms occurring in the course of suppuration of the middle ear which disappear again.

These cerebral symptoms in suppuration of the middle ear however do not show whether we are justified in setting up a separate clinical picture under the name of meningitis serosa, as did *Quincke*.

"Because" as *Koerner* remarked, "it was never the course, but the end of the disease which afterwards led us to enter such cases into the casuistic of meningo encephalitis serosa." We are always in doubt whether there was not a collateral oedema of the meninges and brain, or toxic influences, or a beginning suppurative leptomeningitis which remained circumscribed, that produced these symptoms.

My own observation taught me that *tuberculous meningitis and tubercles of the brain* may start directly from the tuberculosis of the temporal bone. Tuberculosis in the ear, and tuberculosis inside the skull, develop separately in the large majority of cases, though from a common cause present in the organism.

In differential diagnosis of meningitis and abscess of the brain we must also think of *other tumors of the brain* which occur more frequently in children than in adults.

Finally we have to mention under the heading of complications of suppuration of the middle ear:

5. Hysteria in Suppuration of the Middle Ear.

Hysteria has often induced colleagues to operate on the ear but of course in vain. We must therefore discuss it, although it is not really a consequence of suppuration of the middle ear. A few cases of traumatic neurosis, occurring especially in working people who are insured against accident, must also be mentioned.

It is surprising how all details of the symptoms urgently necessitating an operation in diseases of the middle ear may be feigned especially by young hysterical women. Spontaneous pain, and pain on pressure around the ear are often declared to be enormous. Fetid discharge may be produced by uncleanliness, increase of temperature by friction of the thermometer. Even disturbance of consciousness, dizziness, disturbance in the motility of the eyes, a difference in the pupils, etc., may be present.

A female patient with acute suppuration of the middle ear was brought to me in a comatose condition which had lasted for several hours. She woke up during semi-narcosis, and was later on proved to be hysterical.

The finding at the operation in such cases usually suggests that we were deceived.

Such patients usually urge an operation not only *once,* but hardly are they cured in one clinic, when they repeat the performance with a second and third surgeon. Cases became known which had gone through a number of serious operations on both ears.

We can avoid similar mistakes by very carefully considering the objective findings in the ear. They often allow us to exclude at once serious complications, as for example in simple central perforations, or in cases which have a wide open entrance to the antrum and cells.

The location of the sensitiveness to pressure also does not usually coincide with our experience in similar cases. The hyperesthesia of the skin may be equally spread over the whole surroundings of the ear. The answers finally to hearing tests are often such as can not possibly be accurate. There are therefore a number of points which may reveal the true state of affairs.

LECTURE XXV.

Residues of Otitis Media Purulenta with Persistent and with Healed Perforations of the Tympanic Membrane.

Gentlemen:—We find the residues of former suppurations of the middle-ear to be the cause of deafness in nearly **10** per cent of all ear patients whom we have to examine (in my statistics they were 9.5%). The suppuration has stopped and the examination by means of the speculum reveals either a persistent dry perforation, or a scar in the tympanic membrane.

Children are represented in my statistics by 17.3 per cent, *adults* by 82.7 per cent.

The residues concerned both ears in 53.4 per cent, *one ear* in 46.6 per cent of cases. The perforation in the tympanic membrane was closed, leaving a scar in 944 cases of residues out of 1,937 which I compiled, or in nearly half of all cases. These figures furnish the proof for the fact that many perforations close later on by forming scars, even a number of years after we have ceased observing them. The more or less extensive perforations in chronic suppurations of the middle ear may also heal later than it is usually necessary for us to control them.

A. Dry Persistent Perforations.

They are just as diverse as to size and form as those which we see during the suppuration (compare the plate of tympanic membranes fig. 6, 7, 8).

The only subjective symptom which is never absent in dry perforations is the decrease of the power of hearing. Subjective noises are so rare that we must attribute them to other causes than the perforation whenever they are present.

The power of hearing for speech varies greatly. On an average it is only moderately diminished. Among the 1,807 children which I saw during my examinations of school children there were 35 dry perforations. Of these organs of hearing 21 understood whisper at a distance exceeding 4 meters, five of them exceeding 16 meters.

The *hearing of tones* shows two pronounced changes in all cases of perforation of the tympanic membrane. Firstly, there is a defect of hearing by air conduction of tones of lowest pitch. The extent of this defect varies with the size and position of the perforation. The defect diminishes and disappears, the higher we rise in pitch. Secondly, there is a prolongation of the duration of hearing by bone-conduction which becomes more pronounced, the lower in the scale we descend.

This condition which we find in all cases that have visible defects of the sound-conducting apparatus permits us to draw the following fundamental conclusion as to the function of the sound-conducting apparatus, namely, that this apparatus is necessary for the transmission of the sounds of the *lowest part of the sound scale* from the air to the labyrinth. On the other hand we are now justified in drawing conclusions as to defects or abnormities of the invisible parts of the sound-conducting apparatus in cases where the tympanic membrane appears intact, providing the above mentioned functional disturbances are present. We draw the opposite conclusion, namely, that the function of the sound-conducting apparatus remains intact, if an ear hears all sounds down to the lowest pitch perfectly, and there is no prolongation of bone conduction. We shall discuss the great importance of these conclusions for our diagnosis in speaking about the numerous diseases of the ear with negative finding of the tympanic membrane.

We are able to produce a considerable improvement of hearing in many cases of defects of the tympanic membrane by the insertion of a so-called *"artificial tympanic membrane"* consisting of a piece of rubber with a small guiding rod or tube which is pressed against the defect.

Yearsley in 1848 obtained the same effect by means of a small moist ball of cotton which he inserted into the defect. It seems that the majority of authors return to this simple device which has since been modified in many ways.

The improvement of hearing produced by the ball of cotton seems to be brought about exclusively by the pressure it exerts.

There are so far only very unsatisfactory explanations for the mechanism of this physiological effect.

I think however that we can understand it if we remember the antagonism of the two muscles in the middle ear (compare page 49). I recognized an improving effect of *Yearsley's* ball of cotton only in those cases which had an isolated stapes left together with the tendon of the stapedius muscle, and only under the condition that the isolated head of the stapes is pressed inward by the ball of cotton. We saw that the main condition for the transmission of the minutest changes of air pressure is that the whole intact sound-conducting apparatus be extremely well balanced. This result is produced by the traction of the stapedius muscle pulling the superior anterior periphery of the foot-plate outward, thereby stretching the ligamentum annulare which is especially broad at this part of the periphery. At the same time the expansion is counteracted by the tensor tympani muscle which pushes the head of the stapes inward. Suppose now this latter effect is lost on account of the separation of the incus from the stapes, or on account of total absence of the incus, then the pressure upon the head of the stapes exerted by the traction of the tensor may under normal conditions be replaced to some extent by the pressure of an elastic ball of cotton. In this manner we may understand that the footplate of the stapes, which was held fast in an extreme outward position by the traction of the stapedius muscles, becomes more movable and can therefore follow the impulses transmitted to it by the sound waves.

Two objections may be raised against this explanation of the improving effect of the ball of cotton. The first one is that in a large number of cases the long process of the incus is absent, that the head of the stapes is isolated, and as such visible, and that, in spite of this fact, there is considerable power of hearing. The second, that only in a small fraction of such cases a pronounced improvement of hearing can be produced.

You will however readily understand that exactly the same improvement of hearing as by means of the ball of cotton can result from tight adhesions running forward from the head of the stapes, thus counteracting the traction of the stapedius muscle. The result of these adhesions will be much more effective if they run from the head of the stapes to a remnant of the tympanic membrane, which is still able to vibrate, and to the handle of the hammer which is drawn inward by the action of the tensor muscle. These conditions can be recognized with our eyes, and we often find an astonishingly good power of hearing in cases which show them.

All these considerations are not alone of theoretical but of great practical importance.

It was often recommended to make the isolated stapes more movable by cutting such adhesions. You will hesitate, gentlemen, to perform such a circumcision of the stapes in cases which have preserved a certain amount of their power of hearing, if you consider the valuable part which some of those adhesions play, even though in one case or another you may have acquired an improvement of hearing by it.

We see how small the pressure upon the stapes needs to be in order to produce an improvement of hearing in the numerous cases of chronic suppuration, who hear better while there is secretion than after it has stopped. The thin layer of fluid weighing upon the stapes proves adequate to favorably influence the power of hearing. The same result may be acquired by means of a drop of water.

We can not however recommend the *constant* wearing of a ball of cotton, especially if its insertion is left to the patient. It may involve dangers as long as there is still some suppuration, and lead even to necrosis of the bony walls, as the case shows which was reported on page 217.

The simple forcible inflation of boric acid powder after the region of the stapes is moistened, is often sufficient in order to produce the improvements of hearing in cases which do not need high pressure upon the stapes. The improvement after these inflations sometimes remains for weeks.

A permanent perforation of the tympanic membrane requires special precautions in order to keep harmful influences from entering from the outside into the wide open spaces of the middle ear.

A drop of water entering into the tympanic cavity may produce a renewal of a suppuration which had long disappeared. In diving, water may enter the tympanic cavity through the perforation as well as through the nose and the tube, much more easily than if the membrane is closed. On page 237 I described two cases of general sepsis terminating fatally, which followed a similar recurrence after a bath. They demonstrate how dangerous such an acute recurrence of the suppuration may be in an ear which is practically normal except for the perforation of the tympanic membrane; that is a middle ear with well developed pneumatic cells, etc.

Patients with perforations of the tympanic membrane ought therefore to protect their ears by water tight caps and remain under water only during *expiration,* since only for that length of time does the nose remain free from water.

The cartilaginous meatus ought to be lightly closed by means of a piece of cotton in order to keep out dust and the influences of temperature. The patient ought to be cautioned against all kinds of interference, like inserting strips of gauze by means of forceps, etc., into the bony meatus, on account of the thin lining in this part of the canal which is so easily injured.

Marginal perforations on the posterior and anterior superior periphery of the tympanic membrane and perforations of *Shrapnell's* membrane ought always be controlled by the surgeon once every three to six months, even after the suppuration has ceased. Dry crusts develop from time to time either on the margin of the perforation or in the whole perforation, and brownish masses of epidermis appear. Large solid masses of epidermis can sometimes be removed by means of a forceps, if the crusts are first carefully loosened all along the margin by means of a probe. These masses of epidermis are sometimes so large that they must have reached into the antrum and are pure white and moist on the inside.

A few direct injections by means of the antrum tube and insufflations of boric acid are often sufficient to keep the cavity dry for months and years if the masses are removed in time. Granulations will form around the masses and the epidermis will decompose if it is not removed, and all the well known, manifold dangers which are more peculiar to cholesteatoma than to any other form of suppurations of the middle ear, threaten the patient.

B. Residues with Healed Perforations of the Tympanic Membrane.

Daily experience teaches that simple perforations of the tympanic membrane of any size may under favorable conditions heal by formation of a scar. It is not a rare occurrence that we find a scar in place of the whole tympanic membrane which contains neither handle nor the short process of the hammer. I found such scars repeatedly in patients who had the whole tympanic membrane excised together with the hammer and the incus by a surgeon who intended thereby to improve hearing.

Such scars can be easily recognized by the eye on account of their sharp limits and their dark color (compare the pictures of the membrane figs. 12 and 13). They are often partially framed by white, clearly defined incrustations of lime. Such incrustations of lime in the membrane are often the only residues of suppurations of the middle ear which have run their course.

The scars can not always be distinguished from circumscribed atrophic parts of the membrane which are found in occlusion of the tubes that has lasted for many years.

The retraction is often so pronounced in very thin scars and in atrophy of the membrane, that the impression of a total absence of the membrane is produced. The movements of the scar inward and outward can however easily be recognized if the air in the external meatus is rarefied and compressed by means of *Siegle's* otoscope or *Delstanche's* rarefactor.

No treatment of a well developed scar is necessary. Inflations of air whenever they become indicated on account of occlusion of the tubes or gathering of serum, etc., must be given with low pressure only, as scars and atrophic parts burst easily.

The formation of a scar, i. e., the closing of a *perforation* that is not too large, and not marginal, can be induced by systematical cauterizations of the margin of the perforation by means of the crystal water of trichloracetic acid (*Okuneff*). It is applied by means of a probe wrapped with cotton. A continuation of this treatment is of no avail if the size of the opening does not diminish after 6 to 10 applications given at intervals of 2 to 3 days.

Otitis Media Simplex Chronica.

(Chronic Simple Catarrh of the Ears According to Von Troeltsch.)

We discussed a large number of diseases of the middle ear under the headings "occlusion of the tubes" "occlusion of the tubes with gathering of serum" and "occlusion of the tubes with atrophic tympanic membrane," which show a well characterized sharply circumscribed clinical picture. I think I am justified in recording them separately in the clinical statistics. The diagnosis "chronic catarrh of the ear" suffered another considerable restriction when the formerly so-called "dry catarrh of the ear" (otosclerosis) revealed itself as a disease which is not at all located in the lining of the tympanic cavity, and therefore is certainly not entitled to the name "catarrh." This fact was foreseen long ago by *v. Troeltsch* and has been verified lately by a large number of coinciding pathologic anatomical investigations. *v. Troeltsch* taught furthermore that there are often a number of changes in the tympanic membrane which are considered characteristic for chronic catarrh of the middle ear combined with nearly *normal* hearing. Only an accurate functional test of the ear will decide whether hard hearing is really caused by serious changes in the tympanic cavity corresponding to the visible changes in the tympanic membrane. The methods of testing the hearing of sounds by air and bone conduction have been improved in so many different directions since the time of *v. Troeltsch* that they show how often the main and even the exclusive cause of the disturbance of function is beyond the middle ear, in the labyrinth, etc., in spite of pronounced anomalies of the tympanic membrane.

The diagnosis otitis media simplex chronica is today justified only in cases which, besides the characteristic findings of the membrane, present also those functional symptoms that were so far shown to be the effect of a disturbance of the sound-conducting apparatus.

The long duration of hard hearing and the absence of symptoms of fresh inflammation are important factors for this diagnosis. In the findings of the tympanic membrane we must lay especial stress upon the permanent changes caused by processes in the tubes which lasted for many years, or remained after repeated acute and subacute attacks of inflammation.

Otitis media simplex chronica differs from the diseases which are more or less confined to the tube, in that an opening of the tube by means of inflation does not produce the startling improvement in hearing, namely twenty times that of the previous distance, which was given as the main criterion of a more or less pure affection of the tubes.

A prominence of the short process, and the posterior fold extending from it backward and downward as a fold in the membrane, are the most frequent characteristic symptoms of retraction remaining after long lasting affection of the tubes. The posterior fold is often changed into a whitish streak which we may designate as the "posterior cloudy mark." It often continues downward to an accentuated cloudiness in the intermediary zone, extending more or less around the handle of the hammer. The tympanic membrane in chronic otitis media simplex shows different degrees of diffuse cloudiness, contrary to the characteristic dark color in fresh processes of the tubes.

Hard hearing undoubtedly in these diseases is principally due to adhesions between the chain of ossicles, the walls of the tympanic cavity, and the tympanic membrane, which remained after repeated attacks of inflammation. They were therefore called "chronic adhesive processes in the middle ear." We can sometimes recognize such adhesions on the tympanic membrane. The head of the stapes especially is often adherent to the posterior superior quadrant of the tympanic membrane, and is either isolated or still connected with the long process of the incus. The handle of the mallet often looks clumsy and is removed backward while Shrapnell's membrane appears adherent to the neck of the hammer, etc.

The presence of secretion in the tympanic cavity can often be established by means of noises heard in auscultation during inflation through the catheter, if there is still occlusion of the tubes. Such cases are accessible to moderate improvement of hearing if inflation is continued for some time.

In my statistics patients suffering from the disease amount to **3.4** per cent of all ear patients. This figure is at present rather too large than too small since we have learned to distinguish more accurately by means of functional tests. *Children* are represented in this figure by 14 per cent. Both ears are affected in 88 per cent of these cases.

Dysacusis.

The functional findings in a certain number of hard hearing people do not warrant a sharp discrimination between disease of the middle and inner ear. The answers to our functional tests are sometimes not sufficiently reliable to use them for diagnostic purposes, as for example in imbeciles, or in pronounced hysterics, or in patients who are liable to sham for personal interests (e. g. on account of accident insurance). In some cases we have to allow for a simultaneous disease of the middle and inner ear according to our hearing tests.

The term "dysacusis" was chosen in order to classify all those heterogenous forms of chronic hard hearing whose origin can not be definitely ascertained. This expression is not supposed to confer any meaning as to the nature of the disease which is the cause of the deafness, but simply means that we are unable to establish a definite diagnosis. The sum total of these cases in my statistics is **4.2** per cent of all ear patients.

LECTURE XXVI.

Otosclerosis.

Gentlemen:—There is a comparatively large number of hard hearing people whose tympanic membrane appears normal as to form and color, contrary to the findings in otitis media simplex chronica just described. A mild diffuse redness of the intermediary zone of the membrane is found in some exceptional cases and must be explained as an injection of the promontory seen through the membrane (*Schwartze*). By means of the auscultation tube we hear the air inflated through the catheter, bound against the tympanic membrane in a continual weak, medium or strong current, the same as in a normal ear. Whenever I applied posterior rhinoscopy in these cases the ostium pharyngeum of the tube was always found normal.

The functional tests for hearing by air and bone conduction in spite of the *negative findings* of the tympanic membrane and the middle ear reveal all the well known symptoms which are characteristic for an interference of motion and a fixation of the sound-conducting chain. This is the case in such a typical manner, even in patients whose hearing of speech is very little impaired, that the functional tests alone suggest that the lever apparatus must be damaged at the most effective spot of the sound-conducting chain, namely the stapes.

In 1857 *Toynbee* reported in his "Descriptive Catalogue" that among 1,149 specimens of temporal bones he found 126 cases of bony adhesion of the stapes to the oval window.

Comparative hearing tests carefully carried out for air and bone conduction over a period of many years convinced me that there are numerous hard hearing people who show characteristic functional symptoms which, with almost absolute certainty, pointed to fixation of the stapes. I showed for the first time in 1885 the pathologic anatomical proof that ancylosis of the stapes is the real cause for this complex of functional symptoms.

The patient was a man who had suffered from sclerosis of both ears for 16 years, and consequently from continual subjective noises which ultimately caused him to commit suicide. By means of manometric measurements in the manner before described (page 14) I could prove the absolute immobility of the stapes. The temporal bone, after it had been macerated, showed fixation of the foot-plate of the stapes from ossification of the lig. annulare.

A large number of investigators since then established by anatomical examination of a great many cases, that ancylosis of the stapes is the anatomical cause for the peculiar findings at the examination with tuning forks in otosclerosis. We shall now enter into a discussion of these findings. *Katz* made the first *histological* examination. It showed like the next four examinations, which were made by myself and *Scheibe*, partial or complete *bony* ancylosis of the foot-plate of the stapes.

The real seat of the disease is the bony capsula of the labyrinth as *Politzer* was able to ascertain from numerous cases which he examined. The periosteum of the promontory also seems to be not infrequently involved in the disease. Sometimes a number of isolated foci of the disease are distributed over the whole capsula of the cochlea and the other parts of the labyrinth, as far as the porus acusticus internus (*Siebenmann*). The foci are found most frequently in the bony frame of the foot plate of the stapes, and in the foot-plate itself, which often appears increased to ten times and more its original thickness. The niche of the oval window together with the stapes may in very far progressed cases be found filled with new formed bone tissue (*Politzer*).

Very vascular osteoid substance containing a great many giant cells was found in fresh cases in place of the compact bone in the normal capsula of the labyrinth, in other places rows of osteoblasts were met with. Spongy bonesubstance remains wherever the process has run its course The margin of the window is often connected with the foot-plate by a number of bony bridges.

We do not know of any analogy in the pathology of our system of bones for this chronic inflammatory, hyperplastic process, as we must call it on account of its anatomical peculiarities. *Etiology* does not furnish an adequate explanation either. A connection with lues or with some other general dyscrasia was suggested by many authors. I must refute this connection, judging from my many years of experience in more than 1,000 cases. Most of these patients appear perfectly healthy otherwise. All these facts notwithstanding, there can be no doubt but that the general constitution of the patient furnishes the main basis for this disease and that it can not be attributed to a merely local harmful influence affecting exclusively the ear. This fact is shown by the following statistics:

No disease affects *both ears* as frequently as sclerosis. According to my statistics both ears are affected in *88.8 per cent of all cases*, and later investigators obtained similar figures.

Patients comparatively often attribute *an increase of hard hearing* to childbed though only exceptionally its *beginning*.

The beginning of hard hearing sets in between the 20th and 50th year of life in the majority of cases. Only 3.5 per cent of all cases of otosclerosis could be shown to have existed in *children under 15 years of age.*

All authors agree as to the great frequency of *heredity* of sclerosis. In nearly 52 per cent of my cases I obtained positive information that one or several members of the same family, sometimes whole series of relatives, were hard of hearing.

Another fact is still more peculiar. This form of hard hearing concerns especially *the female sex,* contrary to all other diseases of the ear. Only 42 per cent of all ear patients were women while 57.4 to 66.1 per cent of all patients suffering from sclerosis were female, according to my records of the last three years with which the records of other authors coincide.

The statistics therefore open a view into dark influences dating very far back. We can hardly expect that the *pathogenesis* of this peculiar disease will ever be satisfactorily explained, so much more so, as its clinical and pathological picture has no analogy.

Seven per cent of all ear patients suffered from otosclerosis.

The most important part of our *diagnosis* is to distinguish sclerosis from those diseases of the *inner ear* which, like sclerosis, show no changes of the tympanic membrane or of the middle ear at our examinations of the living.

We learned how to accurately distinguish one from the other by means of *functional tests of the ear.*

We proceed in the following manner:

1. The power of hearing is ascertained by whispering numbers (1 to 99) at various distances after forced expiration. The shortest distance and the numbers that are heard the least are recorded.

It is peculiar for this test that those sounds of speech which lie deep in the sound scale are poorly heard as compared to the high ones. We ordinarily exclude the word "100" on account of its very close range of hearing, and use it only once in a while. The numbers "one," "two" and "four" and especially their combinations "forty-four," "forty-two" and "forty-one" are the hardest to perceive, while "three," "six," "seven" are accurately heard at comparatively large distances. The continuation of the hearing tests by means of the tuning forks, etc., showed that our diagnosis was often turned in the right direction as the result of this test by speech.

2. We were able to establish a pronounced shortening of hearing by air conduction at the lower end of the sound scale in all visible changes of the sound-conducting chain, beginning from the smallest traumatic perforation of the tympanic membrane to the most extensive destruction of the ossicles. This fact, which was ascertained without exception, led us to conclude that the function of the sound-conducting chain consists

in the transmission of the lowest part of the sound scale from the air to the fluid of the labyrinth.

Hearing by air conduction of the lowest tuning forks of the continuous series without overtones, is particularly interfered with in sclerosis. Hearing by air conduction of the forks from 12 to 36 double vibrations, representing the lowest normally heard one and one-half octaves, is completely lost, even in cases which show only a slightly diminished hearing for speech. The loss of hearing at the lower part of the sound scale increases with the increase of hard hearing for speech. Patients with sclerosis who hear conversation only partially, and close to the ear, have often lost all hearing up to the middle of the one stroked octave, and the first sound heard by air conduction is g′ which is equal to a loss of nearly five octaves.

The determination of the lowest sound which is barely perceived by air conduction by means of the weighted tuning fork *is therefore one of the most important points for our diagnosis.* We are not justified in diagnosing a fixation of the stapes in patients who hear by air conduction below 32 v. d., and ought to look for another explanation of hard hearing.

3. We had occasion to establish *a prolongation of bone conduction* for the lower part of the sound scale in different interferences of the sound-conducting apparatus, just as regularly as a shortening by air conduction. We test the duration of bone conduction in the lower part of the scale by means of the A tuning fork.

We are justified in diagnosing sclerosis only in such patients who hear this tuning fork, placed on the vertex, longer than a person with normal hearing (*Schwabach's* test compare page 67). Patients who sustained a fracture of the skull at some previous period of their life must be excepted, as their hearing by bone conduction may be considerably shortened although their hearing by air conduction is absolutely normal.

4. Sometimes we find the duration of bone conduction in sclerosis prolonged, but also, not very rarely, somewhat shortened in testing by means of a′ which is two octaves higher than A. I shall give you the explanation for this later on.

5. We compare the duration of bone conduction with that of air conduction by means of an a′ tuning fork (*Rinne's test*). The handle of the fork is first set on the mastoid process till the sound has died away whereupon the prongs are held before the meatus till the sound has died there also. The sound is heard 30 seconds longer by air conduction in the normal ear. In sclerosis, *Rinne's* test is negative, i. e., bone conduction is either just as long as air conduction (*Rinne's* test ± 0) or is even longer by a few seconds (in extreme cases 15 seconds and more).

6. Sounds of highest pitch tested in air conduction by means of *Galton's* whistle are sometimes heard normally. I could not affirm that higher sounds than normal could be heard in the initial state of sclerosis

(*Zwaardemaker*) nor could *Siebenmann* and others. A considerable loss at the upper limit is, however, frequent, especially in advanced cases. In a certain number of patients who were very hard of hearing on account of sclerosis I found besides this nearly constant defect at the upper limit of the sound scale, a well circumscribed gap of hearing a little lower but still within the region of *Galton's* whistle.

We are involuntarily reminded of the multiple isolated foci of ostitis in the capsule of the cochlea which *Siebenmann* found histologically in sclerosis. You will appreciate, gentlemen, the new and beautiful affirmation of v. *Helmholtz's* theory contained in the finding of hearing just described. According to this theory the perception of the whole scale of sounds is distributed over the entire scale of the cochlea. Beginning with the highest sounds in the basal coil, therefore in the immediate neighborhood of the original focus at the foot-plate of the stapes, the perception extends downward in pitch to the cupola. You will furthermore understand why there is not infrequently a decrease of hearing in the middle of the scale for a' as I have explained to you. This decrease must be attributed to the inner ear, as it concerns bone conduction also.

The following triad of functional symptoms, in addition to normal or nearly normal finding on the tympanic membrane and cavity, is necessary in order to diagnose otosclerosis (ancylosis of the stapes).

I. Loss of hearing by air conduction for a considerable part at the lower end of the tone series.

II. Prolongation of bone conduction above the normal duration for tuning fork A.

III. Negative *Rinne's* test for tuning fork a'.

We find furthermore no response to inflation of air, neither through the catheter nor by means of *Politzer's* method. Sometimes we notice an insignificant decrease or an equally insignificant improvement of hearing after inflation. They are explained by the inaccuracy of our examination of hearing by means of speech.

Two symptoms must be mentioned which occur frequently in sclerosis, the first is *subjective noise* the second *dizziness*.

According to my statistics, 22 to 32 per cent of patients suffering from sclerosis complain about dizziness. It is however only exceptionally so pronounced that the patients lose their equilibrium and fall to the floor, or that retching occurs, as is often the case in affections of the inner ear. The statement is sometimes made that dizziness is noticed in stooping.

The subjective noises in the ear and head are mucn more disagreeable to the patient. They occur either temporarily or permanently in 77 to 78 per cent of all patients suffering from sclerosis. 44 to 46 per cent of patients suffer from it continually; many sensitive patients can hardly stand it. The character of the noise is described as whistling, ringing, rushing like escaping steam, more rarely as of boiling water or chirping, in other words the noise may be of high or low pitch. Their variety in pitch and intensity however does not seem to be as great as in diseases of the inner ear.

The subjective noises may be attributed to vascular murmurs, which in the diseased ear are conducted to the labyrinth so much more easily than in the normal ear, on account of the tightened fibres of the sound-conducting apparatus, similar to the sound of the tuning fork placed on the vertex; or they may be explained by the transmission to Corti's organ of the murmurs of the blood vessels which are much louder in the highly vascular foci of the disease in the capsula of the labyrinth than in the normal. The latter explanation must be favored for the reason that a high tension of the ligamentum annulare occurs also in large defects of the tympanic membrane, on account of the preponderance in traction of the tensor muscle, or in cases with isolated stapes on account of the traction of the stapedius muscle; still no subjective noises are complained of as a rule. A third possibility is that these noises are caused by pathological processes in Corti's organ itself, like changes of tension, etc., which often become evident in the later stages, especially by the formation of gaps of hearing in the region tested by means of Galton's whistle.

The symptom of dizziness also finds its explanation by attributing it to a disease of the capsula of the labyrinth in the vestibulum and in the semicircular canals.

Another symptom is often mentioned by patients suffering rrom sclerosis in common with other diseases of the middle ear. These patients understand speech better while traveling in a carriage or a train, or while surrounded by the din of a noisy machine shop, or while the drum is played, etc., than if everything is quiet (paracusis *Willisii*). Under the influence of noise a decrease of hearing for speech is on the contrary noticed in affections of the inner ear. It is therefore probable that a partially immovable sound-conducting apparatus is more sensitive to weaker impulses during the time when a shaking of the whole body keeps it vibrating.

Gentlemen:—The *prognosis* as to complete recovery, or even considerable improvement of hearing can not be favorable if we remember the anatomical condition in otosclerosis. On the other hand our experience teaches that a large number of cases become stationary, with a moderate degree of hard hearing, rendering conversation possible.

The term "progressive deafness" which is often used for sclerosis is therefore not justified. There is only a minority of exceptional cases where hard hearing progresses within a few years to such a degree as to make it difficult or impossible for the patient to understand conversation close to the ear. (The findings of *Politzer* where the whole niche of the oval window was filled with bone, belonged to very old inmates of the poor house. We only exceptionally have occasion to make a functional examination during life of cases which have progressed to such a degree.)

An especially bad prognosis must be given in cases which continually show the transparent redness of the promontory, and furthermore in those with a considerable loss of hearing at the upper limit, and especially those cases which show gaps of hearing in the region tested by means of Galton's whistle.

We can never predict a decrease of hearing. It is therefore our duty to be careful as to what we say to the patient, who often sees his future altogether too dark on account of the depressing influence of the subjective noises. It is true we can never promise an improvement of hearing, but must consider the psychic effect of our prognosis. It eases the mind of many patients to hear from an authority that they will not become deaf, and that it is very likely that their condition will remain stationary. It is, however, advisable to direct the patients to practice lip reading, which will greatly facilitate the understanding of speech should they become very deaf. To a patient who understands conversation only close to the ear I found a hand mirror of great advantage because it enables him to watch the mouth of the speaker who is talking close to the ear. I introduced this method very successfully in Munich into the course of instruction of deaf-mutes who have remnants of hearing.

A speaking tube can not be dispensed with by patients who do not accurately understand whisper close to the ear.

You can improve the gloomy frame of mind of many patients by assuring them that the noise in their head does not indicate some disease of the brain. This care weighs on many patients who do not explicitly inquire about this possibility.

The psychic influence of a trusted physician upon such incurable patients is often the only thing that is able to give back to them their vital energy. In this manner you have done them much more good than if you try to deceive yourself and them as to their future by a series of attempts at treatment extended over a long time.

Methods of treatment recommended against otosclerosis are very numerous as is usual against inaccessible diseases. A large number of operations were advised and generally discarded as useless, often harmful. They consisted in forming an artificial opening in the tympanic membrane, tenotomy of the tensor tympani and stapedius muscles, extraction of the malleus, the incus and even the stapes, etc. *Politzer* recommends a temporary administration of iodide of potassium in early cases of sclerosis. *Siebenmann* advises the internal use of small doses of phosphorus to be taken many years, in the form of *Kassowitz's* emulsion (0.01:100) 1 to 2 tablespoonfuls a day. Neither *Politzer* nor *Siebenmann* expect an improvement, but merely a checking of the progress. It is difficult to gain a judgment as to the effect of this medication since conclusions can be drawn only after many years and since a large number of cases without treatment remain stationary for years or become very little worse.

It is advisable to examine the hearing and ears of these patients at long intervals of time. By means of inflation of air we ascertain whether there are not some general catarrhal symptoms, or an exudation in the middle ear, etc. These processes have a detrimental influence upon the main disease although they are otherwise independent. To hear from their physician about every six months that their power of hearing has not decreased, but remained the same, eases the mind of the patients, who usually suffer from the impression that they perceive a progress of deafness.

Pneumomassage by means of an air pump worked by electricity was repeatedly recommended to alleviate the subjective noises. They often disappear for a short time, but its prolonged use may have a bad influence on hearing.

The ringing in the ears sometimes ceases from most peculiar causes, as the following example will show:

In a case of otitis media simplex chronica I burned the hypertrophic rear end of a turbinal by means of the galvanocautery. The patient came to me the next day with the happy news that the ringing in his ear, which had continually bothered him for many years, had disappeared. I asked him whether this had never happened before for a day or so, when he answered that it had occurred but once directly after he had cut his thumb very badly.

The real cause both times was probably the shock to the vasoconstricting nerves which unfortunately can not always be produced at will.

In habitual congestions in the head, derivatives to the bowels, sojourns at some bathing place, or hot foot baths taken in the evening, at intervals, may be of use.

The patient suffering from otosclerosis feels best on high mountains, while it is a matter of experience that sea baths and cold douches to the head have a bad influence and ought to be avoided.

LECTURE XXVII.

Otalgia.

Neuralgia of the ears occurs rather frequently owing to the abundant sensory innervation of the external and middle ear. You know that acute inflammatory processes of the external and middle ear, which are accompanied by pain, can easily be recognized at our inspection of the external meatus and the tympanic membrane. The presence of exudations in the middle ear may be ascertained by means of auscultation during inflation of air. The diagnosis of otalgia must be made only if all inflammatory symptoms are absent.

In my statistics I counted as otalgia only those cases that did not show a diminution of hearing. They amounted nevertheless to **2.7** per cent of all ear patients. *Children* were represented by 22.7 per cent. *Both ears* were affected in 15.3 per cent.

Inflammatory processes in distant organs are, in the majority of cases, the cause of the pain, attributed by the patient to the ear.

Otalgia was induced by caries of a tooth on the same side in about 50 per cent of my cases (the perforation of the wisdom tooth also may produce ear-ache), in 10 per cent by angina, and in 2 per cent by affections of the larynx. Otalgia may even be found as a symptom of prosopalgia. Pain located in front of the tragus and increasing in chewing ought to suggest an examination of the joint of the lower jaw.

The eruption of herpes blisters in the ear and its surroundings is noticed in rare cases after pain lasted for several weeks due to real neuritis. In very rare cases a transitory paresis of the facial nerve and affection of the auditory nerve were noticed.

Otalgia in both ears suggests some constitutional anomaly.

The therapy of otalgia is self-evident if its cause is caries of a tooth, or angina, or some affection of the larynx.

The local pain in the ear disappears in most cases with the removal of its cause. The other cases of otalgia may, like prosopalgia, be very refractory to the usual local and general antineuralgic therapy. A piece of cotton soaked in equal parts of oleum hyoscyami and chloroform inserted into the ear, and the same fluid rubbed into the surrounding skin, may be used as a palliative treatment.

Motor Neurosis of the Middle Ear.

Endotic noises, i. e., noises audible also to others, may be produced by clonic spasms of the muscles in the middle ear.

A clicking noise which is not synchronous with the pulse, but repeats itself 100 times a minute and more, can sometimes be heard at a considerable distance. It is produced by the separation of the lateral wall of the cartilaginous tube from the medial wall through clonic spasms of the tensor tympani and levator veli muscles. A simultaneous rythmical raising of the soft palate is often visible. This noise is most frequently observed in children and hysterical women.

Low rumbling noises occur in the ear when there is a spasm of the tensor tympani or stapedius muscle. The same noise is noticed physiologically in yawning when at the same time hard hearing of considerable degree can be observed, and in forced voluntary contraction of the M. orbicularis palpebrarum, caused by a simultaneous contraction of the M. stapedius.

According to some authors an extraordinarily acute hearing for sounds of low pitch is observed in paralysis of the facial nerve extending to the M. stapedius. I examined a number of fresh cases of paralysis of the facial nerve by means of a tuning fork of as low a pitch as 12 v. d. They showed no deviations from the normal, and no difference between the healthy and the affected ear.

I made a number of valuable observations about spasms of the M. tensor tympani on a professor of clinical medicine, who was mentally overworked. He suffered at the same time from a fluttering noise which he was able to produce voluntarily. I saw at this moment a simultaneous change of the reflexes of the tympanic membrane. He was able to continue the contraction of the tensor tympani muscle for any length of time, giving me a chance to make an accurate hearing test of the ear, which was normal in every other respect. The hearing distance for whisper did not materially change, but the lowest audible sounds were raised from C_2 (16 v. d.) to B_1 and E. Tuning fork A on the vertex was heard 18 seconds *longer*. Bone conduction and *Rinne's* test by means of tuning fork a′, which is two octaves higher than A, were not influenced.

In this case I could therefore experimentally test the physiological influence of an increase in tension in the sound-conducting apparatus. The insertion of the tensor muscle is situated very favorably for an extension of the axis ligament on the neck of the hammer, but relatively unfavorably for a high tension of the tympanic membrane. This observation shows that the contraction of the tensor muscle influences the hearing of all sounds of lower pitch than a′ in the well known manner, namely: hearing of about the two lowest octaves in the air conduction is completely effaced.

Other objectively audible noises may be produced in the ear by air entering through the tube and passing through the secretions in the tympanic cavity, or by passing through a narrow perforation in the membrane. Endotic noises may be caused in rare cases by aneurysms in the vicinity of the ear.

The *therapy* of clonic spasms of the muscles in the middle ear can only be general roborant.

New Growths and Formation of Cavities in the Middle Ear.

We discussed the most frequent new formations in the spaces of the middle ear, namely granulations and polyps, together with the different forms of otitis media purulenta which cause them.

Malignant tumors of these spaces are very rare. *Kuhn* for example says that of 128 carcinomata seen at the post-mortem table in the pathologic institution in Berne "not a single one was located either in the ear or nose."

In my own statistics I can count only 3 cases of sarcoma and 1 of carcinoma of the middle ear. In other words there is one case of malignant tumor of the middle ear to 5,000 ear patients.

Sarcoma was observed most frequently in small children, carcinoma in the very old.

Sarcoma which develops in the mastoid process, as in the cases which I observed, may present the clinical picture of a subperiostal abscess. It may raise the auricle in the same manner and may even show false fluctuation on account of its softness.

The case of epithelial carcinoma of the mastoid process which I operated, presented a clinical picture similar to a penetration of pus into the neck. A hard swelling was found *below* the mastoid process. It was however produced by lymph glands involved in the new formation.

The whole mastoid process, after a thick layer of bone was removed, was filled with solid, pale masses of granulation showing fine whitish spots which the sharp spoon cut exceptionally easily. The microscope revealed these spots to be perls of cancroid in a characteristic epithelial carcinoma.

The development of a carcinoma in the middle ear is sometimes preceded by a chronic suppuration of the middle ear for many years.

The patients usually seek treatment at a comparatively late stage of the disease when an operation does not afford any advantages, but only hastens the fatal issue by opening avenues for the development of a meningitis. An operation must by all means be avoided when facial paralysis and deafness indicate the formidable extension of the neoplasm.

Kuhn reports a case of prolapse of the cerebellum which formed after several sequesters had been removed from behind the ear. The operator taking it for a tumor removed it. The consequence was a fatal meningitis.

There was a time when we were not able to directly observe through the ear speculum the frequent extension of epidermis over the walls of the spaces of the middle ear, which, as we saw in the discussion of chronic suppuration of the middle ear, furnishes the soil for the development of cholesteatoma. At that time the pathological anatomists could not fail to notice the concentric gatherings of epidermis in the temporal bone on account of the large size which they sometimes acquire and the frequency of their occurrence. They described them as pearl tumor (*Cruveiller*), as cholesteatoma or margaritoma (*Virchow*). They were, and could be considered as nothing else but true heterotopic tumors at that time. The otologist, by clinical observation of chronic suppurations of the middle ear, together with the findings at the numerous radical operations and at the post-mortem table first showed that epidermisation of the spaces of the middle ear is a process of healing in otitis media purulenta chronica with marginal perforations of the tympanic membrane, and that the onionpeel-like gatherings are the consequence of their retention in cavities with insufficiently large openings. It is not surprising that these masses of epidermis may, by pressure atrophy of the bone, extend to all parts of the temporal bone or beyond it in the course of many years.

This is no doubt a very simple and very satisfactory explanation of the development of cholesteatoma in the temporal bone. There are, however, in spite of it, not only a number of pathologists devoid of all clinical experience, but also otologists who even to this day do not want to give up the idea that at least the larger gatherings of epidermis in the temporal bone on account of the large size which they sometimes acquire of particles of epidermis.

The number of cases reported in literature of cholesteatoma, which apparently do not coincide with the usual mode of development, in other words, which seemed to originate independently from suppuration of the middle ear, is so small compared to the many thousands with a clear pathogenesis that we are justified in considering the possibility that the process of suppuration in them was overlooked. This supposition is supported by the fact that in exceptional cases the defect in the tympanic membrane may close over a cholesteatoma.[1] These questionable cases of "primary" cholesteatoma can practically not be considered in making a diagnosis.

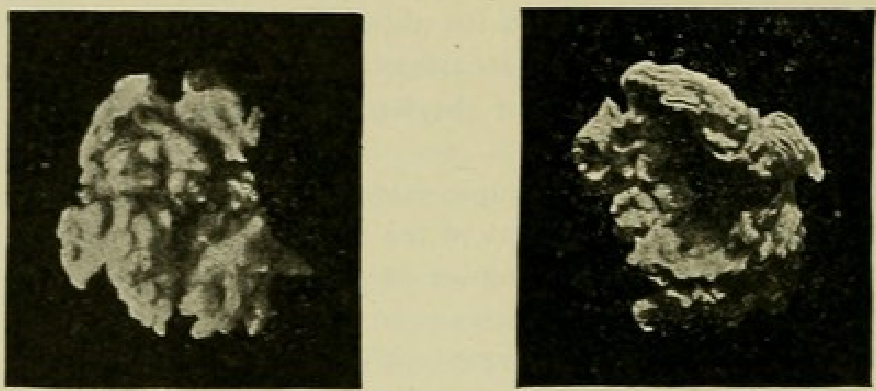
The relative size of the gathering of cholesteatoma can not be a differential diagnostic criterion, nevertheless it appeared necessary to say one more word about these large formations because they lead to the *formation of cavities,* a change in the temporal bone which requires some consideration.

Pressure atrophy produced by the masses becomes the most frequently visible on the posterior superior bony wall of the meatus. The

[1] Otitis media purulenta, etc. Beitrage z. Aetiol. d. Cholesteatoma Inaug. Diss. Munich, 1895, by Karl Hugel, page 86.

masses can often be evacuated if the defect in the bone has become large enough (compare fig. 75). There is a comparatively great number of cases which show at the examination a large cavity more or less empty, that is freely accessible through a defect in the roof of the bony meatus. It sometimes contains some secretion and remnants of cholesteatoma, which are usually very fetid. The removal of these contents is easily accomplished by direct injection through the antrum tube. The pressure of the injection must, however, increase gradually and not become too high, as the dura is often laid bare or the labyrinth is open at some part of these large cavities. The splitting of a bridge of skin in the meatus which has no bony support (compare page 207) is sometimes necessary in order to evacuate the masses. Large cavities in the bone are sometimes found absolutely empty and dry.

It will be of interest to hear something about the real *size* of the cavities formed in this manner in the temporal bone.



a *b*

Fig. 74.

Cholesteatomatous masses removed through a gap in the bony meatus.
a convex surface presenting a cast of the cavity, *b* concave surface directed towards the meatus.

Years ago I described a method for measuring the contents. It consists in that we fill the cavity with some fluid which we measure after evacuation in a graduated glass. The contents of the cavity measured in this manner may appear smaller than it is in reality as the air is sometimes not entirely removed from some recesses, or thick scales of epidermis are still retained, but the result of such measurements can never transgress the real size of the cavity.

I induced *Hummel* to measure in this manner the contents of the external meatus of a large number of adults. He found 1.0 to 1.3 cubic centimeters. We obtain the dimensions of the cavity by subtracting the contents of the meatus from the contents of the whole cavity. *Hummel* found cavities in the living measuring as much as three cubic centimeters.

A short while ago I measured a cavity on the living which showed no less than 8 cubic centimeters without the meatus. We obtained a rarely beautiful picture by transillumination upon inserting a small electric lamp (*Valentin's* salpingoscope) into the cavity through the large defect in the meatus. The limits of the cavity extended upward and backward all around the upper and rear insertion of the auricle. The presence of the large cavity could also be demonstrated by means of a small metal hammer, which in percussion produced a very sonorous sound over the whole extent of the underlying cavity. A very interesting phenomenon was produced by closing the meatus with the finger. The pitch of the sound of percussion became about one octave lower to the musical ear. The cavity showed therefore the same acoustic phenomenon as an open and a covered whistle. Another experiment demonstrated that either the dura or the carotid artery was to a large extent exposed in the wall of the cavity. By filling the cavity with some fluid up to the level of the entrance of the meatus, while the head was in a horizontal position, the fluid showed extensive pulsating movements.

LECTURE XXVIII.

Diseases of the Inner Ear.

General Part.

Gentlemen:—Nearly **11** per cent of all diseases of the ear that we observe are confined to the inner ear (according to *Bezold's* statistics). Of these patients 14.3 per cent=1/7 are children, 85.7=6/7 are adults. One ear was affected in 41.9 per cent, both in 58.1 per cent.

We find here in the first place the cases of deaf-mutism; furthermore the cases of permanent absolute deafness, and those where deafness is combined with defective speech. We shall see in speaking about *infectious diseases of children,* which so often endanger the inner ear, why the serious cases of diseases of the labyrinth occur so often in *children.* These diseases are most important in the etiology of affections of the labyrinth and the acoustic nerve during this period of life. In *adults* there are other causes for the numerous cases of diseases of the inner ear. They are changes due to *old age, to trauma, to professional* or *occasional* influences of very strong sounds and their consequences, to *lues, to intoxications,* and finally to the *last stages of otosclerosis* (spongifying of the capsula of the labyrinth). In a previous chapter we spoke about the direct progress of *suppuration of the middle ear* to the labyrinth. Tumors of the *auditory nerve* occur as often in children as they do in adults.

THE PATHOLOGIC ANATOMY of the labyrinth is not sufficiently investigated in all its details to give us a clear insight everywhere. Histological investigation of the cavities of the labyrinth and their delicate membranous contents enclosed in the hardest parts of the temporal bone was made possible only since imbedding in celloidin and the microtome were introduced into the microscopical technic. Nevertheless we know today a large number of important clinically well characterized pictures, their mode of development, their course, and their final result. This is especially true of inflammations of the spaces of the labyrinth in cerebrospinal meningitis, in syphilis, in suppurations of the middle ear and in trauma, as also in toxic poly-neuritis of the auditory nerve and after infectious diseases.

In the first stages of *suppurative labyrinthitis* we find swelling and hyperemia of the endostium which is the layer of connective tissue lining the bony walls of the cavities. The membranous labyrinth becomes involved a little later on. In very serious cases we see necrosis of the endostium, of the bony contents of the cochlea together with the ductus cochlearis, and also of the membranous semicircular canals, and even of the bony walls after they have lost their endostium. The suppuration may lead to absorbtion of bone and formation of sequesters. Abundant granulation tissue develops which fills the cavities of the labyrinth entirely or partially, changing later on to fine connective tissue or osteoid substance, and finally into bone. The modiolus cochleae together with its gangliar masses is usually destroyed, the auditory nerve becomes inflamed, thereby starting the process of degeneration of its main trunk.

We find macroscopically during the acute stage of *neuritis* of the auditory nerve an increase of volume and a hyperemia of the nerve. Microscopically we see swelling of the nerve fibres and infiltration of the interstitial tissue with round-cells. The nerve fibres atrophy later on, while at the same time the interstitial connective tissue increases in proportion. Such a nerve may appear macroscopically unchanged except for the increase of volume. Furthermore simple processes of degeneration of the nerve elements are observed in the auditory nerve without proliferation of connective tissue.

In post-mortems of deaf-mutes we find, in the minority of cases, a macroscopically visible atrophy of the auditory nerve. The spaces of the labyrinth are usually filled entirely or partially with connective tissue, or bone, in cases which became deaf by *acquiring* a suppurative labyrinthitis. A more or less extended destruction of the membranous parts of the cochlea is always found. The *macroscopical* examination of *congenital* deaf-mutes usually produces few positive results, except in those cases of enlargement of the aquaeduct and of the membranous apex of the cochlea which show only a partial development of the bony walls of those canals. The scala vestibuli and the scala tympani in those cases are divided by the lamina spiralis only in the 1½ lower whorls, and the apex of the cochlea forms one large common bone cavity which contains the ectatic upper part of the ductus cochlearis. The congenital absence of both labyrinths was so far observed in one single case. *Histological changes* of the membranous cochlea were found *in all cases* of congenital deaf-mutism which were microscopically examined by men who know how to use all modern adjuvants. They consisted of a more or less extended *degeneration of the epithelium* of some parts of the endolymphatic space, especially of the *papilla basilaris* (Corti's organ); *changes of the aperture of the membranous ductus cochlearis* are frequently observed, while the membranous and nervous parts of the vestibulum usually differ only very slightly from the normal, or not at all.

We have very little accurate knowledge about the changes in the *senile form* of labyrinthine deafness, in cases of one-sided deafness occurring with *Menière's* symptoms *without* a concommitant infectious disease, and in hard hearing and deafness occurring in cretins.

The clinical picture of diseases of the inner ear is primarily characterized by the kind of interference to which hearing is subjected. The defect of function in exclusive diseases of the external and middle ear is produced by some disturbance of equilibrium in the sound-conducting apparatus, either by overbalancing one part or another, or by fixation, or by partial defect of this apparatus. It can be shown to be a simple interference with conduction by means of functional tests. All functional peculiarities which are characteristic for the presence of an interference with conduction of sound are absent in pure diseases of the inner ear.

I explained to you that in *hearing by air conduction* the lower end of the sound scale always suffers in diseases of the middle ear. A complete loss of hearing for the lowest sounds is always present. The more intense hard hearing becomes the higher this loss of hearing mounts in the sound scale. Hearing may extend, though weakened, to the lower end of the sound scale only in acute processes of exudation. These processes however offer no difficulty to diagnosis by virtue of their objective findings. A more or less extensive loss of hearing for the lowest sounds is always present, even in the slightest defects of hearing, in all other diseases of the middle ear. It is found especially in those cases of otosclerosis which on account of the negative findings of the tympanic membrane are easily mistaken for diseases of the inner ear.

A disease of the middle ear as the cause of hard hearing must *be excluded* in all patients who hear the lowest tuning fork C_2 (16 v. d.) by air conduction. No other possibility is left in such cases than to locate the disease beyond the middle ear; that is in the inner ear.

Hearing of the lowest part of the sound scale in the majority of cases of "nervous deafness," as they are called, is absolutely intact. They are characterized as diseases of the inner ear by their ability to hear 16 v. d. and less by air conduction. Hearing of the lowest part of the sound scale is even preserved in patients who have great difficulty in understanding speech, and even in some deaf-mutes with remnants of hearing.

There is a comparatively small number of cases of diseases of the inner ear whose hearing of the lowest sounds is interfered with or effaced. They are the diseases of that part of Corti's organ which perceives the low sounds and is located in the cupula of the cochlea, according to *v. Helmholtz.*

Another peculiarity of diseases of the middle ear helps us to make a differential diagnosis in those cases. It is never absent even in acute exudations in the middle ear, namely, *an increase and prolongation of hearing of low sounds by bone conduction.*

A disease of the middle ear either alone or combined with an affection of the inner ear is present in all cases which hear sounds inaudible to them by air conduction, *longer* than normal, when the tuning fork is placed on the vertex. All pure diseases of the apparatus of perception interfere equally much with hearing of sounds of any pitch by air *and* bone conduction. Daily experience confirms this supposition to such an extent that we always find a small *shortening of bone conduction* in cases which hear speech badly, but hear well the lowest part of the sound scale.

A gradual increase of hard hearing by air conduction towards the lower end of the sound scale is always found in pure diseases of the sound-conducting apparatus. Diseases of the inner ear, on the other hand, may involve parts of different extension in any part of the sound scale. We may therefore find some parts of the sound scale that are not heard as well as others above and below, or hearing may be entirely destroyed for some parts; that is we find islands or gaps of hearing.

The cause of *total deafness* must *always* be found in the *inner ear.* A remnant of hearing at least in the upper part of the sound scale is always found in pure diseases of the middle ear.

Air conduction and bone conduction are equally concerned in pure diseases of the apparatus of the auditory nerve. Their *relation to each other* therefore does not change, i. e., *Rinne's test* is *positive* nearly or entirely the same as in the normal ear.

The differential diagnosis in nervous deafness of *one ear only* is more difficult.

Weber's test might help us in these cases, but just here the statements of the patients are too unreliable to be used for differential diagnosis.

The *duration* of bone conduction (*Schwabach's* test on the vertex) may be normal, or little longer than normal, for low sounds, especially in cases where there are residues in the sound conducting apparatus. *Rinne's* test may also be negative if bone conduction for low sounds is prolonged, especially if there is a high degree of deafness, because the tuning fork on the mastoid process of the diseased ear is heard in the other ear which is nearly or entirely normal. The functional picture of the diseased ear is therefore covered to some extent by that of the normal or better ear. A diagnosis of nervous deafness of one ear is, nevertheless, usually possible.

The differential diagnosis is most difficult in cases where the middle and inner ear are diseased *at the same time.* An acute disease of the middle ear which develops at the same time as a disease of the inner ear is recognized from visible changes on the tympanic membrane, and by means of ausultation. The simultaneous disease of the inner ear is diagnosed from the disproportionate decrease of hearing which is not of equal intensity in all parts of the sound scale. There are for example numbers, other than those in diseases of the middle-ear, which are not understood so well, especially such as contain sibilants. Hearing of a considerable part at the upper end of the sound scale, tested by the *Galton* whistle, may be lost, or circumscribed gaps may be found in this region.

An accurate diagnosis is especially difficult in diseases of the inner ear, combined with chronic diseases of the sound conducting apparatus which *shows no changes at the tympanic membrane or in auscultation.* Even there we are usually able to recognize and differentiate both diseases with reasonable accuracy. The final stages of otosclerosis are mainly concerned here. They often show a considerable shortening, or even complete deafness, for tuning fork a′ from the vertex, and the loss of hearing of a large part at the upper limit, or gaps in the region of Galton's whistle; but at the same time there is a considerable prolongation of bone conduction for A far beyond the normal, which indicates the simultaneous presence of a fixation of the stapes.

Subjective noises alone are no safe indicators of the seat of the disease as they are at least as frequent in affections of the middle ear (in sclerosis they are even more frequent) than in exclusive diseases of the nervous apparatus. Their great variety is often peculiar to nervous deafness and causes it to be very trying to the patient. The hearing of words or melodies must however always be considered as illusion or hallucination, and must be attributed to the brain center.

There are other functional abnormities observed in affections of the labyrinth, dizziness, nystagmus, interferences with equilibrium, which can be objectively proved. They occur in diseases of the vestibulum and semicircular canals, which may exist either alone or together with diseases of other parts of the labyrinth.

There is a large number of patients with nervous deafness who never suffered from any of these symptoms. We have to locate their illness in the cochlea exclusively, if there is no reason for locating it altogether beyond the labyrinth. We cannot be in doubt as to the origin of the disease being in the labyrinth in cases which show a sudden onset of disturbances of equilibrium together with nystagmus, and where these disturbances set in with such violence that the patients fall down and vomit. Disturbances of equilibrium of a minor degree are often observed in diseases of the sound conducting apparatus especially in otosclerosis.

Some statistical facts must be mentioned. The majority of cases of nervous deafness are men (according to *Bezold's* statistics, 77 to 78 per cent), while more than half of the patients suffering from sclerosis are women. Nervous deafness is mostly a disease of old age, while sclerosis develops rather in middle age and often during, or soon after, the time of puberty.

You will recognize, gentlemen, that our diagnosis in this region hidden to visual examination does not rest on such an unsafe basis as is often pretended, if you consider how often *etiology* from the beginning directs our attention to the inner ear in revealing such points as sudden appearance of deafness with or without a preceding trauma, detonations, simultaneous or preceding general diseases like lues, meningitis, etc.

The functional examinations alone can however not reveal whether the disease is located in the labyrinth, or in the auditory nerve, or in the brain center. Well circumscribed defects in the sound scale, gaps, islands, etc., can undoubtedly only originate in the cochlea.

A disease of only one side of *the first and second temporal convolutions containing the cortical center of hearing,* and of the corresponding parts of the crus cerebri does not cause complete deafness of the other ear because of only partial decussation of the auditory nerves. A disease of the upper convolution of the left temporal lobe leads to amnestic aphasia (inability to find certain words), and very rarely to sensory deafness (psychic or word deafness) where speech is heard but not understood.

We have to discuss the *disturbances of equilibrium* more carefully.

The feeling of dizziness is not a regular, but a frequent, symptom of disease of the labyrinth. It is often the most important symptom in acute labyrinthitis and increases with each change of position. Vomiting may occur during the hight of an attack of dizziness. The patients are sometimes forced to lie in bed for weeks without moving. This symptom in children is often not recognized by the relatives and is taken for simple weakness.

Dizziness occurs later on only in the form of attacks especially after quick movements of the body and eyes. Walking sometimes becomes unsafe, the patient, especially if his eyes are closed, has the tendency to deviate or to fall most often towards the side of the diseased ear.

Dizziness originating from the ear can be differentiated from dizziness produced by paralysis of the muscles of the eyes in that the latter disappears when the eyes are closed, while the former does not, and from dizziness in spinal ataxia by the subjective feeling of dizziness which is present. Cerebellar ataxia causes on the whole the same symptoms as does vestibular ataxia.

Sometimes there is not only a vague feeling of dizziness but a distinct impression of movement, so that the surrounding objects seem to move rapidly over the field of vision in a horizontal direction (rarely vertical). In such cases corresponding nystagmus can be directly observed and can be produced, or increased if already present, by having the patient look towards the side of the good ear. These symptoms occur only when the vestibulum, or the semicircular canals, or the vestibular nerve in its central course, are irritated. The irritation may be increased by 5 to 10 quick rotations around a vertical axis in the direction of the sick ear.

The nystagmus reaction is very strong in this case. It is also present, but less strong, when the experiment is made to turn in the opposite direction, thereby irritating the healthy ear. The opposite to the healthy condition prevails, that is, *the symptoms of irritation are absent,* no dizziness and no nystagmus is produced in rotation of the body around a vertical axis when the stage of irritation in the affection of the labyrinth has passed, and the endings of the vestibular nerve in the labyrinth *are completely destroyed.* Walking, especially in children, remains straddling and helpless for a long time after this state is reached.

The absence of nystagmus and dizziness indicates therefore the destruction of the endings of the nerve in the vestibulum, in the semicircular canals, or of the nervus vestibuli, as deafness is a criterion for destruction of *Corti's* organ in the cochlea or of the nervus cochleae.

The sum of labyrinth symptoms consisting of subjective noises, dizziness also in horizontal position combined with vomiting, nystagmus, and deafness are often called the complex of *Menière's* Symptoms. They may be observed in all diseases which are apt to produce irritation of the vestibular nerve. There is no special *Menière's* disease. According to what *Menière* reported about the single case upon which he based his clinical picture, it was a case of sporadic or epidemic cerebro-spinal meningitis. It is frequently complicated with labyrinthitis of both ears, and may lead to deafness and death, and yet at a superficial macroscopic post-mortem examination no pronounced meningeal symptoms are visible, as happened in *Menière's* case and the well known cases of *Voltolini.*

There is another very rare form of *Menière's* complex of symptoms which shows no loss of hearing but certainly originates from the ear.

LECTURE XXIX.

Special Pathology and Therapy of the Inner Ear.

Subjective Noises.

Gentlemen:—The mildest form of affection of the inner ear is called tinnitus aurium in our statistics. They are cases of subjective noises which neither at the inspection nor at the functional examination show an involvment of the external or middle ear, nor any loss of hearing. Their occurrence is not very rare; *Bezold* found it in **2.6** per cent of all ear patients. Some of them depend upon some general disease, as chlorosis, anomalies of blood vessels, psychic excitement, weakness; some are the consequences of frequent night vigils, etc. The character of the noise is very different; sometimes it is rumbling and low, like the noise of a moving railroad train, or like the street noise heard at a distance, or the humming of an insect, at other times it is of a high pitch and shrill like the chirping of a cricket, the noise of escaping steam, the clear ringing of bells and distinct musical sounds. The noise changes sometimes in the same patient. I observed some patients afflicted especially with noises of high pitch who in later years lost some of their previously normal hearing power. An organic lesion of the auditory nerve had to be diagnosed, as hearing of a considerable piece at the upper end of the audible sound scale was lost, although the hearing distance for speech had decreased only slightly.

Hearing of human voices and distinct words is due to hallucinations and psychical alterations, even if it is the only symptom for the time being.

The treatment must consider principally the general organism; harmful influences like overwork, excitement, etc., must be eliminated. Catheterisation may be tried as a local remedy. The prognosis is favorable if after the first inflation the noise does not disappear for a few seconds only (as this may frequently occur also in organic lesions) but at least for some hours. In such cases the method must be continued till the noise stops entirely. Physical procedures like pressure by means of

Siegle's funnel, or *Delstanche's* rarefactor, or massage, galvanisation, and other methods acting more or less by way of suggestion, usually have no result if the catheter fails. Quinine in small doses (0.2 a day), phenacetine 2x0.5 a day, antipyrine 3 to 4x0.3 a day may be tried internally for several weeks without interruption. Valerian and bromides may act as palliatives.

Degenerative Processes in the Labyrinth. Presbyacusis, Cretinism. Retinitis Pigmentosa.

A certain decrease of the power of hearing is a regular senile phenomenon (presbyacusis). It is however not strictly peculiar to senility but may occur earlier, corresponding to a general law that senile degeneration of any organ may take place in different individuals at different decades of life. Hereditary influences are evident in this regard. The beginning and the development of senile deafness frequently occur slowly and imperceptibly. Other disorders besides senile degeneration must be taken for granted when there is ringing and dizziness present.

Senile deafness always concerns both ears. The functional tests show the clear picture of nervous deafness, modified to such an extent that hearing in the region of *Galton's* whistle is usually considerably reduced. Deafness for the high sibilants s, z, sh, th, (j, g), occurs relatively early, rendering conversation for presbyacutic people more difficult, especially in the noise of general conversation at table. That old people are deaf to chirping of crickets is generally known. A defect of hearing at the *lower* end of the sound scale is rarely observed. According to anatomical findings it is due to calcification of the lig. annulare without a spongifying process taking place in the surrounding bone.

Other histological changes, especially a high degree of arteriosclerosis, could not be established in any part of the inner ear in senile deafness. To determine this fact we examined microscopically a large number of cases, whose functional tests we had made during life, and who had gradually developed deafness while preserving an intact middle ear (though becoming very deaf later on). Other authors however described histological changes in the cochlea which might possibly be considered as senile changes. They consist of a decrease of the aperture (collapse) of the membranous ductus cochlearis and a flattening and even partial atrophy of its sensory epithelium.

The prognosis and therapy are identical with that of senile changes in general.

We find other chronic degenerative processes in the inner ear, without perceptible neuritis of the auditory nerves, in certain congenital predispositions to disease. The cases of slow progressive deafness in *cretinism and in retinitis pigmentosa* must be mentioned here.

Symptoms of irritation of the labyrinth seem to be absent in deafness from cretinism, as also in deafness in connection with retinitis pigmentosa. There are however distinct symptoms of vestibular defect in the stationary, as well as in the slowly progressive form of cretinic deafness. They are evident in the walk and in the carriage of the patient as well as in the rotatory test, in as far as the normal reaction of nystagmus occurs only incompletely or not at all. In deafness in connection with retinitis pigmentosa there are similar pathological processes as in senile deafness, according to our histological examination of one of these cases. The results of examinations of the changes of the labyrinth in cretinism are not yet sufficiently numerous, and not uniform.

It is possible that *the therapy with thyroid gland* may arrest the progress of cretinic deafness. We were however in no case able to produce by it a real improvement of hearing. Apparently favorable results caused by the use of thyroid gland are due to the increase of intelligence and of the power of combination which allows these patients to find partly understood words and phrases by conjecture.

We will also mention at this place several cases of deafness observed after ligation of the carotid artery.

Inflammatory Processes in the Labyrinth.

We have previously spoken about perforations of suppurations from the middle ear into the labyrinth. The cavities of the labyrinth may furthermore be seriously interfered with, in the first place by meningitis and syphilis. Then grouped according to the degree of danger for this part of the organ of hearing, follow scarlet fever, influenza and influenza-like diseases of the respiratory organs, typhoid fever, mumps, measles, osteomyelitis, smallpox, whooping cough.

In the course of each one of the diseases named there are clinically observed cases of hard hearing, or deafness, which we have to attribute exclusively to the inner ear, according to the results of our functional tests. Each one furnishes a greater or smaller number of children for the deaf and dumb institutions.

A peculiar position must be accorded *leucemia,* which is complicated in its pernicious course in more than 10 per cent of its cases with labyrinthitis. It has however less practical than purely clinical interest on account of its almost unexceptionally fatal termination. Its course is sometimes chronic, sometimes apoplectiform, in the latter case it shows *Menière's* symptoms. The histological results are hemorrhages in the semicircular canals and especially in the cochlea, with partial destruction of the membranous labyrinth, and also of the stem and branches of the auditory nerve; furthermore there is lymphoid exudation in the cavities of the labyrinth and in the nerve. Connective tissue and bone may develop later on in the spaces of the labyrinth.

1. Meningitis Cerebrospinalis.

Labyrinthitis occurs on an average in 30 per cent of cases of cerebro-spinal meningitis. Of those who survive more than 10 per cent remain hard of hearing or deaf. Not all epidemics are equally dangerous to the organ of hearing. Children always seem to run the greatest risk, so much so that for several years after such an epidemic has invaded a country some deaf and dumb institutions are filled exclusively with inmates who lost their hearing by cerebro-spinal meningitis. This class of deaf-mutes even today represents half of all the deaf and dumb, although for decades this disease occurred in Europe only sporadically or in small epidemics.

It is of greatest practical importance that the intensity of the clinical symptoms of meningitis is often so insignificant that they are in no proportion to the seriousness of the affection of the labyrinth.

Complete deafness may be caused by very light abortive cases, but even they can not always be recognized as such on account of the absence of a simultaneous epidemic in the town, or of some serious illness in sisters or brothers or neighbors. The same incongruity exists sometimes between the clinical symptoms and the result of the post-mortem of the central organs, as the nature of the disease which terminates fatally in so short a time does not always become evident from those apparently insignificant pathologic anatomical changes.

Inflammation of the labyrinth almost always involves *both ears* (according to *Bezold* in 91.8 per cent). It acts as a destructive process of the perilymphatic space, showing hyperemia, stasis, thrombosis and rupture of the small blood vessels, fibrinous infiltration and necrotic decay of the endostium. Suppuration, superficial necrosis of bone, neuritis of the auditory nerve occur later on, as I told you in the introduction to this chapter.

An inflammation of the middle ear accompanies the meningitic labyrinthitis and the cerebro-spinal meningitis in more than half of the cases. It usually passes rapidly, runs a very mild course, and is therefore hardly ever clinically observed, especially on account of the seriousness of the other symptoms of the disease. Different epidemics seem, however, to vary considerably since some otologists find later on otorrhoea and visible material changes of the tympanic membrane in 5 per cent, others in 10 per cent and more, of patients who became deaf from cerebro-spinal meningitis. An inflammation usually of both middle ears is a regular part of the picture during the first period of cerebro-spinal meningitis, as is shown by the results of post-mortems of cases which took a rapid course. It does not lead to perforation in the majority of cases, not even to clinically demonstrable inflammatory changes of the tympanic membrane. In rare cases otorrhoea precedes the onset of meningitis. In cases where a perforation of the membrane occurs it takes place as a rule later on, sometimes as late as the sixth week and later, after the onset of meningitis. Destructive processes in the bone are very exceptional in cerebro-spinal suppuration of the middle ear. Such a combination of suppuration of the middle ear with labyrinthitis may be called *panotitis*.

In literature there is one post-mortem report of the findings in the labyrinth of a patient who became only moderately hard of hearing from meningitis. The small changes found there are entirely confined to the *perilymphatic* space. In completely deaf patients a destruction of the region of the papilla acustica, together with a more or less extensive alteration of the *endolymphatic* space is always found after an inflammation of the labyrinth has run its course. The endostium is always proliferated in some, or in all parts. The space of the labyrinth contains connective tissue and bone, or is entirely replaced by bone. In extreme cases no cavities can be found in the place of the labyrinth. The stapes, often subluxated from the vestibulum towards the tympanic cavity, is ancylosed and the membrane of the round window thickened from proliferation of connective tissue, or calcified. The aqueducts are closed by connective tissue or bone and the auditory nerve is partially or entirely atrophic. The semicircular canals are most often filled in this manner. The cochlea may appear normal to the naked eye.

We understand very easily that meningitis epidemica fills the deaf mute institutions if we remember that the first year of life is the most susceptible to it, as 13 to 27% of all patients are of that age according to large statistics.

The affection of the labyrinth becomes noticeable most frequently during the second or third week of meningitis, rarely earlier or later. Its course is usually progressive and rapid, exceptionally it has a chronic character with remissions, when it may take an unfavorable turn even after several months. Subjective noise and rapidly progressing loss of hearing are present from the beginning of the disease as far as the age of the patient and the general symptoms, especially the absence of clear consciousness, admit of an examination of the subjective and objective symptoms of the labyrinth. The difficuity of hearing is usually only noticed during the hight of the disease when both labyrinths are attacked. The most prominent symptoms are the manifestations of the feeling of dizziness: these patients are often extraordinarily "weak" for weeks and months after the meningitis has run its course, i. e., they cannot stand up, they cannot sit down, but try to remain in bed, flat on their back for all this time. Older children forget how to walk, and when they learn it again, their gait for years remains unsteady and staggering. A peculiar inclination to stumble and fall is usually spontaneously mentioned by the parents in giving the history of such children.

The normal dizziness and nystagmus can usually not be produced by the experiment of rotation in most people who became deaf after meningitis had run its course. This allows the conclusion that the destruction extended to the vestibulum and semicircular canals.

The diagnosis is often difficult or impossible in the beginning, especially in light sporadic cases, and when it concerns children during their first year of life. It is often made after the disease has run its course, a fact which may be of disagreeable consequences to the general practitioner. You will be led to think of the possibility, or the probability, of a meningitic labyrinthitis if a small child, after a very slight not clearly pronounced meningitic attack, is particularly motionless, while you can not detect any abnormal subjective or objective symptoms, or if the child can not sit or stand when the nurse tries to force it to do so, while the child can move the extremities freely and does not indicate any pain.

Hearing tests are rarely possible, even in adults, during the hight of the disease, but the increasing lack of perception in calling the name of the patient soon becomes evident. Complaints of subjective noises and nystagmus are frequent in the beginning. Nystagmus, feeling of dizziness, and retching may also be due to the main disease. You must be very careful in your prognosis if a patient suffering from meningitis becomes hard of hearing, and you discover in him a suppuration of the middle ear which might or might not be the cause of the hard hearing. On the other hand it is evident that not every meningitis which occurs together with a suppuration of the middle ear and labyrinth, is induced from the ear and can therefore not always be called an "otitic meningitis." The possibility of a genuine meningitis with participation of the middle ear must, especially in children, not be forgotten in cases where we have to decide whether or not to operate in an apparent "otitic meningitis."

Therapy seems to be powerless against meningitic labyrinthitis.

2. Syphilis of the Labyrinth.

Syphilis of the labyrinth occurs as a hereditary, and as an acquired disease.

a. *Hereditary lues of the labyrinth* is mainly a disease of childhood. It begins most frequently at the end of the first, rarely at the end of the second, decade. We observed it as a great exception in a woman of 25 who became deaf during childbed, showing the characteristic clinical picture in anamnesis, and anomalies of the eyes and ears. In another case which was equally clear, presenting *Hutchinson's triad,* we saw deafness develop rapidly in the 49th year of life. Deafness always occurs some time after keratitis diffusa. The characteristic deformity of the teeth described by *Hutchinson* is not present in all cases.

The frequency of occurrence of luetic labyrinthitis is best illustrated by the fact that in the etiology of deaf-mutism, hereditary lues takes first rank after meningitis and suppuration of the middle ear, according to *Bezold's* statistics. Still the statement of several authors that one tenth to one third of all hereditary syphilitic children suffered from some disease of the organ of hearing is wrong, and much too high. Methodical investigations of the conditions of a number of unquestionably hereditary luetic children showed different instances where not one such child out of 40 to 50 was extraordinarily hard of hearing. There is a peculiar fact that the majority of the children are *female,* while the male sex predominates in all other diseases of the organ of hearing in children.

Our *diagnosis* is based upon the presence of keratitis diffusa which had either lasted for a long time or had already healed, less frequently upon iritis or the characteristic choreoiditic changes of the fundus of the eye; furthermore upon the malformation of the upper incisors of the second dentition, upon ozena, gummata, loss of substance, scars in the fauces and other luetic symptoms of the patient and his family, upon several premature births in his mother, death of sisters and brothers soon after birth, etc. Changes in the tympanic membrane indicating prolonged occlusion of the tubes are frequently found.

Inunctions of blue ointment, which were given in about half the cases on account of the preceding keratitis, do not protect the patient against a later occurrence of hereditary luetic labyrinthitis.

A high degree of hard hearing almost always sets in in both ears, and rather suddenly. The disease of the ear may begin with dizziness and ringing. The latter sometimes remains, but either or both of these symptoms may be absent. The disease leads usually to deafness for speech, and deaf-mutism if it occurs in early childhood.

The functional tests by means of the tuning forks reveal the symptoms which are characteristic for disease of the labyrinth. Hard hearing extends over the whole sound scale, the upper end of the scale is not more interfered with than the lower. Sometimes the contrary appears to be the rule, according to our experience. Gaps of hearing are observed in some cases. Hearing of the ends of the scale becomes gradually more effaced later on until only an island of hearing is left, which by and by also disappears. The progress of deafness may become stationary at any stage. We therefore find deafness in one ear, combined with a smaller or larger degree of hard hearing in the other ear, in the same patient. Remnants of hearing which remained stationary for many years may gradually decrease later on.

The prognosis as to restitution of hearing is very bad.

The therapy seems to be powerless in arresting the progress of the process, even though temporary improvements were frequently observed during the treatment by inunction. At all events not a moment must be lost in expectation or with remedies of doubtful value, whenever the diagnosis of a luectic disease of the labyrinth is made. Iodide of potassium may be tried in the very first stage, it is, however, worthless and even contraindicated later on. A result can only be expected of the treatment by inunction which may be combined internally with *Zittmann's* decoction. This treatment must be given in a hospital by well trained nurses, and must be repeated several times at not too large intervals.

b. *In acquired lues* the labyrinth is usually involved during the tertiary, rarely during the secondary stage. In the latter case it is sometimes accompanied by slight inflammation of the middle ear, and by symptoms of retraction of the tympanic membrane. Hard hearing here also develops rapidly, rarely slowly or remittently. Dizziness and subjective noises are observed less frequently than in the hereditary form of lues. Another difference between acquired and hereditary lues consists in the fact that women are much more rarely attacked by acquired lues of the inner ear than men, and that the disease in adults often remains confined *to one ear.* It must however be left to future investigations to decide in how far forms of pure polyneuritic character may act here, and whether or not symptomatology will ever permit a differential diagnosis in this direction.

The therapy seems to show a difference between acquired and herditary lues in that a combination of mercury with the medication of iodides seems sometimes to give better results than either of the two alone.

The prognosis is much better in acquired than in hereditary syphilis of the labyrinth. A complete recovery may occur even in very hard hearing patients, if treatment is applied early and energetically enough.

Post-mortems show that the process in the labyrinth in lues, as in meningitic deafness, terminates in new formation of connective tissue and bone in all spaces of the labyrinth. Otitis interna luetica never leads to meningitis. Swelling and formation of lymphomata in the nerve substance of the branches of the auditory nerve were found in acquired lues. A number of reports of post-mortems of temporal bones belonging to persons who had hereditary syphilis show a destruction of the oval window and the labyrinth, caused by suppurations of the middle ear. These changes were most probably caused by tubercular processes.

3. Scarlet Fever, Measles and Diphtheria.

Clinical and anatomical examinations have shown that labyrinthitis in scarlet fever is caused most frequently by a perforation of the suppuration of the middle ear through the windows of the labyrinth (panotitis). This chapter has been discussed before. There is, however, a minority of cases where suddenly all symptoms of labyrinthitis with very hard hearing or deafness develop, without inflammation in the middle ear or perforation of the tympanic membrane or of the windows. Some of these cases are explained by a meningitic disease of the labyrinth. Future pathologic anatomical investigations must, however, reveal in how far pure polyneuritic processes are found in similar cases of sudden development of deafness.

Measles is sometimes the cause of labyrinthitis, but not by far as frequently as scarlet fever. We must make a distinction here also between a form which propagated from the middle ear, and another, probably of meningitic origin, occurring together with an intact middle ear.

Genuine diphtheria is not very dangerous to the organ of hearing, neither to the middle ear nor to the labyrinth. Nearly all cases of serious deafness attributed to diphtheria may be ascribed to diphtheria after scarlet fever, or rather directly to scarlet fever itself, without fear of making a mistake.

4. Mumps.

The affection of one or both organs of hearing in *parotitis epidemica* is a rare and interesting disease. It is most often confined to one ear only. It occurs usually towards the end of the disease, and leads rapidly to complete deafness of the affected ear. Violent attacks of dizziness with vomiting accompany the disease in some cases, in others there is noise in the ear. Both symptoms may be absent. I have observed the same disease after an inflammation of the submaxillary glands, but only as a great exception. Complete deafness for speech is always present, but remnants of hearing may be discovered in some cases by means of the sound scale.

The anatomical basis for deafness in mumps has not been sufficiently investigated.

5. Other Infectious Diseases.

Serious labyrinthitis resulting in deafness may occur in the course of *influenza,* and *influenza-like* affections of the respiratory organs, as also during *pneumonia, typhoid fever, smallpox,* and *whooping cough.* The middle ear, or a suppuration in its spaces, does not take any part whatsoever. There are so far no post-mortem results which reveal whether the labyrinth alone is diseased in these cases, or whether a post infectious neuritis is the cause of the disease. We are more accurately informed as to deafness in *osteomyelitis* and in *leukaemia,* which latter so far has been counted among constitutional diseases. In these two diseases we know the pathologic anatomical condition, although they are rare occurrences. Both organs of hearing are usually attacked. In osteomyelitic deafness we sometimes find considerable remnants of hearing for speech and the sound scale. Besides the leukaemic and typhoid labyrinthitis an independent leukaemic and typhoid neuritis, or polyneuritis, is observed.

New Formations in the Labyrinth.

New formations do not seem to occur primarily in the labyrinth. Two small neuromata accidentally were found in the vestibulum of two deaf-mutes. They are analogous to neuroma after amputations (*Schwartze* A. f. O. vol. V. page 297 and *Schwabach* Z. f. O. Vol. XLVIII page 303). Tumors of the auditory nerve are not very rare and will be discussed later on. Secondary new formations as a rule penetrate into the labyrinth from the middle ear, or more rarely through the porus acusticus from the interior of the skull. We shall speak about the latter together with the affections of the nerve. Belonging to the first class we find the *sarcomata* in children, furthermore *carcinomata* which develop in the middle ear of young people in the form of basal cell carcinoma, and the flatcell carcinoma of old people, which arises from the external ear, or from a metaplasia of the lining of the middle ear.

Tuberculosis of the inner ear is relatively not so rare. It occurs in children who have usually no affections of the lungs, or appear not to have any, and begins with the symptoms of a common acute, or subacute suppuration of the middle ear, often very rapidly attacking the facial nerve and the inner ear. We observe this disease more rarely in adults. A destructive tuberculosis of the middle ear and labyrinth occurs there more frequently during the far progressed stages of consumption.

The clinical picture of these two forms of diseases of the middle ear was described under the heading of otitis media purulenta phthisica.

LECTURE XXX.

Affections of the Auditory Nerve.

1. Polyneuritis.

Gentlemen:—In the course of our lecture on post infectious labyrinthitis we repeatedly mentioned that the auditory nerve is almost invariably involved in inflammatory diseases of the cavities of the labyrinth, especially if they are of a purulent character. Besides that we know of a form of hard hearing and deafness which is confined to inflammation and destruction of the nerve, leaving the labyrinth intact. This disease belongs to the large class of polyneuritis, as it attacks *both* auditory nerves as a rule. We distinguish three forms as to their etiology. a. post infectious polyneuritis, b. constitutional, and c. toxic polyneuritis. All three forms may attack either vestibular or the cochlear branches of both nerves, or they may attack both branches simultaneously. The diseased part is usually found in the main stem of the nerve, as in a diseased optic nerve. The diseased stem becomes infiltrated, swells up, and the nerve fibres perish. The connective tissue between the fibres proliferates and takes the place of the nerve fibres; sclerosis develops. In other cases degenerative processes prevail. What part the cochlear ganglia take remains to be decided by further investigations. Opinions differ on this point, as well as on the pathologic anatomy of retrobulbar neuritis of the optic nerve.

a. Polyneuritis acustica of consumptives is the best known of all diseases of the auditory nerve due to *infectious diseases.* The clinical picture and anatomical phenomena of this disease were first described by myself. A polyneuritic inflammation and degeneration of the auditory nerve occurs through the blood in rare cases as a concommitant to extensive tubercular processes which run a pernicious course accompanied by fever. It concerns either the cochlear nerve alone or the whole stem of the auditory nerve. Simple atrophic changes of the part of the nerve in the labyrinth, besides the intralabyrintheal disease of the stem, are observed in those rare cases where the patient lives for some time after deafness has set in. The clinical symptoms in the ear consist of rapid loss of hearing leading in a very short time (days or weeks) to complete deafness *in both ears.* The beginning is most frequently acute, rarely slow. Subjective noises occur frequently but not always. The loss of hearing is connected with serious dizziness in the rare cases where the vestibular nerve is also affected.

The tympanic membrane and the middle ear as a whole remained normal in all cases that were observed up to date. I saw a permanent deafness in one ear develop acutely in a man with healthy lungs, during tuberculosis of the glands in the axilla accompanied by fever.

Polyneuritis of the auditory nerve may also be the cause of deafness in *typhoid fever* according to the histologic findings in a case which was in our institution. Clinical observations seem to show that the affection remains confined to one ear in at least one-half the cases. It is hardly doubtful, but not absolutely verified by pathologic anatomical investigations, that polyneuritis plays an important part in other affections of the inner ear observed after acute infectious diseases, especially *scarlet fever and influenza.* There is, however, an accurate report of the pathologic anatomical conditions in the inner ear of an old man who suffered from progressive deafness after acquired *lues.* Lymphomata were found in the main stem of the auditory nerve, besides the residues of a labyrinthitis. New investigations seem to confirm the fact that the *changes in the nerves in tabes* belong also to postsyphilitic affections of the nervous system. Progressive hard hearing is observed in 2 to 10 per cent of patients suffering from tabes. It is less due to polyneuritic processes than to atrophy and gray degeneration of the stem of the auditory nerve (more rarely of the intramedullary part of its central course). It may occur at any stage of the main disease. It is usually observed in both ears and is accompanied by severe subjective noises.

b. The most important details concerning *deafness in connection with leukaemia* were given before. It forms almost the only pathologic anatomical example of a polyneuritis due to *constitutional causes.* We want to add that several cases of leukaemic deafness in both ears are known where the labyrinth and the stem of the auditory nerve were intact, but the medullary part or the nuclei of the auditory nerve were leukaemically infiltrated. We must presume that *diabetes, gout, malaria, cretinism, arteriosclerosis,* and *senility* play an important rôle in diseases of the auditory nerve as they do in other nerve regions. As a peculiar fact it must be mentioned that we found progressive nervous deafness in patients who were not tubercular, but suffered from *ozena,* and in youthful individuals coming from *families which have a poor health record* and often show deaf-mutism, psychoses, and especially tuberculosis, yet present no other etiological factors. There is one more pathologic anatomically carefully examined instance of deafness coming under this heading, namely in carcinoma. It concerns a woman suffering from progressive spongifying of the capsule of the labyrinth, with ancylosis of the stapes. She became acutely deaf during the development of a carcinoma of the liver which led to death. We found circumscribed small cell infiltrations in her auditory nerves at our microscopic examinations.

Therapy is powerless in most of these cases.

c. The nature of *toxic polyneuritis* has been revealed by recent experimental investigations. The inflammatory changes extend in these affections over the stem and the ganglia of the cochlear and vestibular nerves. Hard hearing caused by taking *quinine* and preparations with *salicylic acid* are daily experiences to the busy practitioner. The injuries that *alcohol* and *tobacco* may inflict upon the auditory nerve are less known. The patients usually complain about a certain degree of hard hearing and a feeling of dizziness if quinine and salicylic acid are prescribed in doses large enough to cause serious ringing in the ears. Bone conduction is considerably diminished, and symptoms on the part of the middle ear are totally absent. All symptoms disappear promptly after the patient stops taking the medicine, and no serious damage remains. Permanent injury may be done after long continued use of abnormally large doses. We must however be careful in accepting such statements by the patients, as they are often suggested to them by previous examinations. This is especially evident in cases of uncomplicated progressive ancylosis of the stapes showing considerable prolongation of bone conduction, and a large defect of hearing at the lower end of the sound scale, where the patients frequently asserted that they were previously treated with salicylic acid and quinine. Hard hearing in people who lived for a long time in the tropics, suffering from malaria, and consuming therefore much quinine, is probably not primarily due to a toxic neuritis but to injury to the auditory nerve by malaria.

A number of cases are reported of injury to the labyrinth due to *tobacco*. *Alcoholic* intoxication is of much greater importance to the nerve. I saw typical cases in two students who had consumed exceptionally large quantities during several weeks. They consulted me on account of moderate hard hearing in both ears, which had developed rapidly, and showed the functional character of an affection of the labyrinth. One of the cases was complicated by paresis of the oculomotor nerve. Complete recovery took place in both cases after abstinence. In a third case concerning a night watchman, who for many years was in the habit of drinking a large amount of whiskey, deafness occurred rather suddenly accompanied by serious symptoms, consisting of dizziness and noise in the ears, which disappeared only partially.

Our knowledge of deafness from inspiration of *coal gas*, from intoxication with *lead*, *arsenic acid*, and other kinds of poison is absolutely defective, as such cases are rarely observed. The same must be said about intoxication from *oil of chenopodium*.

d. A paresis of the auditory nerve of one or both ears was frequently observed in juvenile and old individuals of both sexes. It was due to neuritis and could not accurately be placed in one of three classes just described. We may, in short, call it an *essential form* of neuritis of the auditory nerve. It usually sets in with violent noises, dizziness, and very hard hearing or deafness; sometimes there is vomiting, and frequently the beginning is foudroyant, showing *Menière's* complex of symptoms. Dizziness is sometimes absent. In such cases the rotation test also showed normal nystagmus reaction. Attacks of *Menière's* symptoms may exceptionally repeat themselves later on at different intervals. Infectious diseases, anomalies of constitution, abuse of alcohol could be excluded as etiological factors. The disease occurred mostly in otherwise healthy and strong individuals. It is usually a benign process. This is shown by the fact that recovery usually takes place, often after a few weeks only, by the continual use of large doses of antipyrin (4-5.0 a day). Quinine, if antipyrin does not act, may be given in large doses (i. e., 3x0.25 a day) during 10 days.

2. Degeneration of the Auditory Nerve on Account of Diseases in Its Surroundings.

Progressive deafness may of course result from proliferating inflammations of the bone and periostium of the base of the skull when they compress the auditory nerve by narrowing the lumen of the nerve canals. *Luetic processes* may be named here, and especially a rare but characteristic disease of the bones of the skull called *leontiasis,* which leads to blindness and deafness.

An affection of the inner ear was briefly mentioned in connection with otosclerosis. It occurs in both ears, begins in juvenile age, and is mostly noticed in women. The anatomical base *is a spongifying of the bony walls of the labyrinth.* It usually leads to ancylosis of the stapes since it is generally located in the vicinity of the oval window, and shows the functional symptoms of disease of the middle ear. There are however cases, though comparatively rare, which show in one ear the functional symptoms of ancylosis of the stapes, while in the other ear those of affection of the inner ear. In other rare cases the *wall of the labyrinth appears typically pinkish through the normal, but extraordinarily delicate, tympanic membrane, and the hereditary* conditions as well as the anamnesis coincide with the diagnosis. In such cases we do not find in either ear the functional symptoms of disease of the middle ear but the typical symptoms of an affection of the labyrinth. Finally we find middle ear and labyrinth symptoms combined in the same ear. This is even the rule in older cases which have lasted for several decades. The disease of progressive spongifying, taking the form of nervous deafness, is always from the beginning accompanied by very disagreeable noises and attacks of dizziness. The presence of the above named symptoms support the diagnosis in those cases, namely, heredity, occurrence in juvenile age, in female sex, pinkish promontory, normal conditions in the retro-nasal space and in the cartilaginous tube.

I treated two sisters at nearly the same time for progressive hard hearing; one of them showed the functional phenomena of ancylosis of the stapes, the other of pure nervous deafness, while the anamnesis and the findings at the inspection pointed distinctly to spongifying of the capsule of the labyrinth.

The only treatment which so far showed any favorable effect in spongifying of the capsule of the labyrinth is phosphorus in very small doses. It seems in many cases to influence favorably the process in the bone which has a certain similarity to osteomalacia, though it is not identical with it. We cannot promise our patients an improvement but gradual cessation of the progress, if they use it *for several years.* This takes place in at least 50 per cent of all cases, according to my experience. The phosphorus may be given in Kassowitz emulsion 0.02:200.0 one tablespoonful twice a day during the cool seasons. During the warm seasons and in traveling it should be taken in capsules (phosphorus 0.001 : oil 0.6), two a day. The patients are able to take it without inconvenience. Small changes in the distance of hearing, improvement and the opposite belong to the clinical picture, and must not be attributed to the treatment. Subjective noises seem to be influenced the least. We often see other disturbances of the nervous system, which are independent of the disease of the ear, disappear during such a long treatment with phosphorus. Injections of thiosinamin or fibrolysin have no effect according to our experience extending over a series of typical cases which have all used the cure to its end according to the rules.

3. Tumors of the Auditory Nerve.

Tumors of the stem of the auditory nerve and its surroundings are not very rare. They are mostly psammoma and neurofibroma; while glioma, sarcoma, endothelioma, etc., are less frequent. They lead to paralysis of the cochlear, vestibular and facial nerve, having been preceded for some time by symptoms of irritation. The tumors grow into the labyrinth by destroying the bone, if they are of a malignant nature.

Cerebral Diseases as Causes of Disturbances of Hearing.

Besides tumors, embolisms and hemorrhages are important factors as diseases of the central parts of the auditory nerve.

You know that the lowest central nuclei of the cochlear nerve are situated on both sides in the caudal parts of the region of the pons. The fibres run from there, with repeated incomplete decussation in the tegmentum, upward toward the lateral ventral part of the region of the corpora quadrigemina; from there through the superior peduncles and through the corpus geniculatum internum, then, passing underneath the rear part of the optic thalamus to the capsula interna they finally reach the cortex of the temporal lobe. Partial decussation of the fibres of both sides takes place in various parts of this course. This explains the fact that a one-sided lesion of the central course of the auditory nerve does not cause deafness of the contralateral ear. A number of cases of deafness *of both ears* are known from diseases of the center of hearing in *both* temporal lobes, but a material and permanent decrease of hearing was never ascertained in the other ear when there was a destruction on *one side* of this region, or of the crus cerebri.

A serious impairment of hearing in *both ears* from the beginning occurs as a rule if both central tracts of the auditory nerves sustain a lesion at the place where all their fibres come close together, namely in the midbrain. It is therefore justifiable to speak about MIDBRAIN DEAFNESS, similarly to *cortical deafness*. We have to discuss midbrain deafness more carefully, as it offers a number of peculiar characteristics besides the fact that it concerns both ears and occurs comparatively frequently.

Tumors of the midbrain produce disturbances of hearing more frequently than diseases of any other region of the brain. According to a compilation, which has, however, no claim to accuracy as to the examination of hearing, tumors of the cerebellum cause pronounced difficulty of hearing, or deafness, in 20 per cent of cases; tumors of the pons in 25 per cent, and tumors of the midbrain in more than one-third of the cases, namely in 34.5 per cent. The difficulty of hearing in those cases is produced by a lesion of the region of the lemniscus of the tegmentum which is somewhat lateral and below the lamina quadrigemina, but not a lesion of the lamina quadrigemina itself, as I demonstrated conclusively in a large number of cases. Deafness occurs comparatively late in the development of tumors of this region, which includes tumors of the pineal gland.

The first *symptoms* which are always present are head-ache, decrease of the function of the optic nerve, irritability and, in the majority of cases, a short apoplectic attack. Later on there are changes in speech (dysarthria, difficult articulation) *disturbance of the movement of the bulb of the eye*, ataxia, epileptic attacks, disturbances of the motility of the body and of the extremities, and paralysis of the facial nerve. Other disturbances occur less frequently, such as incontinentia, disturbances of the reflexes of the tendons and muscles, paralysis of swallowing, disturbances of sensibility in the trunk and extremities, polyphagia, elevation of temperature.

Hard hearing is rarely noticed at the end of the first month; it usually sets in 3 to 6 months after the beginning of the disease. It generally occurs simultaneously *in both ears*. How rapidly deafness progresses depends principally upon the nature and rapidity of growth of the tumor. Bone conduction is shortened in the beginning, and ceases altogether later on. I examined one case with the sound scale and found that the power of perception was first lost almost exclusively for the lowest sounds, later on equally for all sounds of the scale. In both ears the defect of hearing progressed from the lower and upper limit so that finally only an island was left, as it is observed in the highest degrees of diseases of the sound perceiving apparatus, namely, of the stem of the auditory nerve as well as the labyrinth.

Subjective noises are complained of in scarcely one-fourth of the cases. They were of three different qualities in my patient and annoyed him exceedingly. *Dizziness* is not complained of by bed ridden patients. It only apparently becomes a factor in the clinical picture by forming a part of the complex of symptoms of ataxia. Unsteadiness in walking and standing (*Romberg's* phenomenon) should be distinguished from dizziness attributed to the semicircular canals.

The diagnosis of an affection of the midbrain can be safely made if progressive hard hearing is added to the above named symptoms, which have in the foreground those of the optic, oculomotor and abducens nerves especially if also attactic gait develops. Tumors must almost exclusively be thought of, while hemorrhages and foci of softening of the brain need hardly be considered. In children below 10 years they are as a rule tubercles, during puberty and in adults glioma and sarcoma. Gumma is rather rare in this region; only a few were observed. I saw two cases of luetic ophthalmoplegia combined with progressive hard hearing. Both recovered after general treatment which was begun very early. Almost all symptoms, also hard hearing, disappeared later on, except some very insignificant residues.

The prognosis of deafness due to disease of the midbrain is always very bad except in very fresh luetic diseases.

The attention of neurologists has lately been repeatedly drawn to a certain form of tumor of the pons showing characterictic symptoms. They are the tumors developing in the ANGLE BETWEEN THE CEREBELLUM, THE PONS, AND THE MEDULLA OBLONGATA and are principally neurofibroma, but also gumma, glioma, sarcoma, psammoma, fibrosarcoma, endothelioma, etc. They usually occur on one side only; rarely on both. The neurofibromata are usually complicated by more or less extensive, multiple tumors of the nerve roots and nerve trunks. Most of these tumors originate from the nerves which pass through that angle, especially from the auditory and facial nerves, rarely from surrounding parts of the brain.

Deafness is usually confined *to one ear,* namely the ear corresponding to the location of the tumor, and is in the foreground of the clinical picture as to time of its occurrence and as to intensity. The fact that deafness is confined to one ear, the very early appearance of dizziness, nystagmus, paralysis of the facial nerve and difficulty of swallowing, differentiate this kind of tumors very distinctly from tumors of the region of the corpora quadrigemina, which show ophthalmoplegia in the foreground of the clinical picture. Subjectively and objectively noticeable symptoms originating from the optic nerve are evident in the same manner from the beginning in deafness caused by tumors in the pons, and deafness caused by tumors in the midbrain. The diagnosis of a central neurofibroma is sometimes facilitated by the simultaneous occurrence of neurofibromata in the skin.

It was shown that it is possible to operate such tumors, if they are confined to one side. These attempts were, however, only very exceptionally successful.

LECTURE XXXI.

Hysteria and Traumatic Neurosis of the Auditory Nerve Apparatus.

Gentlemen:—Hysteria and traumatic neurosis, which is a mixture of hysteria and neurasthenia, must be classed in a certain respect with central diseases.

Hysterical symptoms are rather exceptional *in the organ of hearing.* They are recognized as such from the fact that they appear in direct connection with, or some time after, some serious excitement, or other influences which may injure the whole organism, or after a comparatively slight traumatism in an otherwise normal ear, or after a preceding affection of the ear which is, however, well healed. The patients are usually women who have a hereditary tendency towards nervous diseases. Sometimes they are older children, but the strongest disposition is found in those years when the sexual functions develop and are at their hight. The complaints are sometimes of pain in the ear, in the depth of the auditory canal, or in the mastoid process (mastalgia); other times they are of different degrees of hard hearing, or deafness, usually in both ears. The picture may be complicated by passing dumbness, noise in the ears, feeling of dizziness, head-ache. *The diagnosis* may be supported by the presence of other symptoms of hysteria, which may be of a purely psychical nature, or which may belong to the sensitive or motor sphere, as, for instance, sudden change of the symptoms, sudden changes for the better or for the worse, for which there is no apparent reason. In affection of one ear only we may be able to produce the phenomenon of the transfert by magnetotherapy or metallotherapy. Functional tests may sometimes give results which are somewhat similar to those in a real organic lesion, sometimes they contradict our physical suppositions, thereby putting us on our guard. (We refer to page 243 as to the abnormal desire for operations of many hysterical patients.)

Traumatic neuroses are partially of a purely hysterical nature, and subject to peculiar changes in kind and intensity, just as are hysterical neuroses. In that case they cannot be differentiated from the clinical picture just described. The suspicion of a real lesion, or at least of a serious functional disturbance, can, however, not be discarded if functional tests in a case of deafness or hard hearing always give the same results in every new examination, even if the course of the examination is changed. An important question in making a diagnosis is whether the trauma really corresponds to the present symptoms, and whether the symptoms developed soon after the accident, or, on the other hand, whether the clinical picture of neurasthenia was not produced by permanent suggestion or auto suggestion, caused by constant fear of permanent injury, because this anxiety may be sustained by the real presence of some slight insignificant symptoms in the ear. The diagnosis in such cases is sometimes very difficult, and can be made only after long observation in connection with a competent neurologist, who sometimes is able to throw light on doubtful cases.

Injuries to the Inner Ear.

Direct injuries to the inner ear, except from shots, are very rare on account of the protected position of the labyrinth. Indirect injuries caused by concussion, or blows, or falling on the skull, are much more frequent. Injuries to the inner ear from sudden and great changes of air pressure in the external meatus, are also considered among the indirect injuries. The most frequent injury to the inner ear is that from excessive noise, the *acoustic* trauma. The deafness of people who work in places with high air pressure (caisson workers) occupies a peculiar position among indirect injuries.

1. Direct Mechanical Injuries.

We designate direct injuries those from stabbing, operations, cauteries and shots. The labyrinth can be injured by stabbing from the meatus only through the oval window. The facial nerve passes directly above the upper margin of the oval window, and has at this place a very thin covering of bone, which often shows dehiscencies. Paralysis of the facial nerve is therefore not rare in this form of traumatism. Knitting needles, tooth-picks, and other pointed objects which are used to scratch the external canal, may pierce the tympanic membrane and the oval window, if an unexpected shock against the elbow pushes the hand abruptly toward the head, during scratching. This form of injury is not very rare. Similar injuries may be produced by forcible stabbing with a knife. They are rarer, I saw only one of them. The injured person usually falls down unconscious after a trauma of this kind. Fluid escaping from the labyrinth is observed only in a fraction of these cases. Dizziness of the highest degree, vomiting, noise in the ears are always complained of. All these symptoms usually disappear again after a varying length of time, but the ear remains deaf, and the paralysis of the facial nerve is often permanent.

A prolonged suppuration of the middle ear is rarely observed in connection with such traumatisms. They are the rule after extensive *cauterisations of the external canal* which have been intentionally inflicted in order to produce unfitness for military service. These occurrences, together with their consequences, fatal hemorrhages, etc., were described in an earlier chapter (page 129).

Unintentional direct injuries of the labyrinth and of the facial nerve occur sometimes in radical operations, especially if the anatomical conditions are changed by preceding osteitic processes and former operations. These are the only two conditions under which such a serious mistake may be excused. The external semi-circular canal is often exposed to this same traumatism, especially at the spot where, in the aditus above the facial canal it is only very little below the surface. The consequence of opening of the endolymphatic space is probably complete deafness, frequently violent dizziness lasting for many weeks. The same result is usually produced by the unintentional removal of the stapes, which sometimes happens to otologists during the coarse procedure of the so-called evidement of the tympanic cavity, sometimes by unsuitable attempts at removal of foreign bodies from the meatus and tympanic cavity.

Gun shot injuries of the inner ear are usually compound fractures of the skull. Every bullet upon entering the labyrinth bursts the pyramid. The effect of modern fire arms consists in shattering the bone at least to the dura, and in shots fired at close range, fatal injury to the brain. Revolver shots fired with suicidal intent into the external meatus are usually directed more backwards, not against the labyrinth, so that the bullet may advance towards the posterior cranial fossa. It may be stopped on its course by the hard masses of bone of a sclerosed mastoid process. Fissures of the bone may reach the labyrinth, causing thereby an indirect injury. Rifle shots into the labyrinth were observed where the bullet entered from the region of the zygoma or mastoid process, or from the mouth or nose, and passing transversely through both mastoid processes, caused deafness in both ears. Partial and even complete deafness may be caused by ricochet bullets, or grazing shots, by the simple concussion, or by fractures in the bone. Injuries from bullets which reached the pyramid probably always cause complete deafness. They are often complicated by paralysis of the facial nerve, and shattering of the joint of the jaw.

The bullet must be extracted or chiseled out, if it is evident that it remained in the mastoid process, either from the nature of the injury or from x-ray examinations. Conservative treatment is out of place here. The numerous spaces in the temporal bone containing air, explain the fact that a bullet never becomes enclosed as in other parts of the body, but always causes a suppuration which lasts as long as the foreign body remains in the depth, and may lead to a fatal meningitis, or through sinus phlebitis, to pyemia, even after many weeks and months, as experience has shown.

Instillations of fluid and syringing of the ear have to be avoided in gun shot wounds as in all injuries.

2. Indirect Mechanical Injuries.

There is usually a fracture of the temporal bone or of the bony labyrinth, where deafness resulted from the impact of a dull force, as a fall, blow, or stroke on the head. There are post mortem results which show that sometimes a simple fall, striking the head on flat ground, may prove sufficient to cause a fracture through both labyrinths, and total deafness. Large statistical investigations (in the clinic in Zurich) show that the labyrinth participates in one-fourth of all fractures of the base of the skull. It is rare that a fracture is exclusively confined to the pyramid. Both labyrinths are concerned in one-seventh of the cases which survive. The fissures in longitudinal fractures, and in transverse fractures of the base of the skull, usually run in the direction of the impact of the force (fractures from bursting). Fractures due to flexion are observed less frequently. The fissures run in a perpendicular direction to that of the impact. We sometimes find a simple fissure, sometimes several fissures in different directions; in other cases a complete destruction, corresponding to the intensity of the force. The original direction of the fissure in children deviates, if the fissure crosses a bone suture. The fissures follow the suture after the crossing. That is one reason why fractures of the labyrinth are rare in children. The thinner and softer parts of the temporal bone in adults are more frequently fractured than the labyrinth itself. Longitudinal fractures *avoiding* the pyramid, are often observed. They start in the middle cranial fossa, pass over the roof of the tube or the tympanic cavity, and continue in the rear cranial fossa, following along the sulcus of the sigmoid sinus. Perforated parts of the pyramid, which are in its median part the spongy apex, and in its lateral parts the pneumatic spaces, constitute the favorite places for transverse fractures. Fractures passing through the labyrinth are compartively frequent. They follow the cavities of the labyrinth and the porus acusticus internus.

A subdural hemorrhage ocurring in another place may produce the symptoms of a laceration of vessels in the labyrinth, even though there is no fracture of the pyramid, the blood running along the perineural lymph spaces and through the aquaeductus cochleae into the labyrinth. Paralysis of the facial nerve shows in half the cases, and discharge of cerebro-spinal fluid in about one-fifth. Lesions of other nerves besides the facial are observed less frequently, and concern the abducens, oculomotor, trochlear, glosso-pharyngeal and the vagus nerves. Hemorrhage from the carotid artery or sinus are mentioned but rarely in connection with fractures; likewise emphysema of the same side of the neck.

The complication of an indirect injury to the labyrinth, with suppuration of the middle ear, is not very often observed. The cause is usually the entrance of fluid during an injury to the tympanic membrane or the wall of the external meatus.

The most important symptoms of an injury to the labyrinth are deafness, subjective noises and dizziness. The diagnosis is sometimes supported by profuse hemorrhages from the meatus lasting for a long time, while the anterior wall of the meatus is intact; furthermore by a discharge of cerebro-spinal fluid which can easily be distinguished from fresh secretion of the middle ear owing to the large amount of salt and small amount of albumin which it contains. Sometimes masses of brain appear in the external ear, in other cases we see extensive bloody sugillations of the parietal and mastoid region of the eyelids and the conjunctivae, more rarely of the occiput.

About one-half of the patients injured in this manner die during the first 48 hours from destruction of parts of the brain, hemorrhage into the ventricles of the brain, oedema of the brain and complications in the lungs. The greatest danger during the next few days or weeks is meningitis starting from suppuration of the labyrinth.

The consolidation of the fracture takes place very slowly and without formation of a callus. The fragments are sometimes united by connective tissue only. The membranous labyrinth succumbs in the region of the fracture, granulation tissue develops in its place, which leads in the further course to complete and permanent filling up of the cavities of the labyrinth by bone and connective tissue. The final result is the same as we have seen in labyrinthitis after infectious diseases.

According to this the *prognosis* is bad as to recovery of the power of hearing after a fracture of the labyrinth. Subjective noises usually remain, while dizziness as a rule is annoying in the beginning only. It disappears completely later on, or is noticeable only occasionally, for example in stooping or in looking in different directions.

Hearing may be seriously interfered with. Subjective noises and dizziness may occur as the result of some outside force affecting the skull which did not cause a fracture of the pyramid or of the skull. These symptoms are due to shaking of the labyrinth and brain and are called commotion of the labyrinth or brain. Of course we can only surmise as to how far this clinical picture is due to multiple hemorrhages in the auditory nerve and labyrinth, which were repeatedly observed in such cases. They may also be due to a tearing of some of the nervous elements which are fixed in so many different manners.

The *prognosis* is unfavorable if the disturbances do not disappear within the first few days. In some cases these symptoms disappeared after some time. They were of a hysterical nature, caused by shock and excitement.

3. Acoustic Traumatism.

We must differentiate acoustic traumatism into:

1. A form of injury to the labyrinth caused by one short sound like a detonation, explosion, whistle of a locomotive.

2. A form caused by frequently repeated loud noises.

The most frequent of the first kind of injuries are those from shots, which are most injurious to the ear, when it is close to the barrel of the rifle, or when the detonation takes place in a closed room. Even small rifles when used in a room are not at all harmless.

The consequences of the second kind of acoustic traumatism are called "professional hard hearing." Blacksmiths, boiler-makers, coopers, tinsmiths, locksmiths, cabinet-makers, people who work in noisy factories, locomotive engineers, firemen, lose a part of their power of hearing in the course of years.

Hearing tests in both forms of hard hearing show the loss of hearing of a variably large part at the upper end of Galton's whistle. Sharp shooters always suffer from this defect. The lower limit is intact, they hear as low as 16 v. d. and lower, provided that the conditions are otherwise normal.

Subjective noises are hardly ever absent in *injuries* to the sound perceiving apparatus, while in the majority of cases of professional hard hearing they are absent. They are always present in people who became hard of hearing from detonation or shrill sounds, etc., and have usually a high pitch like singing, ringing, whistling. A continuation of the sound of the same pitch as that which caused the trouble is frequently complained of together with a hyperaesthesia for the same sound. Noises which occur as the effect of one strong sound usually disappear again later on, while those after mechanical injuries to the labyrinth remain the same.

Dizziness and *interference with equilibrium* which are a regular symptom in injuries to the labyrinth may occur sometimes as the effect of detonations, but are usually absent in people who are hard of hearing from their occupation.

There is so far one *microscopic finding* known of professional hard hearing. It concerns a boiler-maker and corresponds to the anatomical picture of what was described as presbyacusis: atrophy of Corti's organ and the corresponding branches of the auditory nerve.

The prognosis of professional hard hearing is bad as to improvement, and a progress of the process can be stopped only by giving up the noisy occupation. The prognosis of hard hearing after detonations depends upon the intensity of the acoustic traumatism. The feeling of deafness and the ringing may disappear after hours or days, they have even disappeared after months and years, but they may also remain permanent. An otherwise diseased inner ear is specially sensitive to an acoustic traumatism.

4. Electric Traumatism. Caisson Deafness.

Electric traumatisms to the acoustic nerve without any noticeable injury occur sometimes from strokes of lightning, or through the telephone during a thunder storm.

A peculiar and serious injury to the labyrinth was repeatedly observed in men working in caissons, when they changed too fast from high to low air pressure. The blood absorbs a much larger volume of air through the lungs while the person is under high air pressure in the caisson, than under the general outside pressure of *one* atmosphere. The additional volume of air and gases is set free inside the blood vessels and forms bubbles when the air pressure is lowered too rapidly in leaving the caisson. The bubbles do not only form in the blood vessels but also in the large lymph spaces of the central organs, where they may cause serious mechanical lesions and extensive disturbances of nutrition. Lesions of the organ of hearing were observed from many minutes to several hours after an imprudent exit from the caisson. The lesions consisted of a sudden attack of dizziness, ringing, deafness, vomiting and a feeling of extreme weakness. These symptoms may occur in one or both ears, and sometimes disappear after a few days. Deafness however usually remains permanent. The pathologic anatomical changes that were observed on animals, who were of course exclusively used for such experiments, consisted of perivascular extravasations in the scales of the cochlea and in the semi-circular canals. In the cases of deafness that became known there were probably extensive embolisms of gas in the blood vessels of the labyrinth and in the lymph spaces.

The best therapeutic procedure in such a case is probably the quick return to the high pressure chamber.

LECTURE XXXII.

Deaf-Mutism. Education of Deaf-Mutes.

Gentlemen:—The defects in the organ of hearing which develop either during the embryonal period or during infancy, leading to relative or complete deafness, prevent the patients from learning to talk. Some of these defects are due to anomalies of development during the embryonal period, others to partial or total destruction of the organ of hearing in the course of a number of general diseases, or purely local diseases of the ear during the first few years of life.

Deaf and dumb children are usually brought to institutions for their education between their seventh and eighth years. The general disease, as well as the local process in the ear, is healed in the large majority of children with acquired deaf-mutism. All hopes formerly cherished of curing or improving deaf-mutes by electricity, etc., have long ago been recognized as illusory.

Otologists therefore limited their endeavors to the *statistics* of deaf-mutes in and out of institutions. A close connection between otologists and deaf-mute institutions developed only within the last decade.

As soon as otologists began to study deaf-mutes we learned that a considerable number of them have remnants of hearing which enable them to hear vowels and even words.

Careful investigations of these remnants by means of accurate instruments, and their connection with understanding of speech, showed that *about one-third of all deaf-mutes in institutions have sufficient hearing upon which to base a method of education which allows them to use their ears,* together with their eyes, which were long used for lip reading. The method of education of each newly entering pupil is varied according to the degree of hearing that he possesses. It became the task of the otologist to carefully test the hearing of each pupil, and to decide to what extent he could make use of his ears for education. You will see later on of what importance these examinations are for the future of the pupils.

First allow me to give you *a summary of the statistical results of* *the investigation of deaf-mutes.* A large number of otologists took an important part in their compilation.

The acquisition of these statistics involved many difficulties, such as will always be encountered in the collection of similar material. The line between hard hearing and deaf-mutism is determined by the impossibility in the latter class, of learning how to speak either at home or in the public schools. The children are gathered in the deaf and dumb institutions and there we find a large number of more or less hard-hearing children, besides those who were deaf since their birth, or since their first years of life.

A number of other points are important for the development of speech and the retention of what these children have learned. They are the degree of the defect of hearing, the time when it developed, the intellectual condition of the child and how much time was given to him at home and in school. It happens that children who became deaf in their twelfth year and later lose entirely their power of speech, while others who became absolutely deaf at eight and earlier retain their power of speech owing to incessant endeavors on the part of their relatives and teachers. The relatives during the first five years usually do not know whether the child suffers from deaf-mutism or from slow development of mental capacity and speech. The census, for this reason, shows such a small number of deaf-mutes for the first five years of life that it can impossibly be correct, especially if we take into consideration that in this period of life the largest number of cases of acquired deafness develop, not to speak of the congenitally deaf. Besides these, a considerable number of older, nearly deaf children are dragged along in public schools where they acquire only small fragments of speech. We find such children in every institution for the deaf and dumb; they arrived at the place where they really belong, only after several years spent in vain efforts in public schools. Such older children also will not be counted as deaf and dumb in the census as long as they visit the public schools. There is therefore no doubt but that the figures of the census concerning the frequency of deaf-mutism are far below the real condition, especially concerning the first few years. The last census of Germany taken in 1900 shows among 56,367,178 inhabitants, 48,750 deaf-mutes (10,000:8.6). Only 1,093 are children up to the fifth year, from five to ten 4,244. The figures for every period of five years up to the 40th year of life are larger. There are for example 10,500 deaf between 30 and 40 which abnormally large figure finds its explanation in the epidemic of cerebro-spinal meningitis of 1865. These figures prove without further comment that the greater number of deaf children between 1 and 5 and a very large number between 5 and 10 were not included in the census.

Mygind[1] compiled the statistics of 23 European countries and

[1]) Taubstummheit, Berlin & Leipzig, published by Coblentz, 1894, page 17.

found an average proportion of 10.000:7.9. The number of deaf-mutes in mountainous countries is much larger, in Switzerland for example, the proportion is 10.000.24.5. *Bircher*[1] studied very carefully those mostly congenital and endemic forms which are combined with goiter and cretinism.

Different censuses give extremely varying results as to the number of *congenital* and *acquired* deaf-mutes in different countries. The figures probably do not give a correct idea of the actual condition as they vary between 33, and 174 acquired deaf, to every 100 congenitally deaf.[2] The institutions for deaf-mutes and the statistics compiled by otologists gave less varying and more reliable figures. Deaf-mutism seems to be acquired in little more than half the cases according to those statistics.

As to the age when hearing is most frequently lost from disease, we know that the first and especially the second year of life show the highest figures according to *Hartmann, Mygind, Uchermann* and myself.[3]

Deaf-mutism concerns the male more frequently than the female sex. *Mygind* combined the statistics of Europe with those of North America and found the proportion of male to female deaf-mutes 100:83. This proportion is however not the same for congenital and acquired forms. We owe the most reliable statistics on deaf-mutes to *Lemcke.*[4] He examined personally all deaf-mutes of the state of Mecklenburg and finds a larger number of women among the congenitally deaf, 105:100. A preponderance of the female sex among the congenitally deaf was also found by *Uchermann* in Norway and by myself in Bavaria. The larger number of males among the acquired deaf-mutes finds a simple explanation in the fact that boys suffer more frequently than girls from children's diseases which are liable to destroy the ear. The preponderance of the female sex among the congenitally deaf may have some connection with the other absolutely inexplicable law that more boys are born than girls. We might explain it in this way, that the female embryo is less resistant in the uterus against harmful influences than the male.

There are peculiar conditions as to the *heredity* of deaf-mutism. A direct heredity from the parents and from the grand-parents is very rare. *Hartman* for example found it in less than 1:1000. Even where both parents are deaf, children are deaf only exceptionally. It is however a peculiarly frequent occurrence that two or more children in the same family are congenitally deaf. *Hammerschlag* a short while ago showed statistically that the frequent occurrence of deaf-mutism among sisters and brothers has beyond a doubt some connection with *consanguineal marriages.*

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1 Der endemische Kropf und seine Beziehungen zur Taubstummheit und zum Kretinismus. Basel, 1893.

2 Mygind, Taubstummheit, Table I, page 13.

3 Bezold, Taubstummheit, page 26, etc.

4 Die Taubstummheit im Grossherzogtum Meklenburg-Schwerin. Leipzig, Langhammer, 1892.

Hartmann reports a case of five deaf-mute sisters and brothers whose parents, grandparents, and great grandparents were first cousins.

A short while ago I examined one of two congenitally deaf-mute children whose parents were congenitally deaf-mute and had the same great grandfather.

In my work on "deaf-mutism" I reported another case of two deaf-mute children descending from a marriage of first cousins. I found a third child in that same family who was deaf in *one* ear only. The mother was deaf in *one* ear probably congenitally. The three children and the mother showed at the same time the extraordinary malformation of the eyelids, known as epicanthus, which according to several authors is of hereditary origin. The children were brunettes like the mother, while the other hearing sisters and brothers were blond.

You know furthermore of the multiple occurrence of *retinitis pigmentosa,* often combined with deaf-mutism, which frequently appears in several sisters and brothers descending from consanguineal marriages. Marriage of deaf-mutes may therefore be permitted, *but inter-marriage of relatives in whose families deaf-mutism or congenital deafness of one ear only has occurred must be absolutely cautioned against.*

My considerations about the different *etiology of acquired deaf-mutism* are based upon a study of 233 cases [1] which I examined myself in the course of years. I found like all other authors that *cerebro-spinal meningitis* was the general disease that caused deaf-mutism most frequently. In 74 cases of my statistics, that is in 31.8 per cent, this disease was recognized to be the cause, either by the physician or from unmistakable symptoms, especially rigidity of the neck. Characteristical disturbances of the equilibrium were present in the majority of cases when I saw them, or they had existed for a long time. The frequent occurrence of this symptom was established by *Moos* [2] in his statistics extending over 64 cases. In 47 more cases of my statistics the diagnosis was most probably an inflammatory disease of the brain or of its membranes, as we hear comparatively frequently the diagnosis "typhoid fever" or "typhoid of the brain" and similar expressions.

Cerebral processes as a whole are represented by 51.9 per cent in my statistics, including 74 cases. *The number of deaf-mutes originating from cerebro-spinal meningitis varies at different times,* probably on account of the change of frequency in the occurrence of the disease. *Von Ziemssen* for example for three successive years found exclusively victims of meningitis in the deaf and dumb institutions of Bamberg after the epidemic of 1865.

Scarlet fever is next in frequency among the causes of acquired deaf-mutism. My statistics show 42 or 18 per cent of deaf-mutes due

[1] Taubstummheit. Wiesbaden, 1902.
[2] Ueber Meningitis cerebrospinalis. Heidelberg, C. Winter, 1881.

to scarlet fever. The tympanic membrane in people who became deaf from meningitis is almost always intact. In those deaf from scarlet fever extensive destructions of the membrane and often also of the ossicles were found in 35, or five-sixths of them. The influence of large epidemics in different years is not as prominent in scarlet fever as in meningitis.

All other infectious children's diseases put together do not cause deafness in both ears and therefore deaf-mutism, as frequently as the two just named. The above mentioned statistics show *measles* as the cause of deaf-mutism in 2.1 per cent, *diphtheria* in 1.7 per cent, *typhoid,* 1.3 per cent, *pneumonia* in 0.9 per cent, *whooping cough* and *osteomyelitis* in 0.4 per cent. These figures are so much more startling compared to those of deafness from meningitis and scarlet fever, since about twice as many children acquire measles as scarlet fever, and meningitis is a comparatively rare disease.

Parotitis and hereditary lues were not sufficiently considered as causes of deaf-mutism in the statistics published up to the present day.

There were four of my 233 cases of acquired deaf-mutism, or 1.7 per cent, due to *mumps.* Of all statistics only *Schmaltz's* of Saxony has 0.3 per cent and one of America shows 0.5 per cent (according to *Mygind* page 125) of deaf-mutes due to parotitis.

Hereditary syphilis is mentioned only by *Hedinger* in one, and by *Lemcke* in two cases as the cause of deaf-mutism, among all accessible statistics. In my statistics there were 13 cases or 5.6 per cent of acquired deaf-mutes who showed one or several objective symptoms of hereditary lues. I found for example *Hutchinson's* teeth, destructions of the bony parts of the nose and palate, multiple exostoses on the skull, indolent glands, etc., and at the time that deaf-mutism began there was a still existing or preceding corneitis diffusa in the majority of cases.

The reasons for the fact that the cause of deaf-mutism in hereditary lues remains frequently unknown are these: deafness in hereditary luetic children occurs usually at an age when they have learned how to speak (most frequently about the eighth year). During the time the child gradually loses his power of speech the symptoms of hereditary lues, especially the most characteristical one, the corneitis diffusa, have long disappeared.

I found in my statistics other purely local causes for acquired deaf-mutism in 6.4 per cent which were due to *suppurations of the middle ear,* depending upon no general disease, and in 3 per cent *traumatism* (falling on the head). My statistics are comparatively small but they coincide with other larger statistics and add some important details.

One word about the *comparison of sexes.* Acquired deaf-mutism is found much more frequently in the male than in the female, which is the contrary to congenital deafness. I found the proportion 100:66.

The pathologic anatomical changes leading to loss of hearing are mainly confined to the labyrinth (compare page 266).

Habermann found that the occlusion of *both* windows causes deaf-mutism. The cochlea however usually takes some part in the occlusion of the round window at least. There is no case known up to date where cerebral processes alone caused deaf-mutism. Congenital deaf-mutism is comparatively rarely due to anomalies of formation consisting in a complete absence of the bony labyrinth. The membranous labyrinth which was investigated during the last few years by *Scheibe, Siebenmann, Alexander* and others, shows a number of peculiar anomalies which completely explain deafness.

One case of *Siebenmann* is of special interest for the physiology of the labyrinth. The changes were confined exclusively to the cochlea, while disturbances of the organ of equilibrium, which is situated in the vestibulum and in the semi-circular canals, were absent. In the majority of deaf-mutes these disturbances are manifested by the absence of dizziness and nystagmus during rotation.

The frequency of *remnants of hearing* and their *quality* and *quantity* could only be investigated by means of the continuous tone-series which produces all audible sounds sufficiently strong and pure, in other words free from accidental noises and overtones.

Urbantschitsch tested the deaf-mutes of Vienna by means of a harmonica extending over six octaves.[1] The tones of this instrument have many overtones rendering a test for the perception of each tone impossible. Its tones may even be felt through the floor (*Schwendt*). This explains why *Urbantschitsch* found that almost no person was totally deaf.

My tone series allows to completely analyze the function of the organ of hearing (compare page 53) by testing each tone. I examined the pupils of the institution for deaf-mutes in Munich since 1892. These examinations by means of the continuous tone series have since been repeated by a number of otologists in other institutions in Germany, and elsewhere with results similar to mine.[2]

Originally I only tried to find in the deaf and dumb institutions new proofs for *v. Helmholtz's* theory, that the cochlea alone is able to analyze noises into their constituent parts, by investigating the kind and the distribution of remnants of hearing over the sound scale. I found what I wanted and more. A careful hearing test of the ears of deaf-mutes besides being of great theoretical interest, has an unexpected practical value by giving indications for teaching them to speak and for educating them.

Up to 1898 I tested 276 organs of hearing of deaf-mutes. Of these 79 were totally deaf. The others had remnants of hearing of various extent.

Both ears were totally deaf in only 27 pupils or 19.7 per cent of

1 Ueber Hörübungen bei Taubstummheit. Wien, Urban & Schwarzenberg, 1895.

2 Das Hörvermögen der Taubstummen. Wiesbaden, Bergmann, 1896; 3 additions till 1901.

those 138 pupils. Small remnants were found in 58 pupils. The other 53 or 38.4 per cent showed such extensive remnants of hearing distributed over a large part of the sound scale that they were not different from a large number of adult hard hearing people with whom everybody can converse very easily.

Their speech, which they learned in the institution, did not differ materially from that of the totally deaf with whom they studied articulation, by following the motions of the mouth of their teacher. It was nearly as harsh, monotonous, and slow. Each sound was produced with similar efforts of the muscles as in the totally deaf. Their intellectual capacity was not above that of the others and was mainly confined to concrete objects.

After ascertaining the hearing for the tone series, I began to test by means of speech by talking moderately loud directly into their ears. The pupils who heard best repeated all vowels very easily and even the majority of consonants. After a few attempts they were able to repeat whole words, most of them without the former harshness and with the rhythm and accent in which they were spoken into the ear. They now had two kinds of speech, the articulation speech which they learned artificially, and the natural speech taught by means of the ear.

Some distinct unalterable relationship was found between the hearing of some sounds of speech and hearing of certain parts of the tone series. The sibilants were heard only by those pupils who heard the upper part of the tone series, the consonants R, M, N, L, only by those who heard tones of low pitch comparatively well.

It became evident that by far the most important part of the tone series for the understanding of speech is the part from b′ to g″. Every pupil who did not hear this small part of the whole series of tones, or heard the tuning forks producing those tones for a short time only (up to 10 per cent of their normal duration of hearing) was either totally unable to hear speech or understood it only very insufficiently.

The relation between the hearing of tones and the hearing of speech is explained by the fact that each letter has a distinct pitch and that the pitch of most of the vowels and consonants is within the above-named limit of b′-g″. Many years of experience have shown that all pupils who have sufficient hearing for that part of the scale, may learn to speak at least partially by means of the ear. This holds good *even in those pupils who are not able to repeat a single letter at the time of first examination.* Inability in the beginning to repeat anything they hear is especially found in children suffering from *congenital* deafness.

Hartmann found long ago that *remnants of hearing were more frequent in the congenitally deaf* than in the acquired deaf. It is nevertheless a fact that congenitally deaf children meet with much more difficulty in learning how to speak than children who became deaf at an age when they had previously learned some speaking. They are easily able to keep step as to education of speech with the others who have similar remnants of hearing as soon as understanding of a small number of words is taught them through the ear.

It is evident that these numerous and extensive remnants of hearing which are found in more than one-third of all deaf-mutes ought to be made use of for the purpose of education. The experience in all deaf-mute institutions showed that this is impossible in class instruction where the teacher is several yards away from each pupil. Each new word must be pronounced directly into the ear before it is absorbed and learned. To the majority even then a number of letters are lost which they must acquire by studying the mouth. For this purpose each

Fig. 75.

Class of partially hearing children in the Central Institution for deaf-mutes in Munich.

pupil is provided with a *mirror* which allows him to indirectly see the motions of the mouth of the teacher who speaks directly into his ears.

Fig. 75 shows you how these mirrors are used during instruction of a class of partially hearing deaf-mutes in the R. Central Institution for deaf-mutes in Munich.

The teacher of deaf-mutes Kroiss[1] in a psycho physical study of this question showed how completely the methods of teaching by ear and by mouth supplement each other. The children during general instruction are able to recognize at a distance any word which they have learned with the eye and ear and whose meaning they have ab-

[1] Zur Methodik des Hörunterrichts. Wiesbaden, Bergmann 1903.

sorbed. The instruction of each pupil separately requires therefore only a relatively short time.

Director *Koller* of the deaf and dumb institution in Munich recognized from the beginning the pedagogic importance of the results of the hearing tests. Owing to his unprejudiced and unselfish judgment he recognized the short-comings of the method of general instruction then prevalent and admitted them unreservedly in spite of the almost unanimous opposition of all teachers of deaf-mutes.

The short-comings consisted in totally excluding from instruction the natural organ of perception of speech. Great harm was done to partially hearing children by forcing them, like the totally deaf, to go through the laborious method of learning single sounds and then combining them into words and sentences, while they would have been able to absorb easily most of the sounds and even some words through the ear and to pronounce them with their true accent.

A worse consequence of the common instruction of the partially deaf together with the totally deaf than even the great loss of time and the dissatisfaction of the children with a method that did not correspond to their faculties was the direct *malformation of their speech.* The same short-comings peculiar to the speech of deaf-mutes were forced upon the partially hearing and their speech resembled more and more the speech of the totally deaf on account of daily imitation.

Systematical "hearing exercises" were introduced by *Urbantschitsch* together with the teachers of deaf-mutes in Vienna several years before the remnants of hearing were used at the institution in Munich, and remarkable results were obtained in improving the sound of their speech. There was however a strong opposition by teachers of deaf-mutes because he did not select his pupils and even wanted to include the totally deaf in his exercises. He also made promises of "awakening the auditory nerve" and of real improvement of hearing which were never realized and never could be realized on account of the partial *destruction* of the cochlea in the ears of deaf-mutes. The frequent and futile attempts at hearing exercises made by means of the harmonica brought into unmerited disrepute the real success of the speaking exercises.

Credit is due to *Urbantschitsch* for first introducing a systematical education by means of the ear, although under premises which could not be realized. The first separate class-room for pupils who heard best according to my selection was opened in Munich in 1898. The following year a second class room had to be opened and now there are three special classes for partially hearing among 90 pupils. The instruction in these three grades is given simultaneously by hearing and articulation. The instruction by hearing is based exclusively on the remnants of hearing which are present. These remnants can not be increased, but according to our experience, they are sufficient in themselves to build upon them a natural speech transmitted by means of the ear. Of course the eye cannot be dispensed with nor can the instruction in articulation. The director of the institution sums up his experiences since 1898 with the separate classes for hearing in his yearly report of 1901 to '02 in these words: These children command a vocabulary that the totally deaf can never obtain. Their manner of expressing their thoughts is equal to that of hearing people. Their readiness to speak is surprising. Similar results can never be obtained in totally deaf children. They are unattainable to partially hearing children who are constantly instructed *together* with their totally deaf comrades. *Separation of the partially hearing pupils from the totally deaf ones and instruction in separate rooms or if possible in separate institutions* must be our aim.

At a meeting of the directors of Bavarian deaf-mute institutions in March 1904 the unanimous vote was in favor of separate instruction. Since 1900 the board of health of the German empire requires a complete qualitative and quantitative hearing test by means of the continuous tone series for all deaf-mute children, of school age.

This involves the duty upon otologists of carefully testing the hearing of each deaf-mute pupil and of deciding which plan of instruction he has to follow. This duty is added to that of treating all destructive processes in the ear which may not have subsided when the pupil enters the deaf-mute institutions.

Hard Hearing and Diseases of the Ears in Schools.

Gentlemen:—The organ of hearing represents the main port of entrance for education and mental development. Still a number of other influences may help to compensate and even more than compensate a moderate defect of hearing. A talented child will, in spite of a considerably diminished power of hearing, correctly learn to speak at the proper age if the parents and older children continually occupy it mentally. On the other hand experience has shown that a normally hearing child may remain mute if both parents are deaf-mutes and not sufficient communication is kept up with other people.

Nevertheless it must be born in mind that a survey of large masses of school children shows that even slight degrees of hard-hearing interfere with the normal advancement. I found for example in my examination of school children [1] that, placing all children on a basis of 100, the average rank of the ordinary child is 50th, that of children who hear whisper with one or both ears at a distance of 8 meters or less is 54th, children who hear whisper with both ears at 4 meters or less rank 64th, and those who hear with both ears at 2 meters or less rank 68th.

The teacher is not able to recognize pupils with deficient hearing

[1] Schuluntersuchungen uber d. kindl. Gehörorgan, Wiesbaden, Bergmann, 1885.

without a systematical hearing test for whisper, especially since the majority of cases have remitting and intermitting diseases of the ears, occlusion of the tubes, acute recurrences of otitis media, temporary occlusion of the external meatus with ear wax, purulent secretion, etc. These children, on account of the frequent change from good to bad hearing, are often misjudged by their teacher and by their relatives. They are not considered hard of hearing but inattentive, dull, and indifferent.

We even find in the public schools children who are so hard of hearing that they learned to speak only very incompletely or not at all. Their lot among the good hearing is very dreary. They succumb to the scorn of their school fellows and of their teachers who try to shake them out of their apparent indifference. Some of them, after uselessly remaining in public schools for several years, finally land in deaf-mute institutions where they belonged from the beginning. There such children show at first an intimidated expression, their tears appear at every occasion. They wake up, gain confidence and become cheerful as soon as they enjoy adequate instruction in a class of partially hearing deaf-mutes. They are sufficiently intelligent to keep step with the others.

The examination by means of the tone series revealed an extraordinarily large number of such hard-hearing children in the class rooms for backward children which were found in the public schools of Berlin, Munich and other cities. To have systematical hearing tests of the school-children made ought to be counted among the urgent duties of the school boards. The hard hearing children ought to be carefully examined by an otologist who is able to decide whether they are fit for taking their instruction in the public schools by sitting close to the teacher, or whether they ought to be sent to separate class-rooms for hard hearing children or into the hearing class of a deaf-mute institution or in the rooms for backward children or finally into an asylum for idiots.

Special credit is due to *A. Hartmann* in Berlin for the foundation of separate schools for hard hearing children. No such separate schools can be established in small towns, as each class can only take about 10 pupils. Nothing is left under such circumstances but to give each pupil separate instruction.

There are other besides merely pedagogic reasons for instituting a careful control of all ears which are only slightly hard of hearing.

We saw in our statistical explanations about the mortality from diseases of the ears that nearly 5 per cent of all deaths occurring between 10 and 30 years are due to suppurations of the middle ear. These diseases can be traced back to childhood in the majority of cases. They begin as simple acute inflammatory diseases and even as simple processes in the tubes which are easily amenable to treatment. These diseases are usually not noticed and not treated among the poorer part of the population. Few of these children would then be thus far neglected if these diseases were revealed by expert examinations in the schools and if adequate instructions were given the parents about the dangers of the diseases and the abundant opportunity for treatment in free clinics. There is no doubt that the majority of fatal complications of diseases of the ears could in future be avoided.

The other pupils are constantly exposed to the danger involved in the dissemination of pyogenous germs emanating from the otorrhoea. In my examination of school children I found about one per cent of such children. I suggested that they ought to be excluded from school at least till the pus does not appear outside of the ear. This request was pronounced 20 years ago and has gradually been complied with by all intelligent people.

Children with perforations of the tympanic membrane ought not indulge in shower-baths.

You see, gentlemen, that in future a large field for beneficial occupation is awaiting the otologist in deaf-mute institutions. Greater numbers of children may be benefited in public schools when the public and especially the school-boards are informed what well-trained eye and ear surgeons might accomplish. An adequate number of the latter ought to be provided besides the regular school-physicians.

INDEX.

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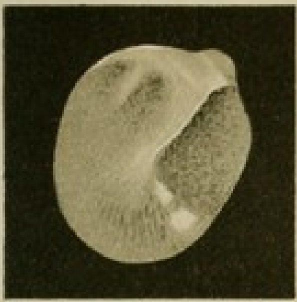
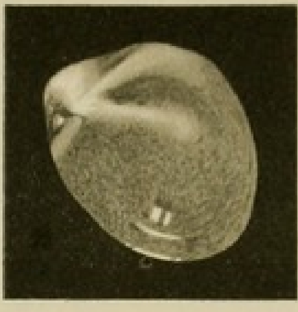
Fig. 1.



Normal tympanic membrane.

Fig. 2.



Retracted membrane; occlusion of the tube.

Fig. 3.

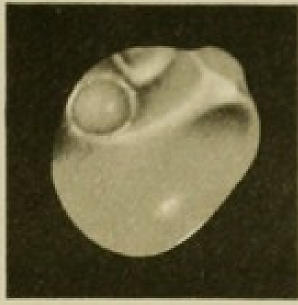
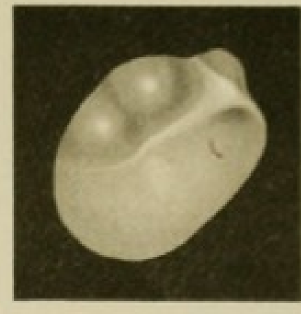
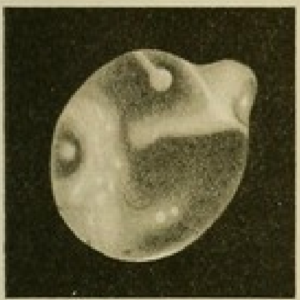


Fig. 4.



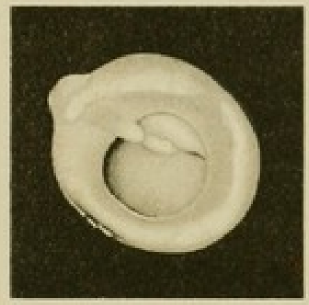
Collapse of the post. part of the membrane. Fig. 3 before, Fig. 4 after inflation.

Fig. 5.



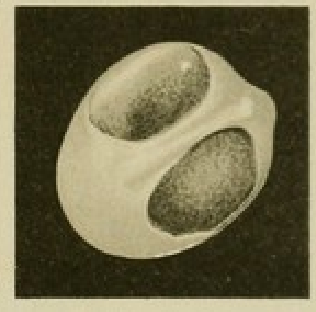
Collapse of the membrane; luxation of the long process of incus.

Fig. 6.



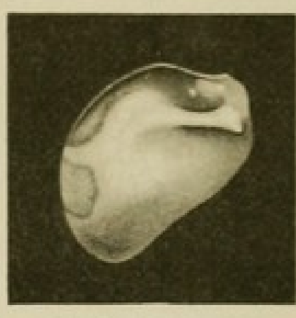
Central perforation; chalk deposits.

Fig. 7.



Double perforation.

Fig. 8.



Total defect; the hammer adherent to the promontory.

Fig. 9.

Perforation in Shrapnell's membrane.

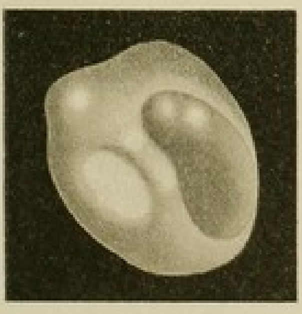
Fig. 10.

As Fig. 9, extending into the meatus. Mallet and incus are lost.

Fig. 11.

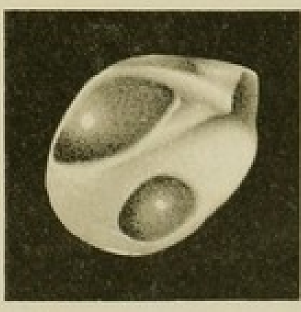
Multiple perforation otitis media purulenta phthisica.

Fig. 12.



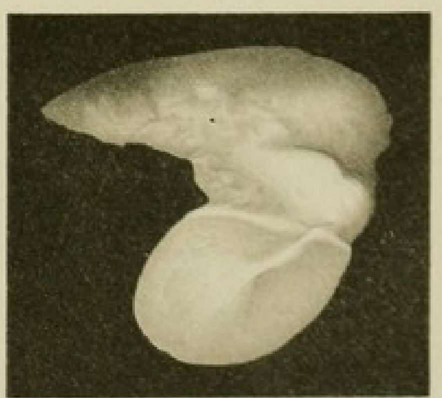
Scar of the membrane; chalk deposits.

Fig. 13.



Double scar; chalk deposits.

Fig. 14.



Radical operation showing antrum and aditus. Ossicles in situ.

Jue