

The surgery of the heart and lungs : a history and résumé of surgical conditions found therein, and experimental and clinical research in man and lower animals, with reference to pneumonotomy, pneumonectomy and bronchotomy, cardiotomy and cardiorrhaphy.

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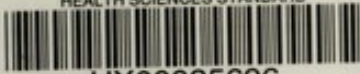
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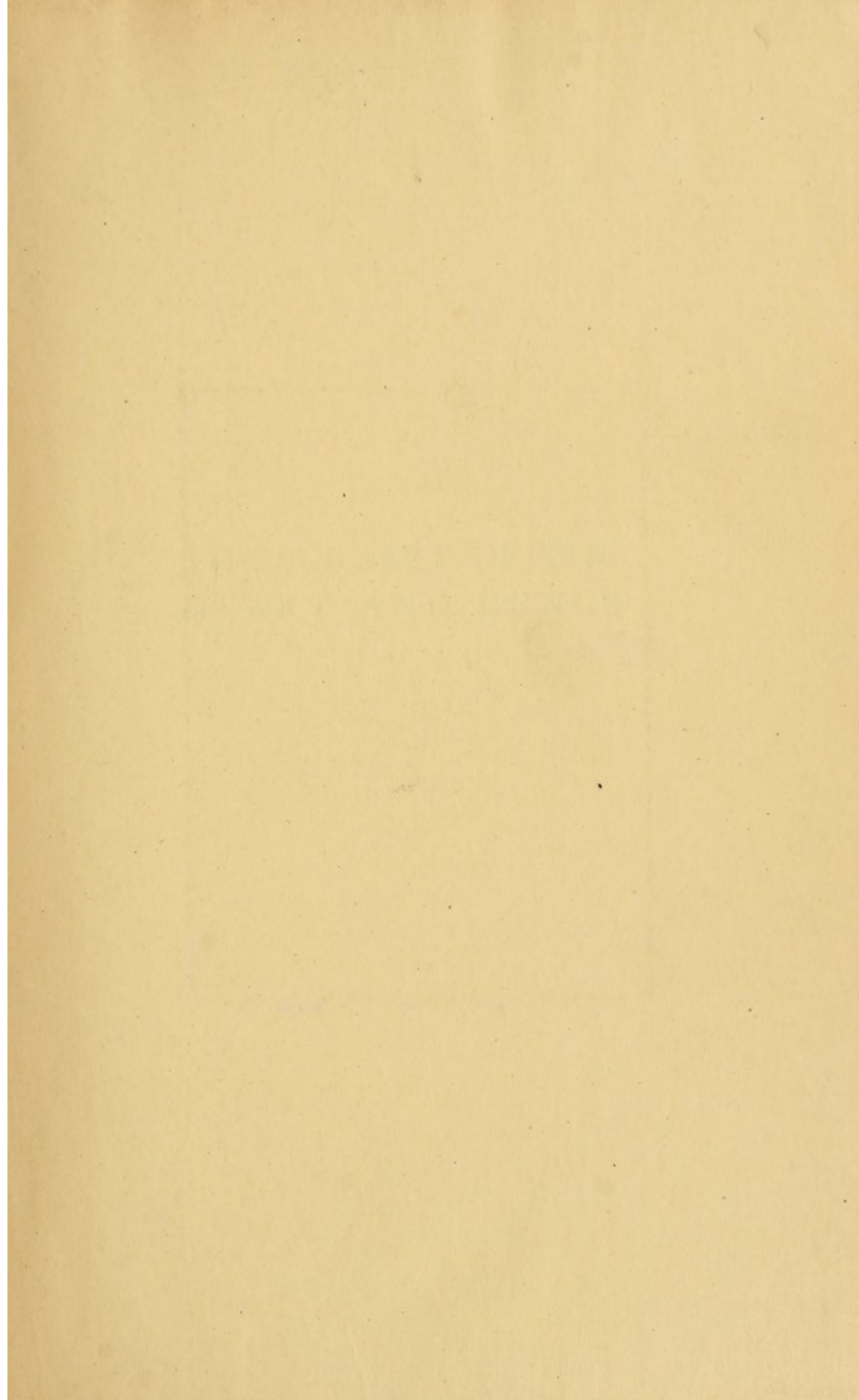
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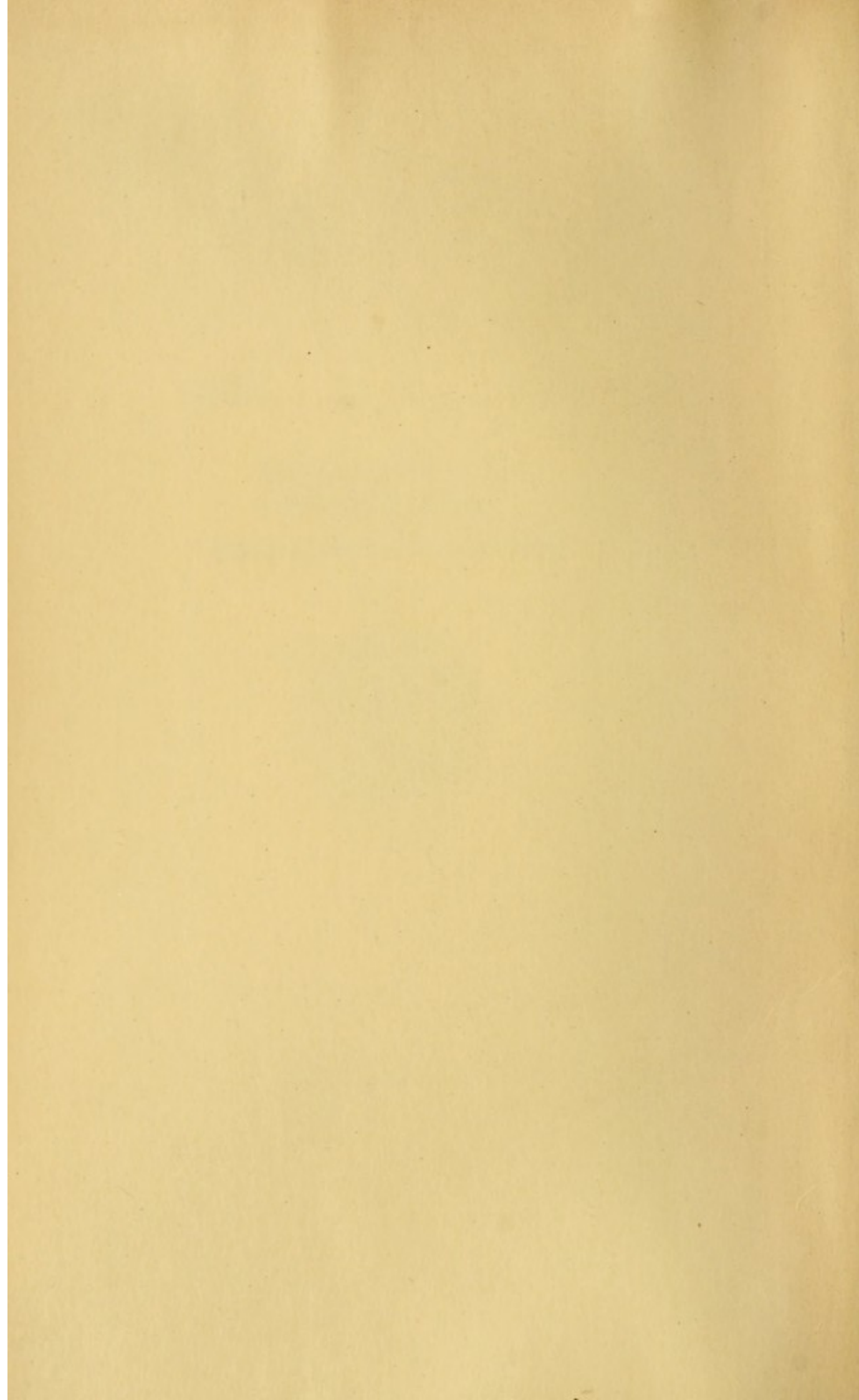
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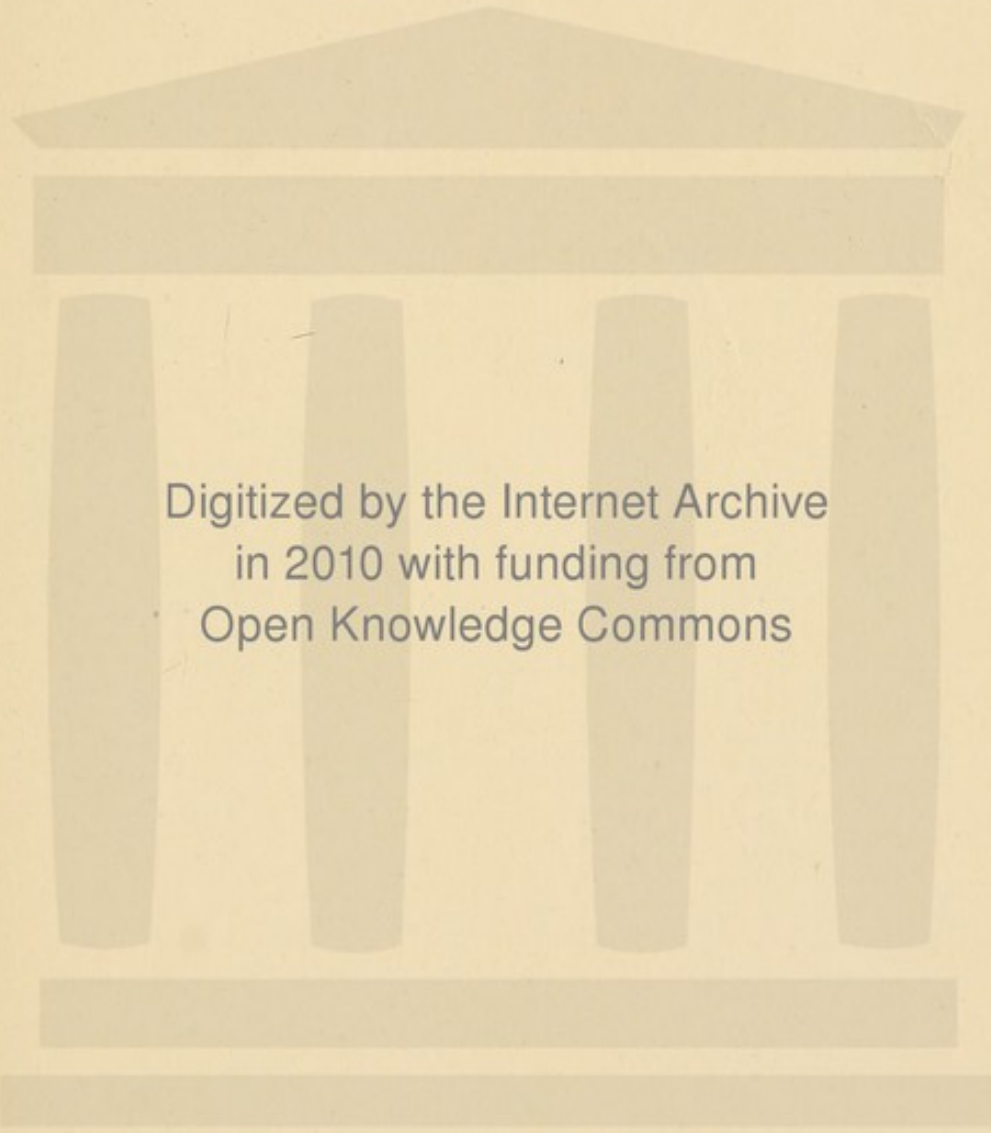




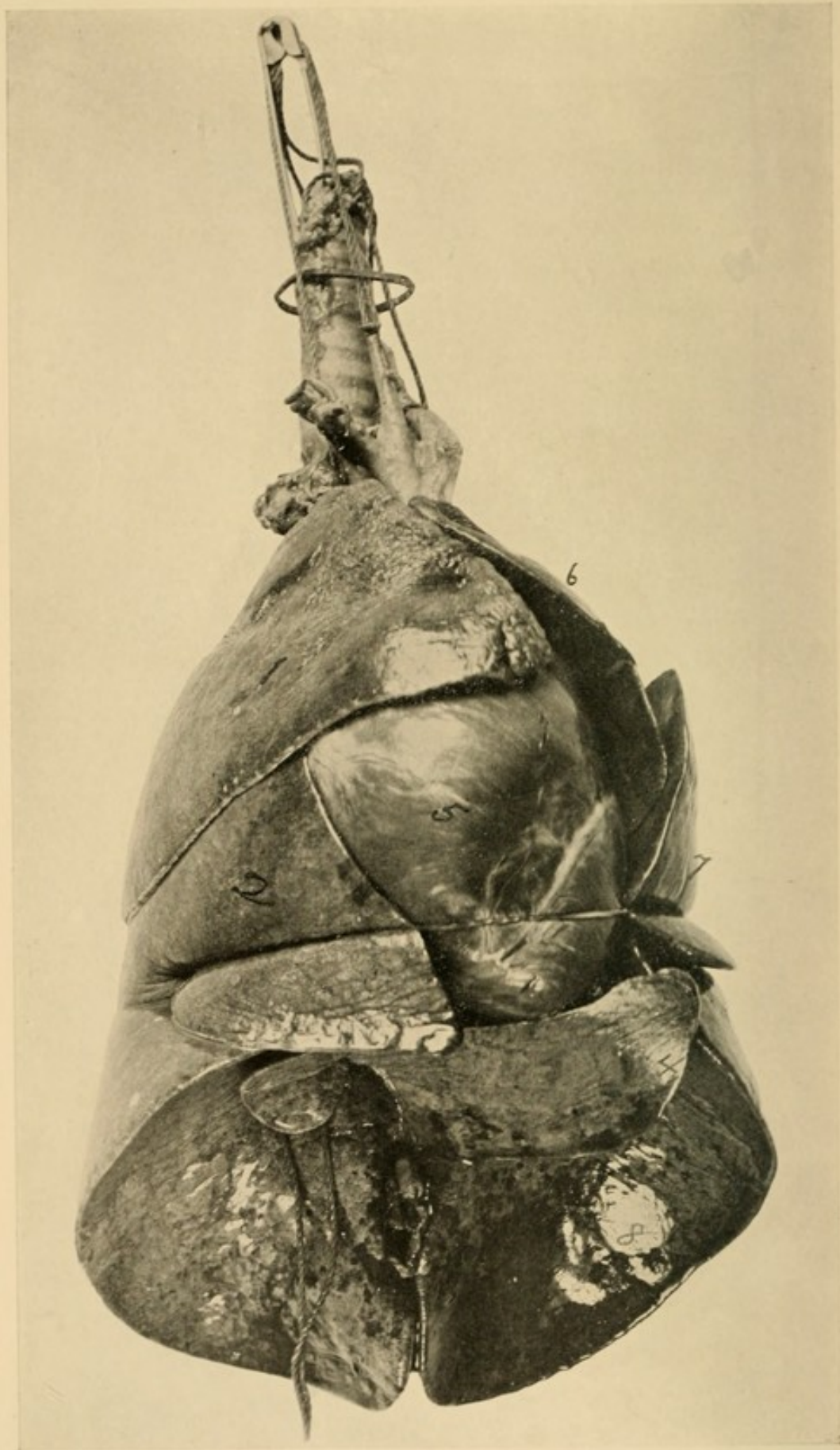


THE SURGERY OF THE
HEART AND LUNGS

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ANTERIOR VIEW OF HEART AND LUNGS OF DOG, INJECTED
IN SITU.

THE SURGERY OF THE HEART AND LUNGS

A HISTORY AND RÉSUMÉ OF SURGICAL
CONDITIONS FOUND THEREIN, AND EX-
PERIMENTAL AND CLINICAL RESEARCH
IN MAN AND LOWER ANIMALS, WITH
REFERENCE TO PNEUMONOTOMY, PNEU-
MONECTOMY AND BRONCHOTOMY, AND
CARDIOTOMY AND CARDIORRHAPHY

By

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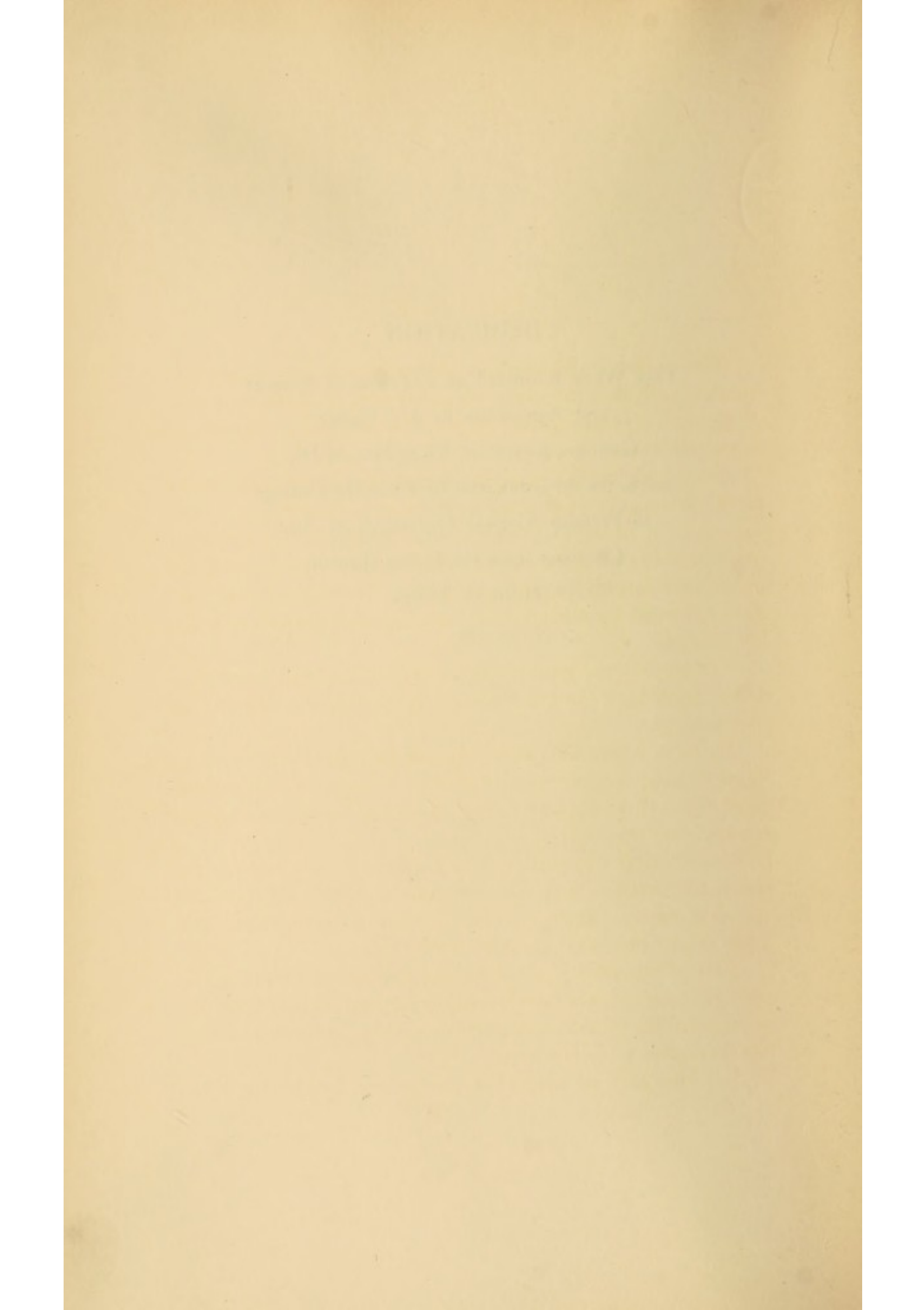
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DEDICATION

This Work is offered as a Token of Respect
and Admiration to My Father
GERARD ROBINSON RICKETTS, M.D.,
and to the Surgeons who have had the Courage
to Perform Surgical Operations of Any
Character upon the Living Human
Heart or Lungs



PREFACE

THE author in his work as a surgeon has been brought in contact with several cases of pulmonary trouble requiring surgical intervention, and has thus become greatly interested in the subject.

On taking up the study he found that there was no one work on surgery that gave more than a brief space to this subject. In order to obtain a knowledge of the operative surgery of the lung, or even a complete description of all the pulmonary lesions requiring surgical intervention, the student is forced to consult many works, and journals in many languages.

For his own convenience the author collected a large mass of material, and compiled several bibliographies bearing on this subject.

He also found that many questions regarding the technique of lung surgery were in doubt. In order to settle these questions to his own satisfaction, he made a series of original experiments on dogs.

Considering the paucity of information contained in the standard treatises, and the inaccessible sources of the most valuable matter, the author thought that a work of this character might prove acceptable to students.

Part of this work is an historical compilation, in an accessible form, of papers and reports scattered through the various journals of this and other countries, together with a bibliography of the subject.

For this part, no originality is claimed, but for the other

part, which details the author's experiments on dogs and the results obtained, he claims entire originality.

No attempt has been made to write an exhaustive treatise on the surgery and surgical diseases of the lungs, but an effort to consider all the diseases of the lung which may call for surgical intervention.

Space has been devoted to each disease in proportion to its importance.

This work is especially intended for practitioners and students. For this reason the descriptions of each disease, with its symptoms, diagnosis, and treatment, have been made as concise as possible; the aim being to enable the practitioner to recognize the various surgical diseases of the lung, in order that he may seek surgical assistance promptly when necessary.

Each chapter has its own bibliography, so that those desiring information on any particular subject need not consult a great mass of matter in which, perhaps, they have no interest.

The reader must not think that all the works and reports mentioned have been read by the author; this would be a physical impossibility for a man actively engaged in his profession.

The most important, however, have been perused, every statement and reference has been verified and the authority for all statements has been given.

This has been done in order that credit might be given where it is due, and also that the author of this work might not be held responsible for some other man's statement.

It has been the author's aim to secure accuracy, but in a work of this character it is not always possible.

An effort has been made to form a complete bibliography. The author, however, does not claim that it is exhaustive. The literature is so vast, and published in so many languages, that many papers and reports may have been overlooked by

the compilers of the various indices. Only those works and reports were inserted whose titles clearly indicated their subject matter.

Too many writers, unfortunately, choose obscure titles for their works. Then, too, some writings have not appeared in the kind of publications in which one would naturally expect to find them.

Some reports of interest are, perhaps, hidden away in the proceedings of societies, and clinical reports of hospitals, and have never reached the ordinary channels of publicity.

The second part the author considers the most important, because his experiments have cleared up certain questions of practical importance, and settled certain details of surgical technique. All original experiments blaze the way for future work.

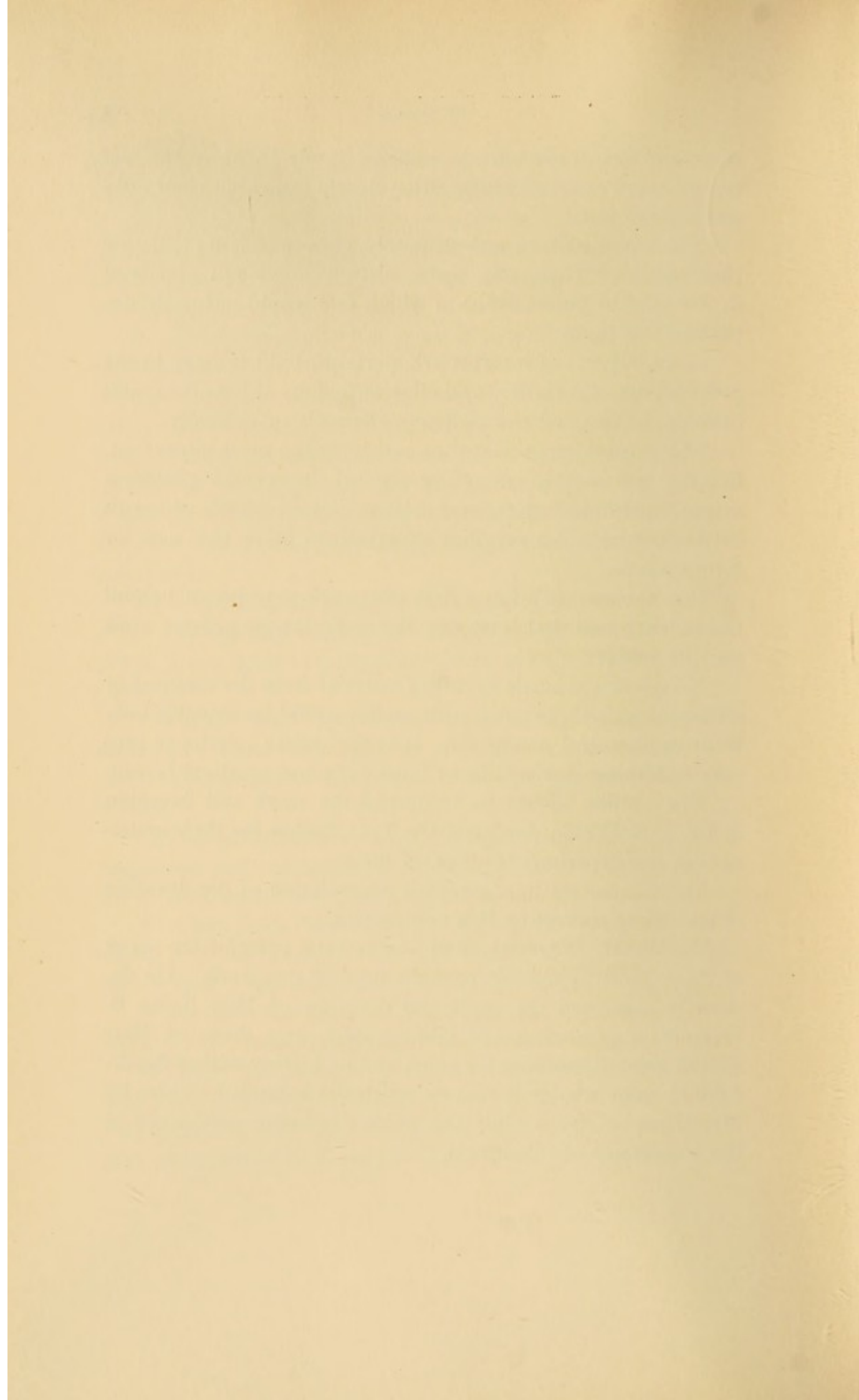
It is the author's hope that this work may prove helpful to students, and that it may be the incentive for greater work on this subject.

No effort was made to collect material from the classical or mediæval writers, because such matter would be valuable only from an historical standpoint. It is the author's desire to provide something that will be of immediate and practical benefit.

The author wishes to commend the work and devotion of Dr. J. S. Wallingford and Dr. T. G. Sellew for their assistance in the experiments upon the lung.

He also desires to express his appreciation of the devotion of his wife in correcting this manuscript.

To W. H. Wamsley, Esq., he is very grateful for many of the excellent photomicrographs used in this work. He desires to commend the work and devotion of Miss Sadie B. Helbert in arranging the bibliography, and those of Miss Bertha Karl in handling the copy, and he further wishes thankfully to acknowledge the many courtesies extended to him by Mr. Howard Ayres while the work was being conducted at the University of Cincinnati.



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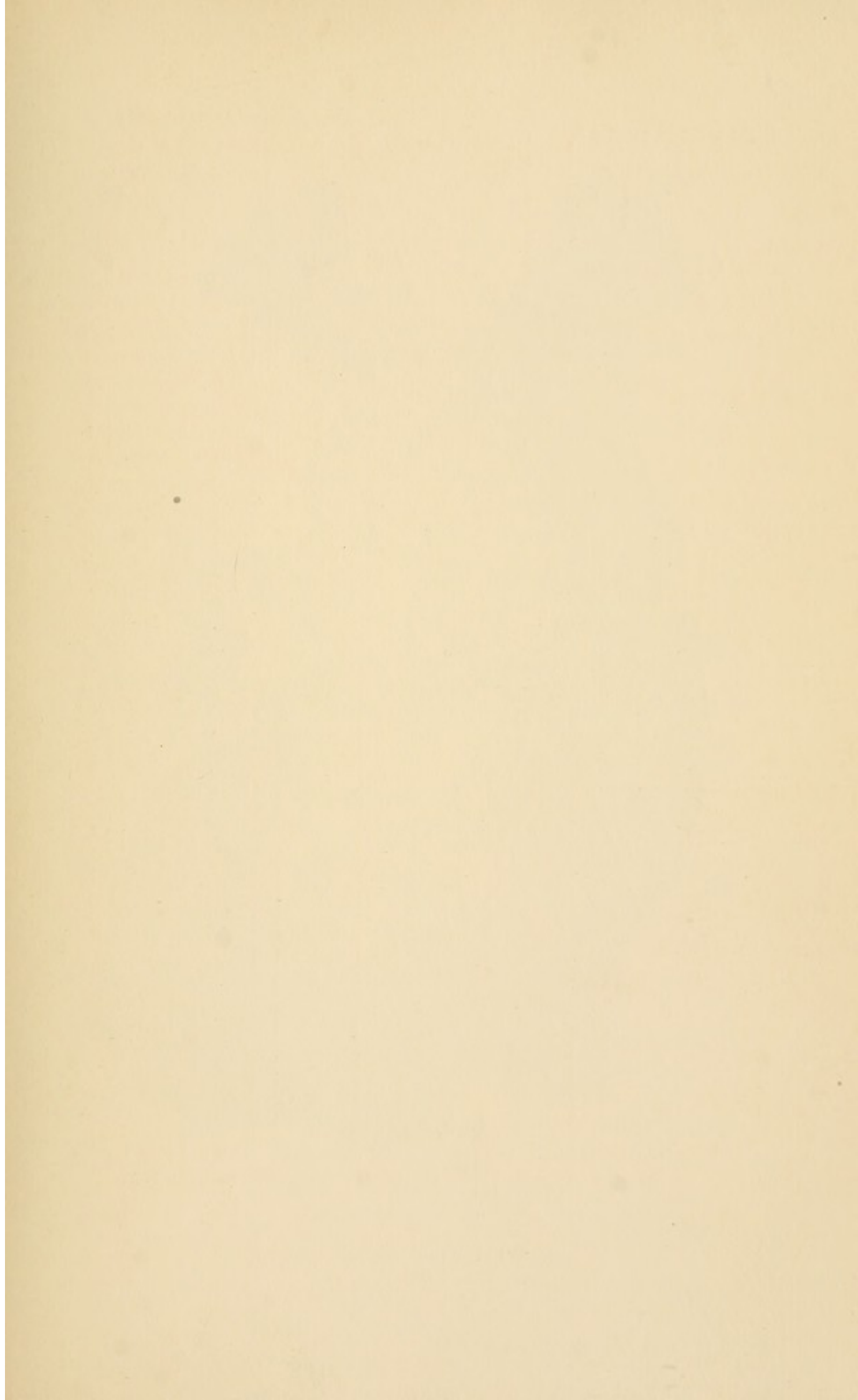
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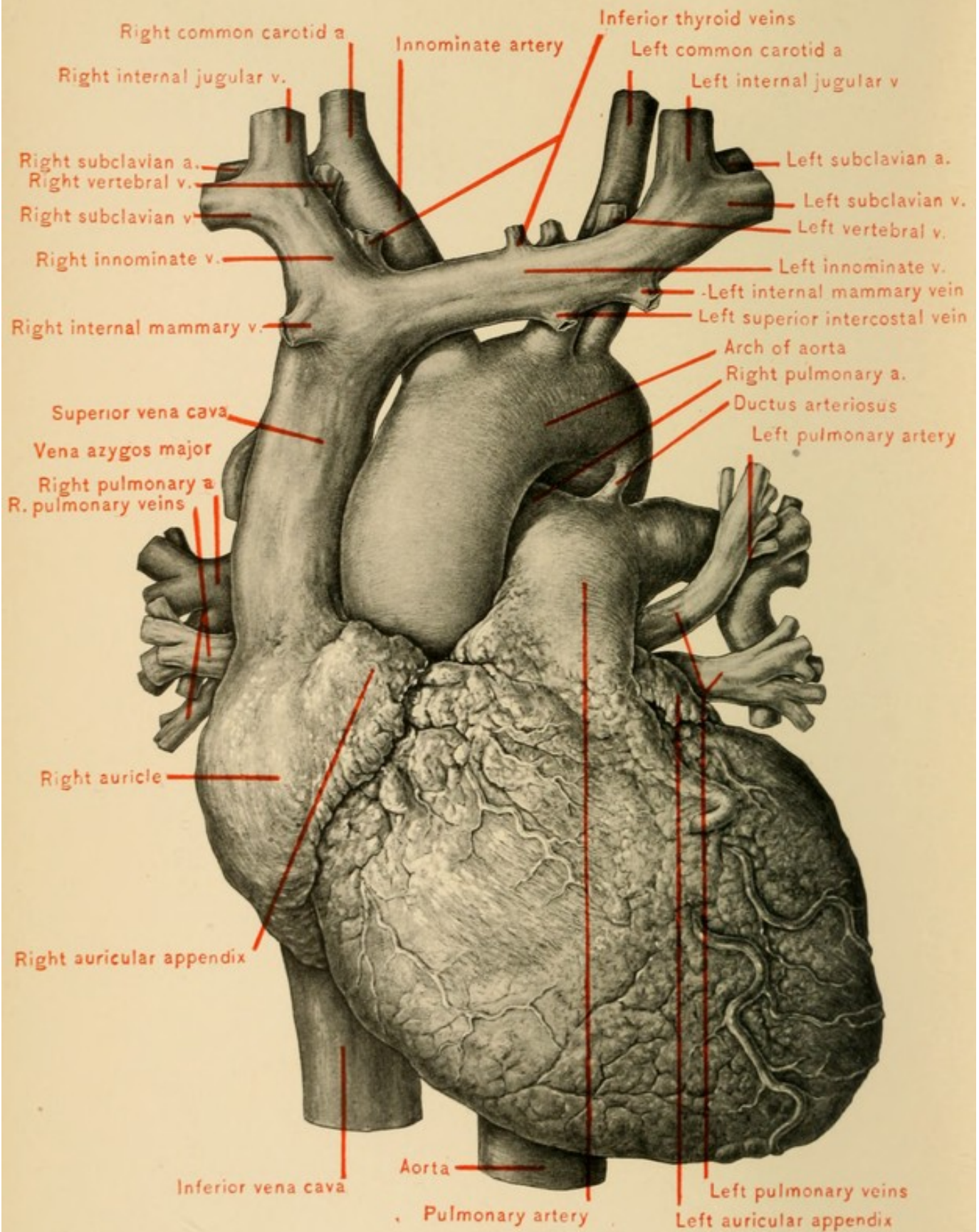
PART I

THE SURGERY OF THE HEART

1844

THE HISTORY OF THE BEAR





ANTERIOR VIEW OF THE HEART

(From Deaver's "Surgical Anatomy.")

PART I

THE SURGERY OF THE HEART

INTRODUCTION

INJURIES and diseases of the heart have resisted surgery longer than almost any of the tissues or organs of the human body. They, however, no longer offer such resistance, but find themselves subject to attack on the same surgical principles as other parts of the body. The recovery of twenty cases out of fifty-six penetrating wounds of the human heart, after having been closed by suture, is significant, and this, too, all having been done since 1895. The object, therefore, of this work is more fully to demonstrate by the cases operated upon, a general résumé of injuries, pathological conditions, and experimentation, that it should no longer be exempt from surgical measures.

The chapter on anatomy refers to both the human and comparative features to a limited degree, and of necessity calls for a consideration of abnormalities, such as malpositions, displacements, and malformations, each of which has a separate chapter. The frequency of abnormalities is becoming generally known, and their importance in cases requiring surgical intervention better appreciated. Experimental research bearing directly upon the surgical aspect has been exceedingly limited as compared with that of physiologic or anatomic research.

Wounds of various kinds are included in a separate chapter, that the character of wounds most amenable to surgery

might, if possible, be determined. Aneurysm, foreign bodies, ossification and calcification, together with abscess, syphilis, and gangrene, possess features which will have a great bearing upon and will influence the future surgical work on the heart.

The application of surgical principles in certain cases of aneurysm of the heart will, no doubt, be accomplished by suture, electrolysis, or the injection of gelatine or something of a similar character.

The removal of a certain class of foreign bodies, whether they have formed within or have entered from without, should and no doubt will, be accomplished. That a cardiac abscess should be incised and drained there can be no doubt. In a selected number of cases the application of carbolic acid counteracted with alcohol after an abscess of the heart has been incised, might possibly permit of closing the walls of the abscess with suture. The same principles might be successfully applied to cases of gangrene of the heart.

Tumors of a pedunculated variety, on the external surface, should be removed, even when pedunculated within the cardiac chambers, their removal is about as possible and rational as the removal of foreign bodies from the chambers of the heart.

Parasitic cysts (animal or vegetable) when upon the external surface, or in the wall of the heart, should be incised and drained.

TERMINOLOGY

Acardia.....	absence
Acardiohæmia.	lack of blood
Acardiotrophia.	atrophy
Aerendocardia.	presence of air in the heart
Angeiocardiokinetic.	agents stimulating vessels of heart
Angeiocarditis.....	inflammation of heart and blood-vessels
Atelocardia.	poor development
Cardiac cycle	a complete movement
Cardiagra.	gouty attack
Cardialgia.	pain
Cardianastrophe.....	displaced to right
Cardianeuria.....	lack of nerve stimulus
Cardiant.	affecting the heart
Cardiarctia.....	stenosis
Cardiasthma.	dyspnœa
Cardiatelia.	poor development
Cardiatrophia }	atrophy
Cardiatrophy }	
Cardiauxe.	enlarged
Cardiectasis.	dilatation
Cardielcosis.....	ulceration
Cardiempyria.	obstruction of current
Cardiocele.	hernia
Cardiocentesis.	aspiration
Cardioclæsia.	rupture
Cardiocrystallus.	heart crystal
Cardiodemia	fatty degeneration
Cardiography	description
Cardiohæmothrombus.	heart clot
Cardiokinetic.	exciting the heart
Cardiolith.....	concretion in the heart
Cardiology.	anatomy, physiology and pathology
Cardiomalacia.	softening
Cardiomegalia.	enlargement

Cardiomorphia.	malformed
Cardiopalmus.	palpitation
Cardiopathy.	disease
Cardiopericarditis.	inflammation of heart and pericardium
Cardioplegia.	paralysis
Cardioptosis.	downward displacement
Cardiorrhexis.	rupture
Cardiosclerosis.	hard
Cardiostenosis.	constriction
Cardiotomy.	dissection
Cardiotoxis	poison
Cardiotrauma.	injury
Cardiovascular.	pertaining to blood-vessels
Carditis	inflammation
Carditopography.	topographical anatomy
Dexicardia	} to right
Dexiocardia	
Dextrocardia	
Ectocardia	} abnormality of position
Ectopia cordis	
Hæmatolysis.	imperfect coagulate
Hæmatomyces.	fungus
Hæmatopericardium.	blood in pericardium
Hæmatophyte.	vegetable organism
Hæmatoxin.	blood poison
Hæmatozoon.	animal organism
Hæmocardiorrhagia.	hæmorrhage of heart
Hemicardia.	one auricle; one ventricle
Monocardium.	a single chambered heart, or one not completely divided
Mycosis.	pathological mycosis
Orthodiagraphy	X-ray picture of the heart

CHAPTER I

ANATOMY OF THE HEART (HUMAN AND COMPARATIVE)

THE embryonic heart of the lower vertebrates differs both in form and origin from the heart of the higher vertebrates. In some of the lower vertebrates the heart never develops much beyond the embryonic stage. This form persists throughout life. Anomalies of the human heart are very often only cases of arrested development of the embryonic heart. This arrest may occur at any stage, hence anomalies of the human heart may show any of the embryonic forms. The heart is the first permanent organ of the embryo to take up its functional activity. In its earliest forms it presents the characteristics of the central impelling tube of the invertebrates, which is functionally analogous to the heart of the vertebrates. This impelling tube of the invertebrates is a very simple mechanism to perform its office. The arteries empty into the anterior, and the veins into the posterior extremity.

One school of evolutionists points to the development of the mammalian heart as proof of their dictum, that the embryo of the vertebrates presents at various stages of its development the characteristics of the adult heart of all the lower forms.

At first the heart of the human embryo is exactly similar to the invertebrate heart described above. Then it takes the form typical of that of the fish, *i.e.*, an organ of three cavities, a simple auricle, a simple ventricle, and a bulbus

arteriosus at the origin of the aorta. The subdivision of the aorta into four or five arches resembles the entrances of the gill-cavities of the cartilaginous fish. This form of circulating apparatus is common to all vertebrates, at least in the earliest stage of their development. This is the permanent form in fish, although in some there is further development of the vascular system.

In the higher vertebrates the plan of circulation is totally changed, because of the formation of new cavities in the heart and the formation of new vessels. Hence it is not strictly correct to speak of the vascular arches in their necks as branchial arches, since no branchiæ, or gills, are ever developed. The highest pair of the so-called branchial arches, by union of the aortic trunk, help to form the subclavian and carotid arteries, the middle pair undergo the greatest change, the right becomes obliterated and the other becomes the "arch of the aorta."

Many of the anomalies of arteries and veins can also be explained as arrested development in the embryonic state.

In birds and the lower mammals there are two *venæ cavæ superiores*. At the birth of the human foetus there is a change in the plan of circulation on account of the cessation of placental circulation. With the first breath of the new-born an immense quantity of blood is transmitted to the lungs. In a short time the ductus venosus and ductus arteriosus shrivel up and become mere ligaments; at this time the foramen ovale becomes closed by its valve. The circulation, which had been reptilian in character, now becomes of the permanent form found in birds and mammals.

The heart of the dugong is so deeply cleft from apex to base as to seem two separate organs. The same condition is found in the human foetal heart at a very early period.

In man the vena porta is analogous to the aorta of the fish. This shows that it is properly regarded as arterial in character. It bears the same relation to the general circula-

tion in man that the respiratory circulation in the *Mollusca* and *Crustacea* does to the general circulation of these orders. The mammalian heart may be described as an organ whose functions are those of a pumping-engine to propel blood through the body.

The human heart is an oval or pear-shaped organ, three to five inches wide and three to four inches thick, weighing nine to seventy-two ounces, rarely above twenty-five ounces, normally nine to twelve ounces in the male and seven to ten ounces in the female.

The broadest part of the heart, called the base, is directed upward and backward and to the right, extending from the level of the fifth dorsal vertebra to the eighth. (Heath says from the sixth to the ninth.)

The apex, or pointed end, of the heart can be felt between the fifth and sixth ribs, a little below the inner side of the left nipple. (Quain says three and one-quarter inches from the middle line of the sternum and one and one-half inches below the nipple.) The margins of the lungs cover all but a small part of the heart. This part of the heart left uncovered is part of the right ventricle, is irregular in outline and about two inches square in area. The heart has four cavities, the right and left auricles in the base, and the right and left ventricles toward the apex. It may be considered as a double heart, keeping in mind the typical heart of two cavities found in the lower orders.

Like the lungs, and other important organs, the heart has a separate individual envelope known as the pericardium. Normally the pericardium conforms to the general shape of the heart reversed. It is pyriform in outline with the small end uppermost; the base rests upon the diaphragm. It is continued above to cover the great vessels of the heart, and connects with the deep cervical fascia at a height of two inches above the origin of these vessels.

The four cavities of the heart approximate one another in

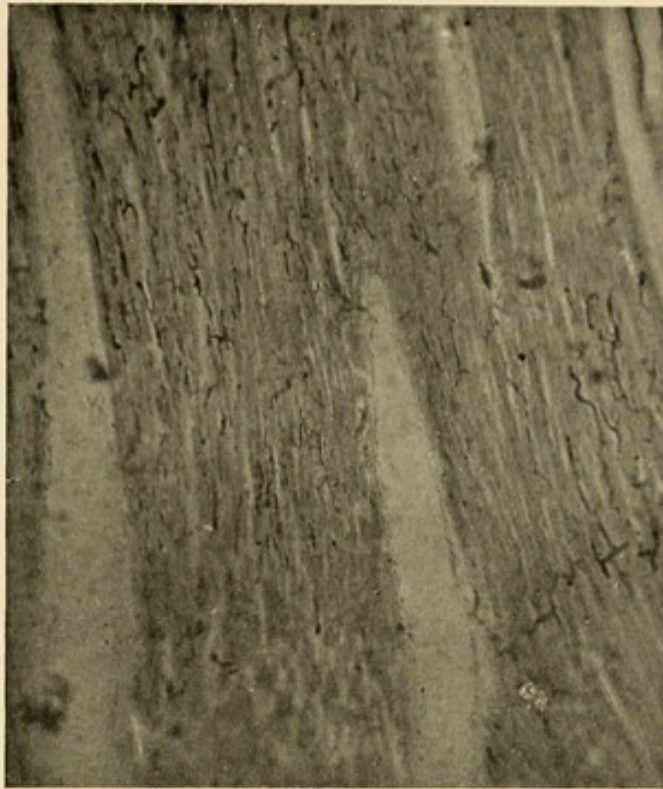
size. The contents of each cavity are about three ounces. The auricles will hold a fraction less. The walls of the left ventricle are much thicker than those of the right. This is undoubtedly in compensation for the greater work that it has to perform.

It has been found experimentally that the left ventricle contracts with more than double the force of the right. The walls of the left ventricle are nearly three times as thick as those of the right. All this is in agreement with the laws of mechanics, since the left ventricle has far greater arterial resistance to overcome.

In regard to the capacity of the cavities, it has been noted that the ventricles receive more blood from the auricles than the latter could transmit by simply emptying themselves once. If three ounces be taken as the capacity of the ventricle, and eighteen pounds the weight of the blood in the body of an average sized man, it will require ninety-six strokes to force the whole amount of blood through either side. If seventy-two pulsations per minute be taken as the average, it will require one and one-third minutes for a given particle to return to a given point, that is, if it was not sent elsewhere.

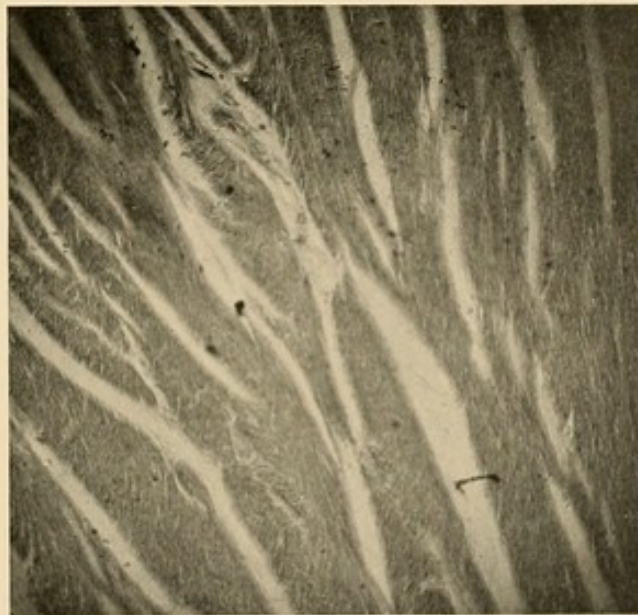
It is not only interesting, but of great practical importance, to consider the mechanism of the heart and circulation in the various orders of vertebrates, for by such study a more thorough understanding of the human cardiac and circulatory apparatus can be obtained. This comparative study also throws light upon some of the seemingly inexplicable human anomalies.

Comparative Anatomy.—The ventricles of the heart are but imperfectly divided in the class Reptilia, except the crocodilian group, in which they are completely divided. In some of the Chelonians the communication between the auricles is permanent. The *fossa ovalis*, which represents the primitive division of the heart, is more completely obliterated in



X 160.

INJECTED SECTION OF HEART MUSCLE SHOWING RAMIFICATIONS OF CAPILLARIES AMONG THE MUSCULAR FIBRES AND HOW THEY APPEAR TO PASS INTO THEM. (Dr. A. V. Meigs.)



X 300.

LONGITUDINAL SECTION SHOWING CAPILLARIES AND MUSCULAR FIBRES. (Dr. A. V. Meigs.)

the kangaroo than in man. In those Batrachians which have but a single ventricle the root of the aorta is dilated into a bulbous aorta or *bulbus arteriosus*. The latter is rhythmically contractile in the Elasmobranchii, but not in the Teleosteans.

Where the heart consists of but two cavities, one auricle and one ventricle, as in fishes, the root of the aorta is dilated into a *bulbus arteriosus*, and the venous channels terminate at the heart in a *sinus venosus*.

The heart of the lancelet consists of but a single tube. The cavity of the pericardium is continuous with that of the peritonæum in the Myxinoid fishes and Elasmobranchii. The crocodilian heart gives rise not only to the pulmonary artery, but also to the aortic arch. In frogs and most of the reptiles a special arrangement of valves is provided for the propulsion of the venous blood into the pulmonary arteries, and the arterial blood, for the most part, into the aortic arches. These groups have pulmonary arteries coexisting with a single or an imperfectly divided ventricle. The apex of the heart of the dugong is deeply notched; this fact can be detected externally. The heart of birds is more elongated than the human heart, while that of the Chelonian is shorter and broader. In *Amphioxus*, the simple vesicular heart is continued forwards preaxially, into a median artery, whence on each side diverge very many pairs of arteries. The same condition is found amongst the vertebrates in the lancelet. In no other member of that sub-kingdom can aortic arches by any calculation, or at any period of life, be found to exceed eleven on each side. (St. George Mivart, "Elementary Anatomy.")

Amongst sharks the genus *Heptanchus* have probably seven distinct branchial arches on each side. In the *Lepidosirens* and *Ceratodus* there are five branchial arches on each side; the perch has but four. In the frog, at that period of its tadpole stage when the gills begin to atrophy, three branchial arteries coexist with the three corresponding vessels going

to the dorsal aorta. At this time there is direct communication between neighboring arteries and veins, although each artery and vein minutely divides in the gill beyond the points of communication. In the adult frog there is no breaking up of the aortic arches by any interposed ramifications.

At an early age of his existence man possesses a *ductus arteriosus* connecting the pulmonary artery with the aorta. In *Cryptobranchus* this connection is permanent and on both sides of the body.

The crocodile has two aortic arches, each ventricle giving off one. The two common carotids and the right subclavian originate in one trunk in the lion. The hedgehog has two innominate arteries. The two common carotids in birds ascend in close juxtaposition. One of these is sometimes much reduced in size, or even aborted. The vertebral artery in the llamas perforates the neural laminae instead of passing through the cervical transverse processes. Birds have a primitively double aortic arch springing from the left ventricle, but only the right half develops into the permanent form. It is the left half of this primitively double arch which is developed in mammals.

The great arteries which supply the head and forelegs originate in common from the aorta as one great trunk. But in the dugong all the great arteries which supply the head, et cætera, have each a separate origin arising from the aorta. In the domestic ox, the internal carotid breaks up inside of the skull into a network of small arteries, *rete mirabile*.

There are differences in the proportions existing between the external and internal carotids, and also variations in the course taken by each which characterize different groups of mammals. In the sloths and slow lemurs, the branchial artery breaks up into a number of branches running side by side. The femoral arteries in the same animals and also among the *Echidna* are similarly divided. In some of the Cetacea (porpoise), the intercostal arteries form great convoluted *retia*

mirabilia. In the osseous fishes and in the *Lepidosiren*, a small *rete mirabile* is developed from the first, or hyoidean, aortic arch. In many fishes there is a less number of intercostal arteries than intercostal spaces; in this class of animals the artery of the pectoral limb is given off from the dorsal aorta immediately after its formation.

The dorsal artery dilates beneath each vertebral centrum of the abdomen in the carp. In fishes this artery gives off many small branches to the kidneys.

The internal iliac arteries do not share with the external in a common origin. The middle sacral artery continues much farther and is of larger size in the kangaroo than in other vertebrates, the internal iliacs are larger than the external and the inferior mesenteric artery is aborted.

A *rete mirabile* is formed in the Porbeagle shark by the ramifications of the coeliac arteries.

In one point there is a great difference between arteries and veins. Excluding *retia mirabilia* and all gill structures, it will be found that the arteries never, after dividing, reunite to form second aggregations. But the veins do break up and reunite to form, so as to speak, a new system. The so-called portal circulation is thus formed. The portal veins break up into a minute network in the liver, and then gradually reunite to form the hepatic veins which carry the blood to the heart.

The venous *rete mirabile* attains its maximum in the abdominal region of the porpoise. The two *azygos* are equal, or nearly so in the monotremes. Rabbits have two superior *venæ cavæ*. Each of these opens into the right auricle by a separate and distinct aperture. The middle sacral vein is greatly increased in size and, of course, in importance in the Cetacea, all of this class having a very large coccygeal region.

The veins of the caudal region and the pelvic limbs enter the kidney in the Batrachians and there form a network. These ramifications reunite on emerging from the kidney to

form a new trunk to carry the blood to the heart. Thus in this class there is a tertiary distribution of blood in the kidney, similar to the secondary or portal circulation in man. The abdominal veins, however, go directly to the liver and do not help to form this renal circulation. The abdominal veins of birds go directly to the *vena cava* inferior. In most Batrachians and reptiles the great veins dilate into a rhythmically contractile *sinus venosus*.

The permanent venous system of fish is exactly reproduced in the human embryo. Fish have two cardinal veins uniting to form a *ductus Cuvieri* which empties into a *sinus venosus* at the heart. The veins themselves are contractile in certain groups. The portal vein of Thyxine contracts rhythmically; the eel possesses a pair of small contractile vesicles on its caudal vein; in the limbs of many Batrachians the root veins are contractile; the veins which traverse the membranes of the wings of bats are similarly contractile; and *Amphioxus* is *sui generis* in this regard, as in many other points. Not only is the portal vein contractile, but many veins of lesser importance also possess this property. The veins of the Cetacea have no valves.

In fish and young batrachians, the blood is not propelled in a double circuit as in man, but makes a single great circuit, only returning to the heart when the whole round has been completed. In this case only venous unaerated blood is propelled by the heart. The blood leaves the heart by the bulbous aorta, passes to the gills, where it is aerated. This aeration is accomplished by the reception of oxygen from the particles of air mechanically mixed up with the water in which the animals live.

All air-breathing vertebrates like man possess two circulations; that is, part of the blood returns to the heart, before being distributed to the body generally; but both venous and arterial blood are more or less mixed up in the heart itself in all batrachians, and in such cases the aortic arches propel

an impure fluid. The arrangement, structure, and mechanism of both the chambers of the heart and aorta are so complex that the mixture of the venous and arterial blood is incomplete. Nearly all the blood from the lungs is forced into the aortic arch, which supplies the anterior portion of the body. This process is found also in some still lower orders, as in the common frog.

Although the two states of the blood are strictly divided between the two sides of the heart in crocodiles, yet the blood in the circulation is impure. This is because of the communication between the two aortic arches after leaving the heart. In the perch, the blood carried to the gills can enter the dorsal aorta only by means of the capillaries of the gills. There is a complete continuity of each arch from the heart to the dorsal aorta in the embryo of the fish. In the *Lepidosiren* and *Monopterus* this condition persists throughout life.

Certain lesions of the heart cannot be diagnosticated until constitutional disturbances are produced. But the same lesion, even in the same person, need not produce the same constitutional disturbances. It is essential in all heart lesions which might be benefited by surgical treatment, that the cause be discovered early. The patient who undergoes any cardiac surgical operation requires all the strength, vitality and resistance possible successfully to withstand the shock. The same may be said of operations on any of the internal viscera. Because of the lack of knowledge of the pathological physiology of the viscera, and especially because of the uncertainty surrounding the pathological physiology of the heart, this and correlated subjects are taken up much more fully than is usual in a work of this character.

The pericardium consists of two layers, a fibrous and a serous layer. The fibrous layer is a dense membrane which is attached to the diaphragm. Eight tubular sheaths are formed from the superior portion of the pericardial sac for the great vessels at the base of the heart. The serous layer is

formed into a closed sac. The muscular tissue of the heart is similar to the ordinary striped or voluntary muscle. There are both longitudinal and transverse striations. Each individual fibre consists of a number of muscular elements. The latter consists of a nucleus, and a film which presents the appearance of granular protoplasm. This nucleus, in which is found an intranuclear plexus, together with the thin film, constitute what Max Schultze calls the muscle corpuscle. Each of these so-called muscle corpuscles is surrounded by a mass of that material which seems to be the functionally active part of the heart substance. The ends of each individual muscle element, which are serrated or bifurcated, dovetail into a similarly formed end of another element. These elements are cylindrical in shape. Each fibre is made up of several of these muscle elements united, and because these elements do not always unite end to end, but laterally and otherwise, thus there is produced the reticulated appearance of a section of the heart. In elderly persons a golden yellow or brown pigment is sometimes found at the poles of the nuclei of the muscle corpuscles.

The interstices of muscular network are filled by a highly vascular connective tissue, which is in direct contact with the muscular elements.

If the human heart be removed very soon after death, the inner surface of the endocardium will be seen to consist of a single layer formed of nucleated endothelial cells, flattened. Beneath this endothelial layer there is a reticulated stratum, also formed of flattened cells, which, however, are branched. Trabeculae run from this layer into the connective tissue found between the muscle fibres. In the substance of this network of cells, are minute muscular bands analogous to those in the myocardium. A stratum of elastic tissue lies beneath this layer of network disposed cells.

Numerous arteries and veins are found on the surface of the heart. All of these vessels are of ordinary structure.

Within the walls of the heart, only the veins of large size have three coats. The walls of the smaller veins are composed of a single layer only of endothelium. In other words, the smaller veins running through the heart's walls are identical in structure with the capillaries.

The structural composition of the walls of the arteries within the substance of the heart is normal, *i.e.*, three coats. There is one peculiarity characteristic of the cardiac arteries. This refers to the way in which the arterioles become merged into capillaries. The number of efferent capillaries is greater than the number of afferent. The capillaries run in all directions among the muscular fibres. As A. V. Meigs says: "The capillaries not only enter the muscular fibres, but also actually penetrate to their very centres." ("Origin of Disease," Philadelphia, 1899; p. 65.)

"The superior, middle, and inferior cervical ganglia form the cerebro-spinal nerves of the heart." The above mentioned ganglia are of the *sympathetic* and form no part of the cerebro-spinal system. *From* them we have the superior, middle, and inferior sympathetic cardiac nerves given off. These enter the thoracic cavity, and uniting with branches of the pneumogastric, form the cardiac plexus. Therefore, the pneumogastric is the cerebro-spinal nerve, and the cardiac branches from the superior, middle, and inferior cervical ganglia are sympathetic. From the plexus thus formed by the pneumogastric and sympathetic, cardiac branches are distributed to the heart."

W. E. LEWIS.

The structure of the veins within the walls of the heart proves that nature has made abundant provision for its nourishment. The veins, very probably, participate largely in the nutrition of the cardiac tissues and furnish the means of transportation of waste material; because of their distensibility they may act the rôle of reservoirs.

These peculiarities in structure of the heart have an im-

portant bearing in the production of the cardiac movements. It is only in the light of these peculiarities that the mechanics of the heart-beat becomes comprehensible. An intimate acquaintance with the nervous mechanism of the heart is of even greater importance. Branches from the superior cervical ganglion, middle cervical ganglion, and of the inferior cervical ganglion form the cerebro-spinal nerves of the heart. The glosso-pharyngeal, pneumogastric, hypoglossal, and the first cervical nerves also originate in the superior cervical ganglion. The cardiac cerebro-spinal nerve originates in the middle cervical ganglion, and is placed in communication with the fifth and sixth cervical nerves at its origin. These connections must be kept in mind in order to demonstrate how and why the heart is influenced so profoundly by lesions of other organs and tissues.

Peripheral branches of the above mentioned cervical ganglia, and sometimes also a branch from the first thoracic nerve, by their union with the cardiac branches of the pneumogastric, form the intricate *plexus cardiacus* around the base of the heart, under the arch of the aorta. Usually these branches divide into two portions: The superficial portions lie in front of the aorta, and the deeper portions lie behind and below the aorta. The latter portions are the largest.

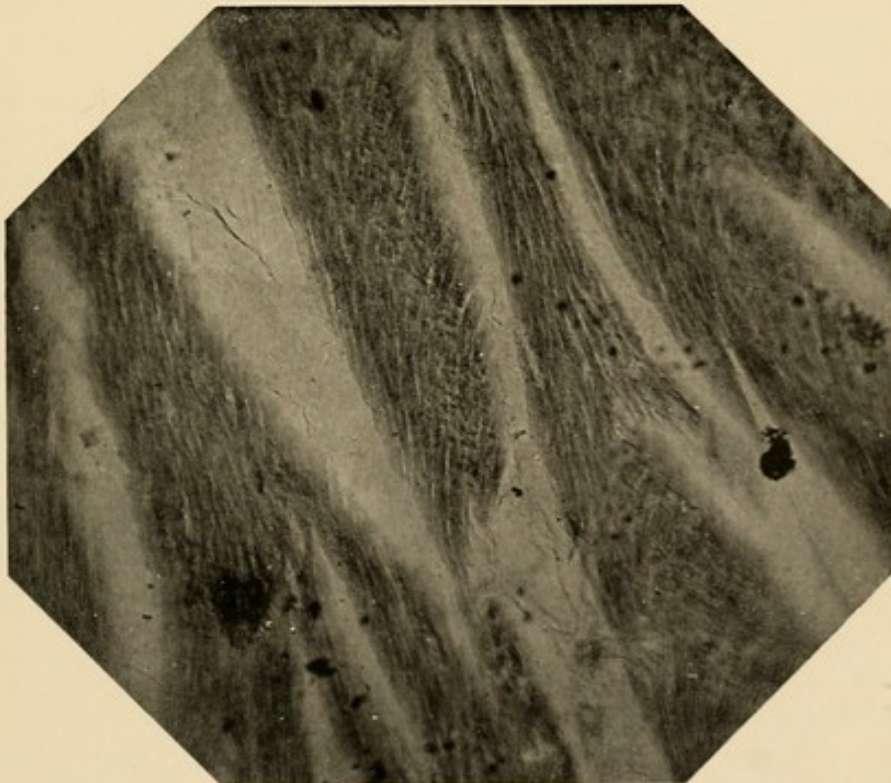
The walls of the heart are pierced by filaments from the *plexus cardiacus*. On the nerves as they ramify through the heart are many microscopic ganglia. Wrisberg's ganglion in the centre of the *plexus cardiacus* plays the most important part of these ganglia. In some of the lower orders these ganglia have been proven to perform the special function of regulating and controlling the functions of the heart. In these orders, they have the power to insure the continuance of the heart-beat, even after the connection between the heart and the central nervous system of these animals has been severed.

The pneumogastrics or vagi are the most important



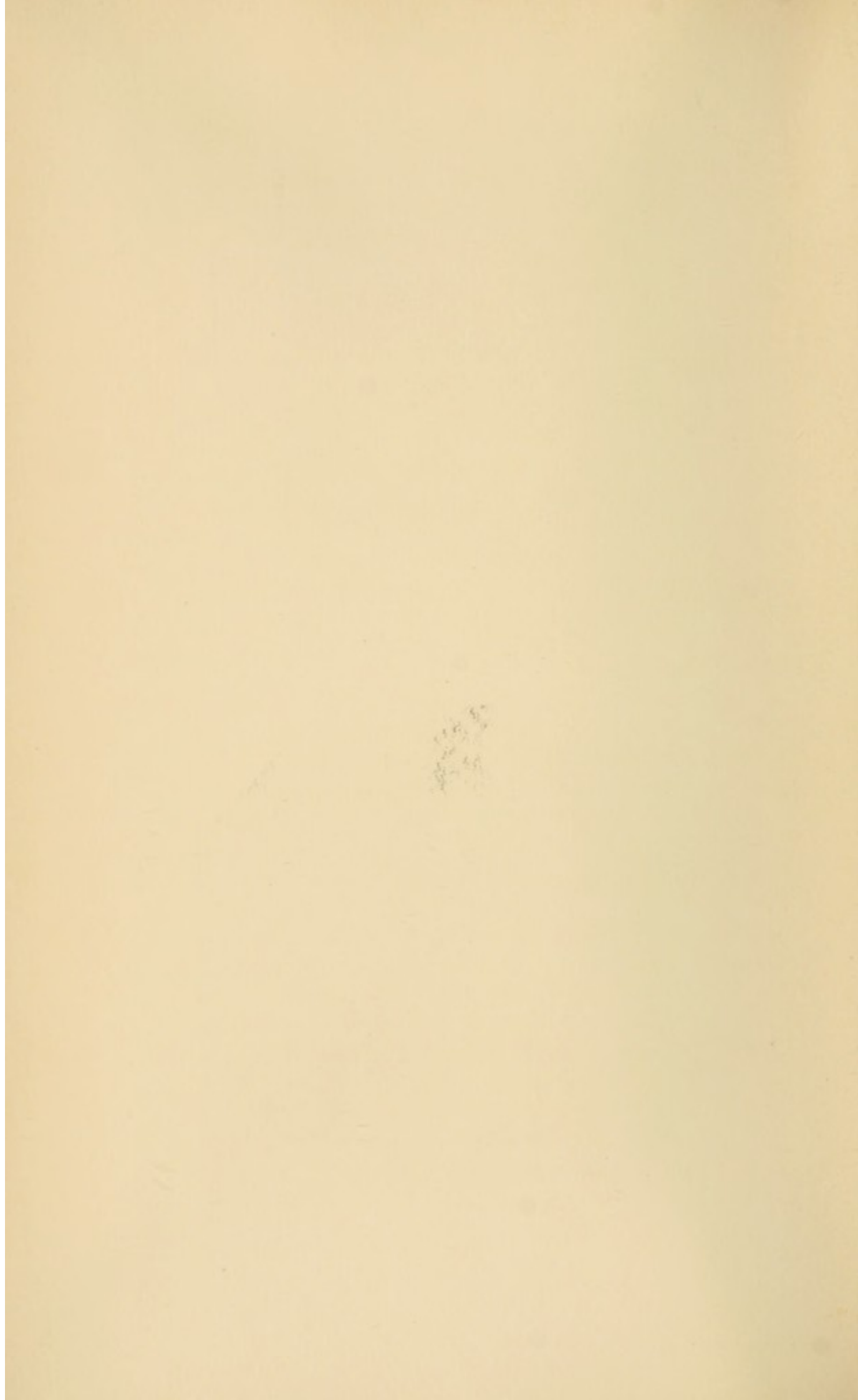
X 100.

LONGITUDINAL SECTION OF CARDIAC MUSCULAR FIBRES
AND CAPILLARIES. (Dr. A. V. Meigs.)



X 160.

LONGITUDINAL SECTION SHOWING MUSCULAR FIBRES.
(Dr. A. V. Meigs.)



nerves in the body. They are the only cranial nerves absolutely essential to life. If both vagi be severed, death will follow in a few hours. The connection between the pneumogastric and the sympathetic system is exceedingly intimate. In some of the lower orders of the animal kingdom it performs the functions of the sympathetic, and in others it takes the place of the sympathetic. It is what may be termed a double-acting nerve, since it possesses both motor and sensory activities. These impulses are transmitted to the heart by separate systems of nerve fibres; centrifugal impulses which slow the heart-beat over one set of fibres, and over the other centripetal impulses pass which influence the heart's movements by reflex action. The pneumogastri-
cs are closely connected with many nerves of the cerebro-spinal system. They anastomose immediately after their exit with the neighboring nerves, and pneumogastri-
cs and sympathetic unite with both the hypoglossal and glosso-pharyngeal nerves. The vagus has a recurrent branch which goes to the *dura mater*.

Some scientists hold that the hypoglossal is simply a coalescence of the anterior roots of the vagus. In some of the mammalia and in embryos it has a posterior root and a ganglion of its own. It is believed by many comparative anatomists that the hypoglossal is formed by the coalescence of certain spinal nerves, three in number, found in certain of the lower orders of animals, but not found in man, in any stage of existence.

Many experimenters have attempted to discover the exact function of the vagus, at least in regard to the cardiac movements, but there is still much uncertainty surrounding the subject. A nerve centre, situated in the floor of the fourth ventricle, produces normally similar effects to those caused by irritating the vagus.

The cardiac ganglia previously mentioned are not only found deep within the cardiac tissues, but are numerousiy

scattered over the walls of the heart just beneath the external surface. It is claimed that the injury of any one of these ganglia results in instant death. This explains the cause of the almost instantaneous deaths in many cases of cardiac wounds. It also shows why cardiac surgery must be always a formidable undertaking.

There is another cause for caution in suturing or incising the heart in that the external cardiac blood-vessels are so highly elevated above the surface of the heart. The coronary arteries are raised to a relatively great height above the exterior surface of the heart. Each artery is accompanied by the corresponding vein. These blood-vessels branch in almost regular order, and the branches are thrown off at almost right angles to the main vessels. Whenever an artery branches, the accompanying vein also does the same, but there is a slight distance between the places of division.

The intra-cardiac ganglia proper are never macroscopic in size. They are made up of scattered unipolar cells, but a few may be bipolar. The connection between each ganglion and the other ganglia is very intricate; so is the connection with the external cardiac nerves.

The most powerful of the intra-cardiac ganglia proper lies in the auricular sæptum. The paralysis of this ganglion by opium will cause a reversion of the cardiac contraction; and the motion will be from the ventricles to the auricles, instead of the normal contraction from the auricles to the ventricles. The other important ganglia are Remak's in the wall of the sinus venosus, at the point of union with the auricles; Bidder's near the junction of auricles and ventricles, and the one in the auricular sæptum. There are no ganglia in the ventricular sæptum or apex.

Mechanics of the Heart-Beat.—Although much work has been done to clear up the mystery surrounding the cardiac movements Ziemssen says, "The heart moves upward and to the right during contraction;" while Senac claims that it is

depressed forward and downward. Perhaps it would be well at this time to recall the fact that there is no anatomical connection of the muscular fibres of the ventricles with those of the auricles, therefore influences which affect the one need have no effect on the other.

The cardiac movements, in fact, are found to be in accord with the theory. The two auricles contract simultaneously; before this action ceases and about one-tenth of a second after it begins, the two ventricles contract in unison. The ventricular contraction never varies, no matter how rapid or how slow the heart-beat as a whole may be. A fourteenth of a second is consumed for the contraction of the ventricles. (Kirke, "Text Book of Physiology.")

There are exceptions to the generalizations concerning the heart. A case was reported by von Ziemssen and Ter Gregorianz of a woman who was badly injured in an accident. They made several observations on the heart-beat, and found that the auricles kept contracting after the ventricular systole had commenced.

The impulse-beat may be best detected in the left fifth intercostal space. The rhythm of the heart-beat and the extraordinary vitality of the heart are full of interest and of great practical importance. There is nothing unusual about the contraction of the cardiac muscles, it is simply analogous to that of the unstriped muscles. The movement of the heart, as a whole, during the heart-beat, has been happily described as a peristaltic contraction. This power of contraction of the heart-beat seems to be a force or power that is inherent in the substance of the heart. Even before the embryonic heart is differentiated from other structures, that is, when the heart consists of only ordinary cells, before it has any nervous mechanism, even before the formation of a nervous system in the body at large, there are cardiac contractions.

The inherent force or power which seems to impel the

cardiac substance to contract is well illustrated in the common frog. A frog's heart, and that of a tortoise, have been known to beat several hours, and in some cases even days after removal.

When the beats become infrequent, which they will sooner or later, an additional one can be induced by stimulating the heart with a blunt needle. The latent period (time interval between application of stimulus and resultant), however, is much increased.

See says: "Ligation of one coronary artery in a dog, in two minutes caused the regular cardiac contractions to give place to fibrillar twitchings, and that ventricle is first chiefly affected whose coronary artery has been ligated." (See Chapter on Results of Experiments.)

The auricles can be made to pulsate independently of the ventricles, and at a different rate, by a transverse incision through the junction of the auricles with the ventricles.

The rhythm of the cardiac movements in a heart wholly excised differs from that of an unremoved heart. The rhythm in an excised heart is in order, auricles, ventricles, *sinus venosus* and *bulbus arteriosus*. The heart has been removed in some experiments at the junction of the sinus venosus and auricles, and in such cases it was found that while the remaining portion of the heart continued to beat as usual, the excised portion remained motionless for a variable period, and when movement was resumed, the rhythm differed from the unexcised portion.

If only a ventricle be removed, the period of quiescence will be longer than in the above experiment. The rhythm also of the excised portion will differ from that of the unremoved portion.

Division of the heart lengthwise will not cause any change in the rhythm of the two parts; each will continue its activities as before the incision. If an auricle be cut into several

pieces, each piece will still pulsate. Mitchell (*American Journal of Medical Sciences*, Volume VII, p. 58) inflated the heart of a sturgeon with air, and it continued to beat after removal from the body, until the auricle became so dry that it rustled during its movements.

The irritability (property of reaction to stimuli) of the heart of the higher mammalia is of greater duration in very young animals. This experimental fact agrees with the law that the very young of the higher mammalia resemble the cold-blooded vertebrates, in the power of sustaining life for lengthened periods without oxygen.

There are two modes of stopping the heart's action, *i.e.*, by diminishing the strength of the systole, or by increasing the length of the diastole. It has been found that the contractile power of the right side of the heart continues long after the left side has ceased to react to stimuli.

The exact mode in which each part of the heart comes into a state of rest, or death, has not been determined. It has been found that the ventricles cease first to contract; the left auricle stops entirely; finally the right auricle stops as a whole; but a most distinct peristaltic movement may follow along the auricular appendix, which finally gives place to a gentle fibrillar tremor, and the heart is at rest forever.

As the heart beats more and more slowly, there is a marked interval between the auricular and ventricular contractions. ("Reference Handbook of the Medical Sciences," Articles, Circulation of the Blood; Thorax.)

The heart will beat rhythmically aside from the body even if entirely deprived of blood. Reaction to stimulation of the intracardiac ganglia will be manifested by the livelier action of the heart, but the influence is lost sooner and the heart will come to rest more quickly than if the stimuli be applied elsewhere. External pressure will cause a variation in the rhythm of the heart's action, but the heart-beat will be more vigorous.

The effect of a blow near the umbilicus, in causing the cessation of the heart action, proves the intimate connection existing between the cardiac nerve mechanism and the sympathetic nerve system, since the inference is very plausible that the stoppage is produced by reflex inhibition, conveyed through the sympathetic system.

In a former paragraph reference was incidentally made to post-mortem changes in the heart. Another has been remarked regarding the ventricles; it is said that in a well-marked state of *rigor mortis* the ventricular cavity will be found obliterated, on making a transverse section.

The connection between the action of the heart and the function of respiration is of great practical importance in operative surgery. In all studies of the mechanics of the heart action it must be kept in mind that the respiration is the most important of all the dynamic agents which affect this action. The existence of extracardiac centres of nerve force which exert a remarkable influence on the heart beat, has been discovered. These extracardiac centres are in juxtaposition to the respiratory centre; hence it may be justly inferred that they too are influenced by the effects produced by variation in the volume of oxygen contained in the blood supply.

Observation has shown an alteration in size of the heart with each pulsation; this causes a rhythmical compression of the adjoining lung tissue. The process by which part at least of this effect is produced, has been explained as follows: The branches of the pulmonary artery receive accession of blood at each right ventricular contraction; this causes them to expand rhythmically in accord with the heart-beat.

The periodical expansion of the arteries produces a corresponding compression of the bronchi. There is nothing extraordinary in this, since it has been remarked by comparative anatomists that this "cardio-pneumatic movement"

is a factor in changing the air in the lungs of hibernating animals.

Clinical experience in certain diseases where there is great dyspnœa, has shown that the dyspnœa, if prolonged, makes the left ventricle beat feebly sooner than the right, so that the left side of the heart becomes congested. This dams back the blood into the pulmonary veins. This may be a probable cause of the pulmonary œdema observed in the death agony.

The influence of the respiratory function is apparent not only in reference to the cardiac movements, but also in reference to the arterial circulation. The expansion of the chest, in respiration, relieves the extracardiac pressure; and the contraction of the chest in expiration increases the pressure upon the heart, thus producing a higher arterial tension. There is a double aspiration carried on by the chest and by the heart itself. Dogiel says that "artificial respiration slows the blood current and may interrupt it, until dyspnœic stimulation of the respiratory centres results." Zuntz claims that "opening the chest wall annuls its aspiration." Beneke found that the pulmonary pressure is relatively higher in a child than in an adult. Lichtheim says that the plugging of one branch of the pulmonary artery will not necessarily alter the aortic pressure. "No known method will cause a permanent general alteration, of any extent, in the blood pressure of the whole body." (Cohnheim.)

The work done by the heart is enormous. The pressure within the cardiac cavities is also considerable; there is both a positive and a negative pressure. The negative pressure of the right ventricle equals two-thirds of an inch of mercury; that of the left ventricle equals from two inches to two and four-fifths of an inch of mercury. Part of this negative pressure of the left ventricle is due to active dilatation. This has been found to equal four-fifths of an inch of mercury. Positive pressure in the right auricle equals four-fifths of an

inch of mercury. At each diastole the pressure in both auricles sinks below the atmospheric pressure (fifteen pounds to the square inch, thirty-nine inches of mercury).

Opening the thorax in operations is said to cause a fall in blood pressure. Part of this loss of pressure is due to the active muscular action (dilatation of the auricle itself independently of respiration).

The negative pressure in the right auricle is equal to one-third of an inch of mercury. Work done by the right ventricle is only one-third of that done by the left ventricle. The work done by the right ventricle is equal to one and one-eighth foot pounds. The work done by the left ventricle at each systole equals three and three-eighths foot pounds. The total work done by the heart, or rather by the two ventricles, equals four and one-half foot pounds.

It has been estimated by Haughton that the mechanical energy expended by the heart in twenty-four hours, equals one hundred and twenty-four foot tons. Taking seventy years as the limit of a man's life, the work done by a normal heart in a lifetime of this length will equal three million one hundred and twenty-four thousand and eight hundred foot tons, a force too stupendous to be grasped. A force of this magnitude would move a train of fifty-two of the largest freight cars loaded to their fullest capacity (twenty tons), over one-half of a mile.

In the several veins the blood-pressure varies greatly, but it always diminishes toward the heart. Change of position will have a greater effect upon the venous pressure than on the arterial. The pressure in all the large veins at the heart has been found to be always negative. (Ludwig, Volkmann, Weyrich.) W. G. Thompson says that he experimentally proved the statement.

The force of each systole—the work of the heart—is one-tenth greater than the arterial resistance. The blood was driven around the entire circulation by an equal force

produced by the pressure of mercury. (In all references to mercurial pressure it must be remembered that it is in addition to the atmospheric pressure of fifteen pounds to the square inch, or thirty-nine inches of mercury.)

An amount of blood equal to one-half or two-thirds the whole volume normally found in any of the higher vertebrates, may be injected or transfused, without danger to the animal injected. Death follows the injection of a volume of blood equal to one and one-half times the normal volume. But, however large the volume of blood injected may be, short of death, the increase is temporary only; the blood soon shrinks to the volume normal to the animal. The normal volume of blood cannot be increased by the ingestion of any amount of food. Increase of the watery element of the blood produces only a temporary increase in the total volume of the blood. Loss from hæmorrhage does not cause a permanent diminution, but the loss of the watery element in certain diseases will cause a diminution in the volume of the blood. In such cases the blood becomes dark, almost black, and of the consistency of tar.

The color of the blood varies considerably, but as a rule the arterial blood is brighter than the venous; pure arterial blood has a vivid red color. Any impurity, any difference in oxygenation, and even the slightest admixture of impure blood will cause a decided change in color. Truly arterial blood is nearly saturated with oxygen, and the plasma contains only a small amount of carbon dioxide.

The process of coagulation has an important practical bearing in operative surgery. Coagulation of the blood is caused by the formation of fibrin. Fibrin does not exist pre-formed in the blood, nor is it held in solution in the plasma, as was once thought. It is formed by the action of fibrinogen and fibrinoplastin in the presence of a certain ferment. The plasma holds the fibrinogen in solution, and the white corpuscles contain the fibrinoplastin, or paraglobulin, and

also the ferment. The fibrinoplastin and ferment are set free by the death of the white corpuscles. The fibrinoplastin, thus freed, is acted upon immediately by the fibrinogen, under conditions that permit chemical action. The ferment does not seem to take any active part in this process, but performs that inexplicable function observed in many chemical reactions.

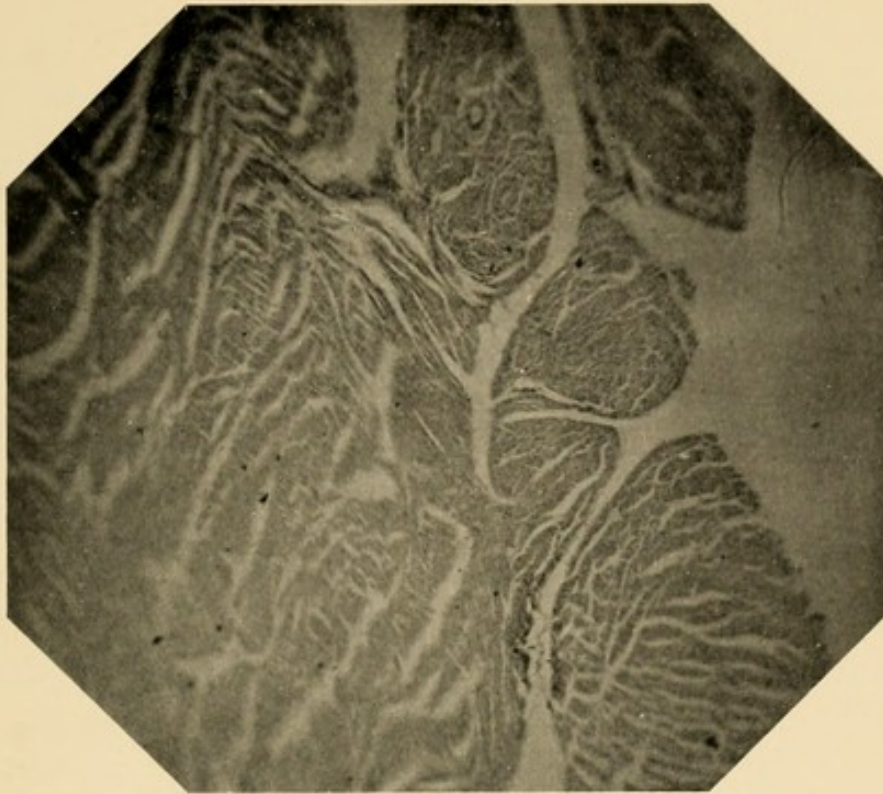
Many chemical combinations can be produced only when the constituent elements act upon one another, in the presence of some substance, which forms no part of the resultant substance, and does no discoverable work in the chemical reaction.

When, from any cause, there is loss of lining endothelium, white blood-corpuscles adhere to the denuded spot, and by their death bring about the formation of fibrin.

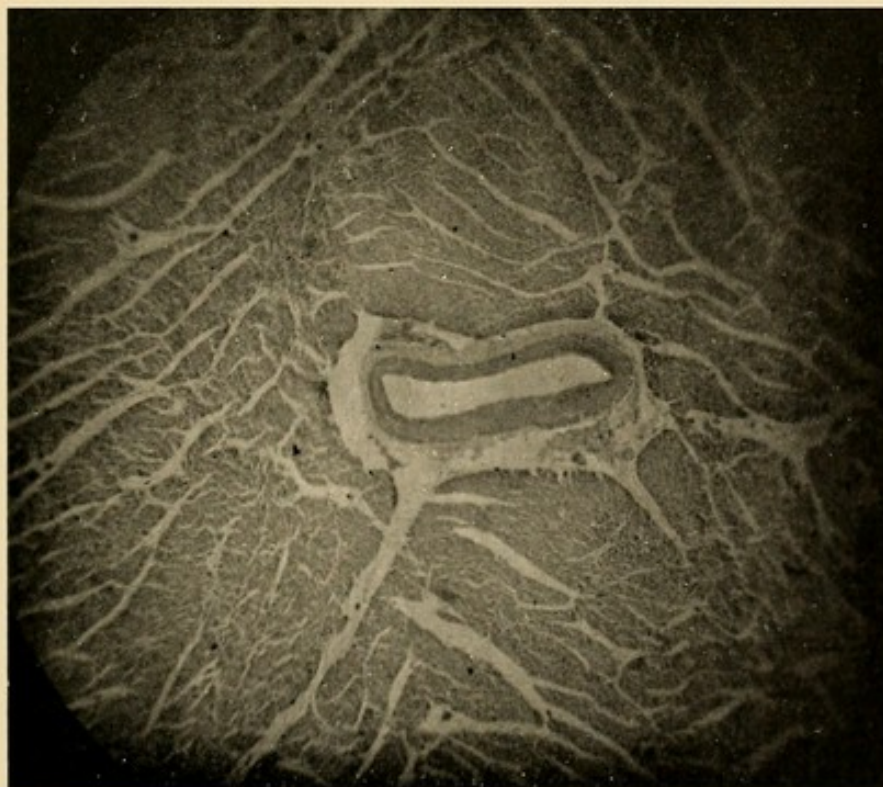
If infection occurs, the presence of micro-organisms or the chemical compounds, however formed, resulting from their presence, will cause a septic or putrid softening under the above circumstances. These processes will account for the formation and structure of the exudative adhesions, observed in the autopsies of the dogs used for this series of experiments. (See Chapter on Results of Experiments.)

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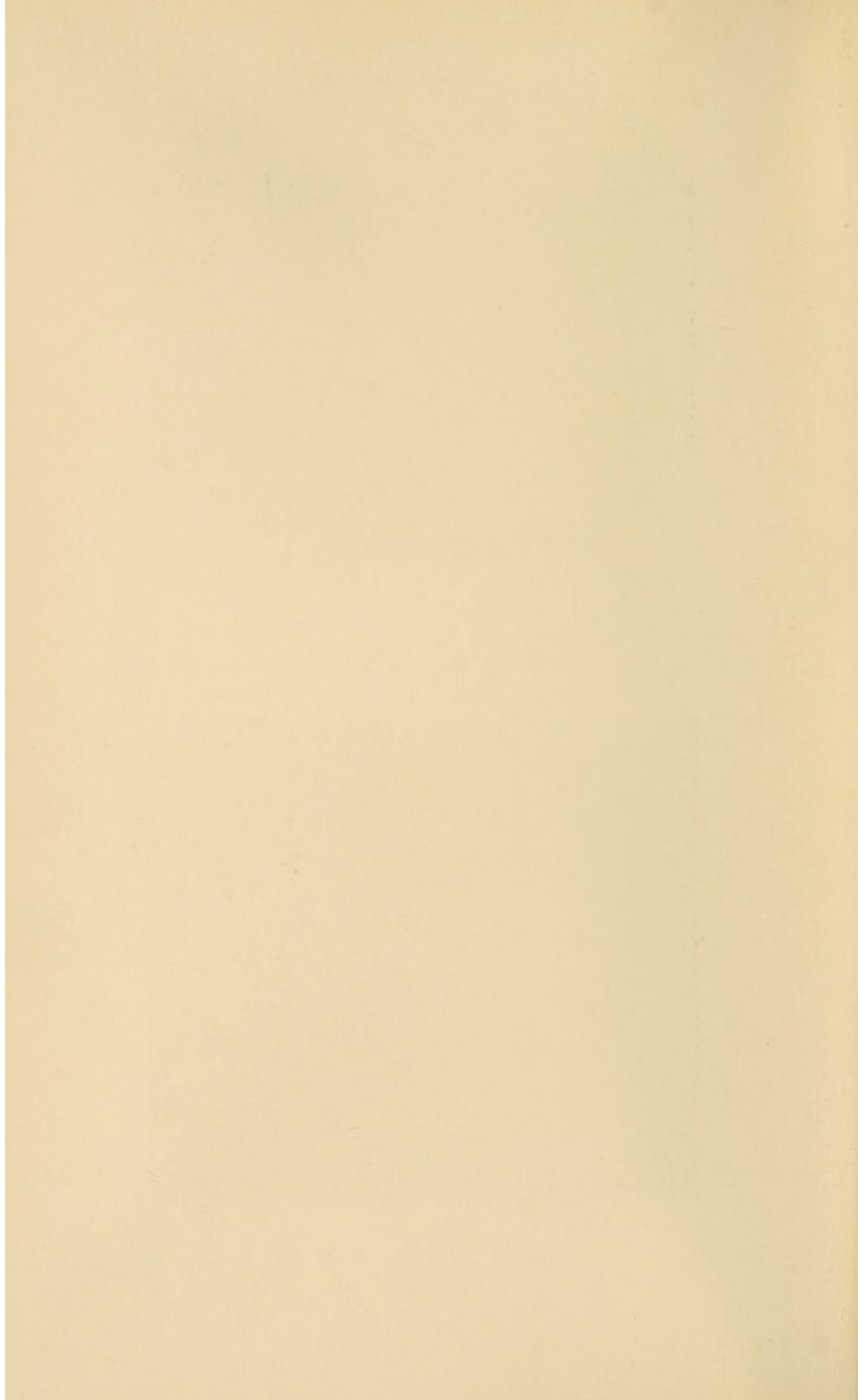


X 160.
TRANSVERSE SECTION OF CARDIAC MUSCULAR FIBRES
SHOWING CAPILLARIES AND THEIR RAMIFICATIONS.
(Dr. A. V. Meigs.)



X 160.
TRANSVERSE SECTION OF CARDIAC MUSCULAR FIBRES
SHOWING MAIN BLOOD VESSEL AND ITS RAMIFY-
ING CAPILLARIES. (Dr. A. V. Meigs.)

(Anatomy of the Heart.)



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CHAPTER II

EXPERIMENTAL RESEARCH

IN reviewing the literature pertaining to the experimental research referring to the surgery of the heart, little is found as compared with that bearing on the physiology of the heart. Physiologists have offered but little if any encouragement in dealing with cardiac injuries. What has been done experimentally and with injuries to the human heart has been independent of the teachings of the physiologist. As soon as the investigator had concluded his work upon the lower animals (and every such investigator appears to have been a surgeon) he reasoned from animal to man, and justly so, as proven by subsequent events in the domain of surgery upon the human heart.

Historical.—Hering was the earliest to ascertain the rapidity of the circulation. He introduced prussiate of potash (cyanide of potassium) into one part of the system and drew blood from another. Legallois, in 1813, experimented on the principle of life, and particularly on the principle of the motion of the heart and on the seat of this principle. Wittbank, in 1824, made a series of experiments to determine the cause of the action of the heart. Hope, in 1830, entered into an experimental and clinical study of the physiology of the heart's action. Brown-Séquard, in 1853, Chauveau, in 1856, Halvord, in 1858, Upham, in 1859, Berner and Flint, in 1861, and Bernard, in 1879, each made an extensive experimental study with reference to the heart's action.

Roberts, in 1881, determined from experimental investigation that puncture of the heart with suture of it would

become a therapeutic measure. Block sutured the cut ventricular wall of a rabbit in 1882. It was not until 1884 that Howell and Donaldson made their experiments upon the dog. Sewall, in 1884, conducted experiments with reference to the physiology of the intermittent heart. Kronecker and Schmey, in 1884, showed by experiments upon rabbits that needle puncture at a certain point in the sæptum between the ventricles produced death by injuring the large nerve ganglia, which are derived only from the sympathetic. The influence is, therefore, sensory and not motor. Pennock and Moore also experimented to determine the action of the heart. Senn, in 1885, made an experimental and clinical study of air embolism (thirty-nine experiments on dogs). He showed that it was possible to remove air from the chambers of the heart by means of an aspirating needle without fatal results. Phillipson made experiments to determine the advisability of applying sutures in wounds of the heart. This was in 1886, and he was followed by Del Vecchio in 1895, who showed by experiments upon dogs the possibility of suturing heart-wounds in man.

Cohnheim showed that pressure in the pericardium from fluid was upon the auricles, that the ventricles would continue to contract, and that sufficient pressure would stop contraction of both auricles and ventricles. Romberg showed, before nerves and ganglia were found in the cardiac muscle, that the foetal heart contracted rhythmically.

Porter says that the cause of rhythmic contraction of the ventricle lies in the ventricle itself. (*Journal of Exp. Med.*, 1, 1895, p. 319.)

Ten out of sixty animals, though their hearts had ceased to beat, were restored to life by the puncture, and completely recovered. One of them, indeed, after two experiments, recovered twice. All except one puncture in the ten cases were made in the right ventricle. These experiments were made by Watson and are referred to by Paget, 1897.

They demonstrate in a beautiful manner that such means of cardiac stimulation may, at times, be beneficial, now and then completely restoring life. Crile, in 1897, showed that gunshot wounds of the heart, not penetrating the chambers, caused but temporary arrhythmia for several beats. Dana, in 1897, stated that he had often punctured the heart in animals, and by so doing had stimulated and never checked it; but he got no results in two cases in practice.

Elsberg, in 1899, made a most elaborate experimental investigation of the treatment of wounds of the heart by means of suture of the heart-muscle. He has shown conclusively that suture of open wounds of the heart is a most rational procedure. However, it had been successfully accomplished in man in 1896. Elsberg thinks there is much doubt as to the existence of new muscle fibres in hypertrophic hearts, especially in the *longitudinal* diameter of old fibres. But connective tissue may degenerate; if it does, the normal tissue surrounding it does not seem to do so. He further says that muscle fibres are destroyed by trauma and replaced by connective tissue, but the change does not interfere with cardiac function. In one of his experiments he amputated the apex of the heart, necessitating the opening of one of the ventricles, and sutured the cut surfaces together without loss of the rabbit's life.

Brunton (*Journal of the Amer. Med. Ass'n.*, March, 1902, p. 589) has conducted a series of experiments upon cats and the dead human body to show the possibilities of surgical operations for mitral stenosis. He states that not only should the pericardium be opened for the operation, but that it should be left open to give exit to any oozing or hæmorrhage, as the heart has little power to resist rapidly occurring intrapericardial pressure. He also says that hæmorrhage is greater from a needle puncture in the auricle than in the ventricle, even though the same needle be used.

N. I. Botcharoff made pharmacologic experiments on the

isolated heart of warm-blooded animals. Villar conducted experiments upon suturing wounds of the hearts of animals. H. M. Sherman reported his observations on experimental heart surgery. G. V. N. Dearborn, in 1903, made a physiological study on a crustacean heart.

"Conclusions.—The operations which have been recorded mark only the beginning; the heart is now destined to be submitted to many manipulations, provided they may be done without stopping its action at once. It is a very unsafe thing to prophesy, but that more will be attempted can easily be inferred, for interference with the mitral orifice has already been suggested and the immediate neighborhood of the heart has been invaded and a sacculated aneurysm of the aorta has been tied off, the success of this well-executed manœuvre being prevented only by the failure of the atheromatous vessel walls to heal. Possibly the next step may be delayed as long as the application to the heart of common surgical methods was delayed after Desault had taught us to open the pericardium. Perhaps it may come soon. It is not impossible that a new surgical technic may have to be created, but it is most probable that the next step will be based on the new application of the very old matters of suture and drainage."

(H. M. Sherman, Suture of Heart Wounds, Journal American Medical Association, 1902, xxxviii, 1560-1568.)

Surgical Shock.—"Surgical shock is in all probability allied to the physiological phenomenon of inhibition, but differs from the physiological condition in that it involves to a greater or less degree the entire nervous system. An inhibition of unimportant areas is not likely to be followed by serious results, but an inhibition of vital centres will prove fatal if severe or long continued.

"Of the important nerve centres in the nervous system, the vasomotor centres take first rank. Hence, in surgical shock it is the vasomotor inhibition which calls most urgently for treatment.

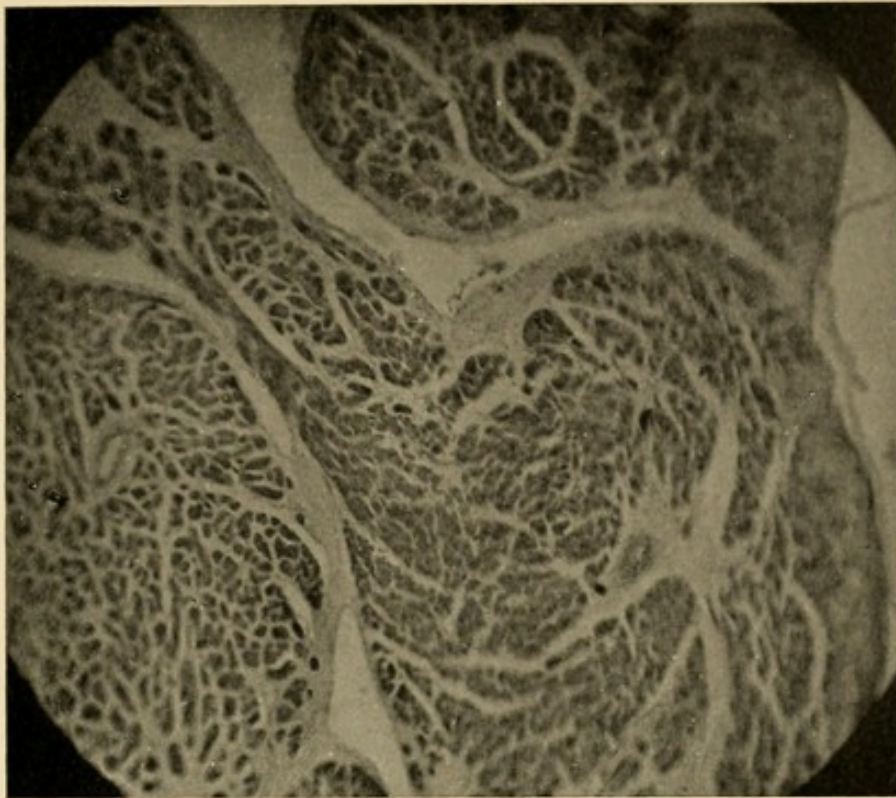
"It is necessary to keep in mind the fact that vasomotor collapse involves principally the arterioles; the heart, probably through its connection with the nervous system, is also implicated, but much less seriously. The heart is an organ that will stand a great many insults and much hard treatment, as those who work on lower animals are aware; but the vasomotor system is exceedingly sensitive and immediately resents any abuse by causing a relaxation of the arterioles throughout the body. In consequence of this, the blood pressure falls, the pulse weakens or disappears, and unless some heroic method of resuscitation is adopted the patient dies of collapse. The heart continues beating for some time after the arterioles relax, but its contractions are feeble and often irregular. Later on, the heart stops its contractions; but here again the cause lies not so much in the heart as in the falling blood-pressure produced by the relaxed arterioles. When the blood pressure sinks, blood can no longer be forced into the coronary arteries, and the heart stops in consequence of a lack of oxygen. It is for this reason that the mammalian heart does not beat rhythmically when excised from the body; its removal stops the coronary circulation, and the organ ceases its beating. When defibrinated blood is transfused through the coronary vessels, the mammalian heart can be made to resume its contractions outside of the body. It is the vasomotor system, then, rather than the heart, which requires treatment in conditions of sudden collapse.

"There is another factor in vasomotor collapse which must not be overlooked. When, in consequence of overstimulation or of some poison in the blood, the vasomotor centres give way and the arterioles relax, the circulation in the central nervous system, where vasomotor centres reside, is interfered with. As a result less blood circulates through the brain and the spinal cord, and therefore less blood is carried to the failing vasomotor centres. A vicious circle is estab-

lished in this way, and eventually the blood-pressure sinks to nil, unless we can break the vicious circle and give the vasomotor centres a chance to recover under an increased blood supply. Strychnine and whiskey act principally by direct stimulation of these centres, and their administration is followed by the desired results, provided the nerve cells are not beyond the capability of reaction. When, however, the nerve cells are powerfully shocked, a direct stimulation depresses rather than stimulates them.

“ The injection of normal saline solution is then more likely to be followed by favorable results, because the liquid, by mechanically filling the blood-vessels, partially compensates for the loss of tone produced by the relaxed arterioles. If the vasomotor centres are not too seriously involved, they react under the increased blood supply brought about by the injection, and recovery results. But, as all surgeons know, even the normal saline solution occasionally fails to do its work properly; in fact, we found in our experiments that even copious injections were accompanied by a distinct fall of pressure in animals suffering with severe vasomotor shock.

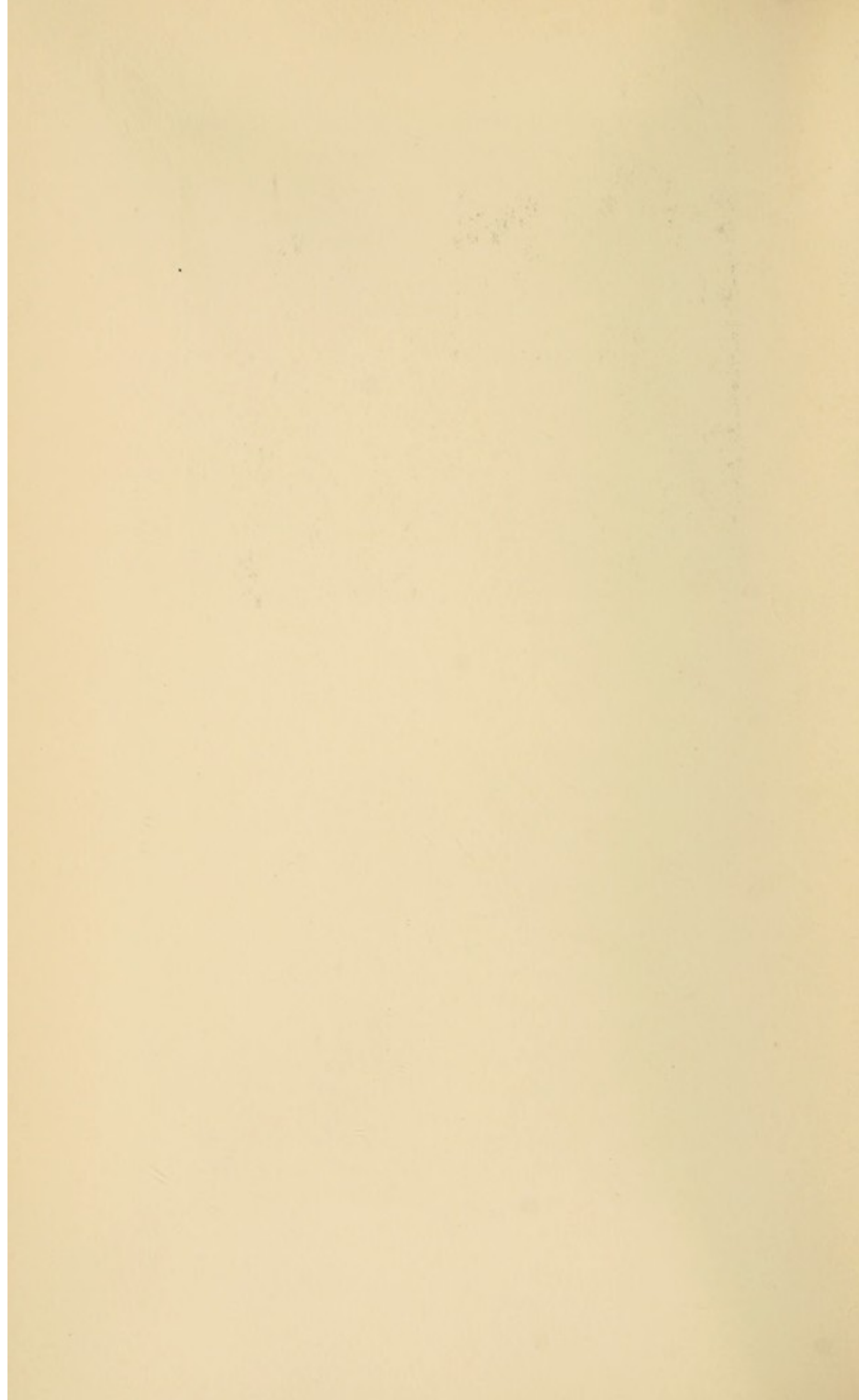
“ Adrenalin, according to Takamine, is the active principle of the medulla of the suprarenal bodies. When injected into the circulation, it causes an enormous rise in blood pressure, due not so much to the stimulation of the vasomotor centres as to the direct stimulation of the heart and arterioles. It produces its effects almost as well on the heart and blood-vessels isolated from the central nervous system as when they are in physiological connection with their nerve centres. When it is injected directly into the blood stream of an animal, the rise is prompt, powerful, but not prolonged. The remedy appears to be very rapidly destroyed or neutralized in the blood, or more probably in the tissues. In adrenalin, then, we have an agent which can rapidly overcome vasomotor shock by acting, not on the centres themselves, but



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(Dr. A. V. Meigs.)



directly on the heart and arterioles, but which unfortunately is very evanescent in its action when injected into the blood. In order to make it a useful remedy for the treatment of the condition under consideration, its action must be made more prolonged and preferably less powerful.

"In a research undertaken by Dr. May Miles and myself, we found that when the adrenalin was diluted to one in ten thousand and about one cubic centimetre was injected hypodermically, the vasomotor collapse consequent on ether poisoning could be completely overcome. The blood pressure in the rabbits experimented on rose rapidly and remained elevated for two hours or longer. The site of the injection must be vigorously massaged in order that absorption may be promoted. We inferred from these experiments that adrenalin in the strength and by the method indicated would be a valuable remedy for surgical shock. The increased blood pressure, by improving the circulation through the central nervous system overcomes the inhibition and permits a restitution to a normal physiological tone."—William Muhlberg, M.D.

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CHAPTER III

CARDIAMORPHIA

Ætiology.—Embryologists claim that the sæptum of the auricle is completed by the sæptum growing backward, as it were, and uniting with the sæptum intermedium. However, before this process is completed, several other changes occur, while the superior sæptum is forming the sæptum intermedium is also in a state of formation, and between these two sæpta at this stage of development there is an opening which was formerly thought to be the origin of the foramen ovale, but Bern and other investigators have shown that a secondary rupture occurs in the superior sæptum.

The opening thus formed by the secondary sæptum of the superior sæptum becomes the foramen ovale. It is very probable that many of the cases of patency of the foramen ovale which have been reported have not been in fact what they were thought to be. There is a very great possibility that the condition observed was due to an arrest in the normal development of the embryo's heart.

The opening that is found between the superior sæptum and the sæptum intermedium has never been closed, either because the union of the two sæpta has been hindered or because further development of this part of the heart has ceased from some cause.

In other cases the effect may have been produced later. Some cause may have prevented the development of the secondary sæptum, or it has not conformed to the changes which have taken place. It is not enough of a secondary sæptum to make (also) a valve for the foramen ovale.

The heart may be abnormally small (hypoplasia). Virchow says that such a condition is most frequently found in chlorotic persons—the hæmophiliacs. Two or more imperfect hearts may be found in the same chest. Atrophy of the heart's walls may occur without lessening the size of its chambers.

Malformations of the heart are of many varieties, and they all vary more or less in degree and must necessarily be considered in a work of such a character as this, the object being to present those defective hearts that will best illustrate the object intended, namely the surgical features. Malformations and anomalies must of necessity be considered together, while displacements and malpositions can be similarly classified.

No doubt death from non-closure of the foramen ovale is less frequent than is generally supposed, other abnormalities being the cause. Autopsies are secured in but a small per cent. of such cases.

Historical (1675-1903).—Openings between the ventricles may be congenital or acquired, and are of many varieties, degrees, and locations, as shown by the various reporters, among whom Marshall, in 1830, mentions a very interesting case, as does Bertody, in 1845, also, when he reports a case of communication between the ventricles of the heart, the aorta originating from both ventricles. In the case of Parker, in 1846, the aperture was in the sæptum of a heart having considerable contraction of the pulmonary orifice, with the aorta arising entirely from the right ventricle. Quain (1846) showed a congenital perforation at the base of the sæptum ventriculorum. A similar one is mentioned by Bennett (1846), but that of Peacock (1848) was a much larger foramen ovale than is usually found dependent upon contraction of the aortic orifice. In the case of Mayne (1847) the open foramen ovale had caused remarkable derangement of the circulation. In Jenner's cases (1848) the subjects did not

have any disturbance of the circulation, but in that of Lloyd (1848), there was considerable dilatation of the right side of the heart. None of these manifestations was displayed in the case of Wienholt (1848). However, there was great cyanosis in a case reported by Lee (1849), in which the opening between the ventricles was near the mouth of the aorta, with contraction of the pulmonary artery. One of the most interesting of the pathological conditions of this type of anomalies is reported by Hutchinson (1853), in which he mentions a malformation of the heart in a child who had suffered from cyanosis. There was an imperfect ventricular sæptum, with a rudimentary right ventricle which had been divided into two chambers by a fleshy sæptum between its sinus and its infundibular portion.

Peacock (1859) reports a large open foramen ovale without cyanosis, while Callender's case revealed a perforation of the sæptum ventriculorum with clots in some of the pulmonary arteries undergoing various changes. Wagstaffe (1868) reports two cases of free communication between the auricles by deficiency of the upper part of the sæptum auriculorum in persons aged fifty-two and six years respectively. There was no cyanosis in either case. In the case of Holt (1884) there was an open foramen ovale and an open ductus arteriosus with stenosis of the aorta and hypertrophy of both ventricles. Haddon (1890) reports a case in which there was a patent foramen ovale in an adult, and Griffith (1896) mentions a case of perforate sæptum ventriculorum and remarks on its diagnosis. Solomon (1898) reports a case of patent foramen ovale and an extra coronary artery.

Aorta and Pulmonary Artery.—Transposition or obliteration of the pulmonary artery is quite common. It may open into any one or all of the cavities of the heart, as may the aorta also. Indeed, the pulmonary artery may connect with the aorta directly. Reid (1835) reports a case of obliteration of the vena cava superior at its entrance into the heart,

while West mentions a case of malformation of the heart and great vessels attended with cyanosis. In the case of Bertody (1835) not only did the aorta originate from both ventricles, but there was a communication between them.

In the diseased heart reported by Dalrymple (1846) the root of the aorta had an opening common to the ventricles. In Parker's case (1846) the aorta arose entirely from the right ventricle. Cheever (1846) reports a case illustrating the earliest stage of malformation, usually known as distribution of the descending aorta from the pulmonary artery. Peacock (1847) reports a case of malformation of the heart in which death resulted from obstruction in the trunk of the pulmonary artery. He again reports (1848) a case in which there was contraction of the pulmonary orifice which partially originated from the right ventricle.

In the case of Canton (1848) there was complete obliteration of the origin of the aorta. In Ward's (1850) case there was transposition of the aorta and pulmonary artery. Grieg (1852) mentions a case in which the pulmonary artery was given off from the descending aorta and left subclavian artery. In the case of Peacock (1853) there was great contraction of the pulmonary orifice with deficiency of the *sæptum ventriculorum* and open foramen ovale. In another (1855) both auricles opened into the left ventricle and there was transposition of the pulmonary artery and aorta. In still another (1859) he reports absence of the ductus arteriosus with a small-sized pulmonary artery and the aorta arising from both ventricles. There was great irregularity in the course of the aorta. In the case of Baly (1856) the pulmonary artery was impervious at its origin. In the case of Schilling (1857) there was an abnormal arrangement of the larger vessels to the heart.

Abrahamson, in 1857, reports a case in which there was partial obliteration of the ascending aorta. Meigs, in 1860,

briefly reports a case in which there was transposition of the heart's vessels.

Nunneley (1862) writes extensively on a condition which he found, in which the aorta freely communicated with both ventricles, and these with each other; the walls were small and thin and the pulmonary artery had a small slit-like opening into the ventricle. There was an open foramen ovale. Cockle (1863) reports a case in which there was transposition of the great vessels of the heart. Peacock (1864) reports a case in which there was obliteration of the orifice of the pulmonary artery, with an open foramen ovale and ductus arteriosus; there was cyanosis. In another case which Peacock mentions (1869) there was atresia of the orifice of the pulmonary artery, and the aorta communicated with both ventricles. He speaks of a similar case the same year and of another one in 1870. During this year (1870) he reports a case of great contraction of the pulmonic orifice, the aorta arising from the right ventricle, but communicating with the left by an aperture in the sæptum; he also reports this year (1870) a case of almost complete separation between the sinus and infundibular portion of the right lung, the aorta arising from both ventricles.

Green (1867) reports a case of malformation of the heart with absence of pulmonary artery and the aorta springing from the right ventricle. The sæptum ventriculorum was incomplete and there was a patent foramen ovale. Vulpian (1868) speaks of a case of complete obliteration of the orifice of the pulmonary artery. Hickmann (1869) reports a case of malposition of the heart and transposition of the auricles and aorta; there was absence of the pulmonary artery and the foramen ovale was patent, communicating with the ventricles, with lateral transposition; there was visceral cyanosis. Again, Hickmann (1869) reports a case in which there was transposition of the viscera, with malformation of the heart, the pulmonary veins from the right lung enter-

ing the left auricle and those from the left lung entering the right auricle.

Allis (1871) reports a case of malformation of the heart in which there was stenosis of the pulmonary artery, perforation of the ventricular sæptum, and dilation of the right ventricle. Rex (1874) reports a case of congenital malformation of the heart, contraction of the pulmonary artery, and deficient sæptum ventriculorum, the aorta originating from both ventricles. There was no cyanosis. Janeway (1877) reports a case of malposition of the pulmonary artery and aorta, thrombosis in the heart, cerebral embolism, and death from intestinal hæmorrhage. Archer (1878) reports a case in which there was a congenital band across the origin of the aorta. Stone (1878), from among his clinical cases, reports a congenital malformation of the heart without a pulmonary artery.

Peacock (1876) reports stenosis at the commencement of the conus arteriosus, at the right ventricle, and at the origin of the pulmonary artery. The aperture in the sæptum ventriculorum and aorta arose partly from the right side. The foramen ovale and ductus arteriosus were closed; there had been cyanosis. In another which he reports (1880) there was great stenosis of the orifice of the pulmonary artery, the aorta arising from both ventricles. There were defects in the folds of the foramen ovale, but the ductus arteriosus was closed.

Lees (1880) reports a case of malformation of the heart with transposition of the aorta and pulmonary artery. Shattock (1881) reports atresia of the aortic orifice in an infant, while Ashley (1881) records a case of transposition of the aorta and pulmonary artery in a child seven months old. One of the most interesting cases of this class of anomalies is reported by Cronk (1881). The aorta arched over the right bronchus and the pulmonary artery closed about the semilunar valves. Abercrombie (1882) reports a case of con-

genital atresia of the right ventricle with patency of the ductus arteriosus.

Livingstone (1883) reports on a congenital communication between the right side of the heart and the beginning of the aorta. Meyer (1883) mentions a case of cyanosis due to congenital defects of the aortic orifice. The child lived twenty-seven days. Bury (1884) reports a case of congenital contraction of the orifice of the pulmonary artery from fusion of the valves, the foramen ovale being open. Again, in 1887, he notes a case of congenital malformation of the heart, congenital atresia of the conus arteriosus, incomplete sæptum ventriculorum, and the aorta arising mainly from the right ventricle. Little (1880) reports a case of abnormality of the great cardiac vessels with absence of the superior vena cava. Habershorn (1887) reports a congenital malformation of the heart and kidneys with obliteration of the pulmonary artery, the aorta arising from the right ventricle. There was imperfection of the sæptum ventriculorum, and the lungs were supplied from the aorta by a large ductus arteriosus dividing into right and left pulmonary branches. There was a horseshoe kidney. De Renzi (1889) reports three cases of abnormality of the heart and one of the great vessels also. Cadet de Gassicourt (1890) reports a case of malformation of the pulmonary artery. Howard (1892) reports a case of congenital malformation of the heart and atresia of the pulmonary artery with persistence of the fœtal circulation. Stuertz (1894) mentions a case of obliteration of the aorta. Nazaroff (1895) reports a congenital deformity of the heart (narrowing of the cone and the orifice of the pulmonary artery with an opening on the intraventricular and interauricular sæptum), so diagnosticated during life and confirmed by autopsy. Bovaird (1895) reports two cases of congenital cyanosis due to stenosis of the pulmonary orifice with an interventricular foramen. Holt (1895) reports a malforma-



TRANSVERSE SECTION OF HEART, $\frac{3}{4}$ INCH FROM APEX.



TRANSVERSE SECTION OF HEART, $1\frac{1}{2}$ INCHES FROM APEX.



tion of the heart with pulmonary stenosis, a deficient ventricular sæptum, open ductus arteriosus, and the aorta arising from both ventricles, but principally from the right. Caubet and Baylac (1896) report congenital cyanosis and complete inversion of the viscera. Caillé (1896) reports a case of transposition of large vessels in the heart, as does Rolleston (1897), also Gallaverdin (1896) reports a case of cardiac malformation with absence of the pulmonary orifice.

Cavities.—That a human being may live indefinitely with two, three, four, five, or six cavities of the heart has been shown by the various reports herein mentioned. Such facts, however, have been recognized from the earliest writings on anatomy. Foster (1846) reports a heart with only two cavities, while Crisp during the same year mentions a heart with only a single auricle and ventricle. Ramsbotham (1846) reports the heart of an infant with only one ventricle and auricle. Hutchinson (1853) mentions a case of rudimentary right ventricle, giving the heart five chambers. Dalton (1855) reports a heart in which there were but one auricle and one ventricle. Clark (1857) reports a case of but a single heart. Bradley (1873) reports a tricœlian human heart, while Fenton (1873) reports a heart with five cavities. Heineman (1878) writes exhaustively on a malformed heart in which there was absence of the right ventricular cavity with occlusion of the pulmonary artery. Baldwin (1879) reports a most interesting condition found in a case of malformation of the right heart. There was dropsy involving only the lower extremity and half of the trunk. Stone (1881) reports a case of tricœlian heart with insufficiency of the ventricular sæptum. Turner (1882) reports a malformed heart consisting of but two cavities. Schrötter (1887) mentions a case of dextrocardia, while Shattock mentions a heart with a bifid apex. Holt (1890) reports a congenital malformation of the heart resembling

dextrocardia, with entire absence of the *sæptum ventriculorum*, pulmonary stenosis, and patent foramen ovale. Mayer (1892) records a double-hearted freak.

Cowan, John, on obstruction of the coronary arteries, *Glasgow Medical Journal*, 1902, lvii, 260-275; 2 fig.

Dr. Cowan in a résumé states:

1. The coronary arteries may be obstructed—(1) at their origin; (2), in their course.

2. If the obstruction involves a main artery and the closure is gradual, compensatory enlargement of the other artery may prevent damage to the cardiac muscle, but perfect compensation is rare, and necrosis or fibroid change commonly ensues, if, however, the closure is rapid, sudden death is the usual result.

3. If the obstruction involves a small artery no compensatory arrangement is possible, and the nutrition of the cardiac muscle will suffer whether the closure is rapid or gradual.

4. (a) If the obstruction is partial some of the muscle may degenerate (granular or fatty degeneration) and may ultimately disappear and be replaced by fibrous tissue; (b) If the obstruction is complete some of the muscle will become necrosed (infarct) and the patient may die from slow cardiac failure or from rupture of the heart; if, however, the infarct is of small size healing may take place and a fibroid scar be ultimately formed.

For other abnormalities and for the formation of the heart and its great vessels, reference may be made to the bibliography.

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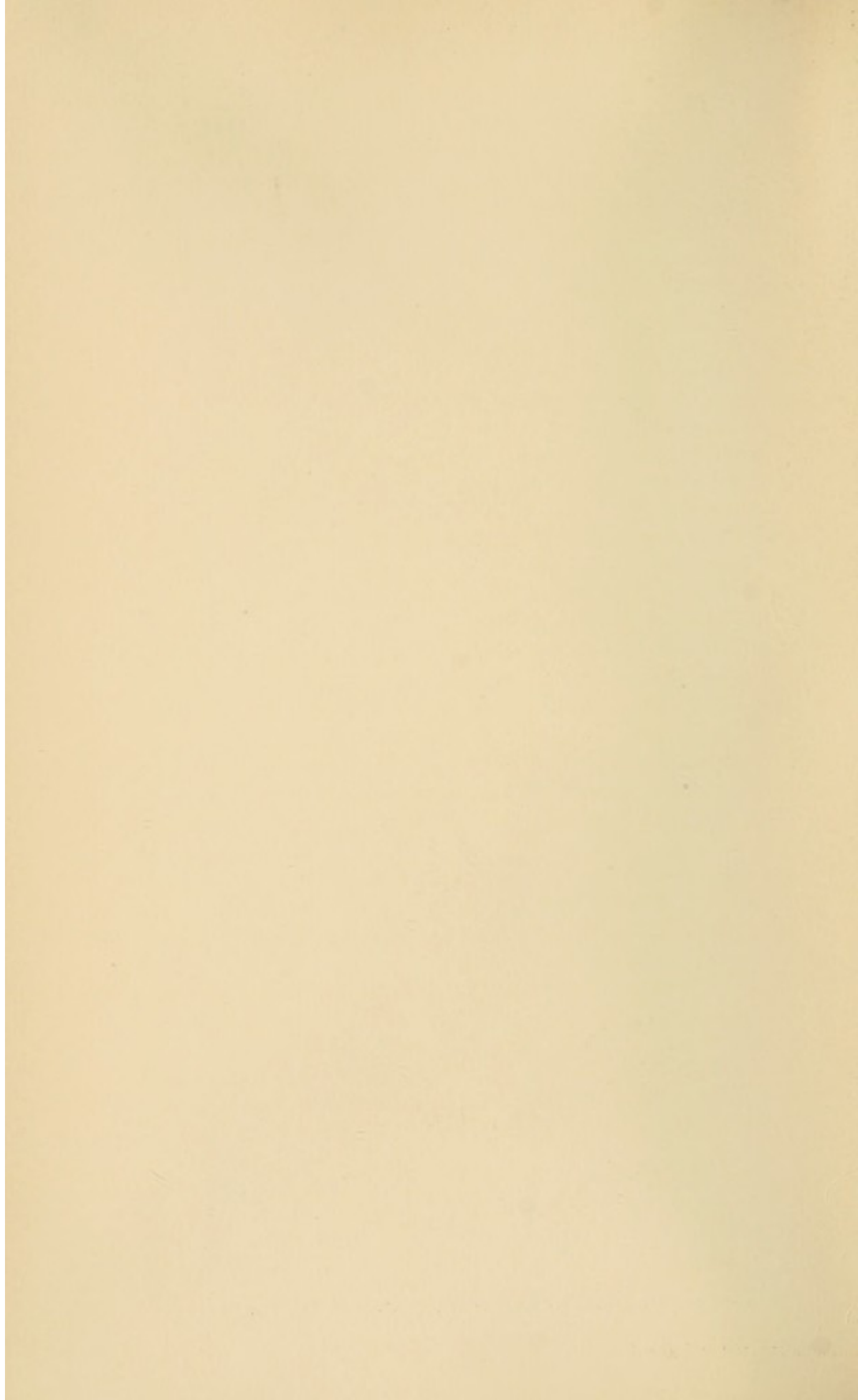
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TRANSVERSE SECTION OF HEART, $2\frac{1}{4}$ INCHES FROM APEX.



TRANSVERSE SECTION OF HEART, 3 INCHES FROM APEX.



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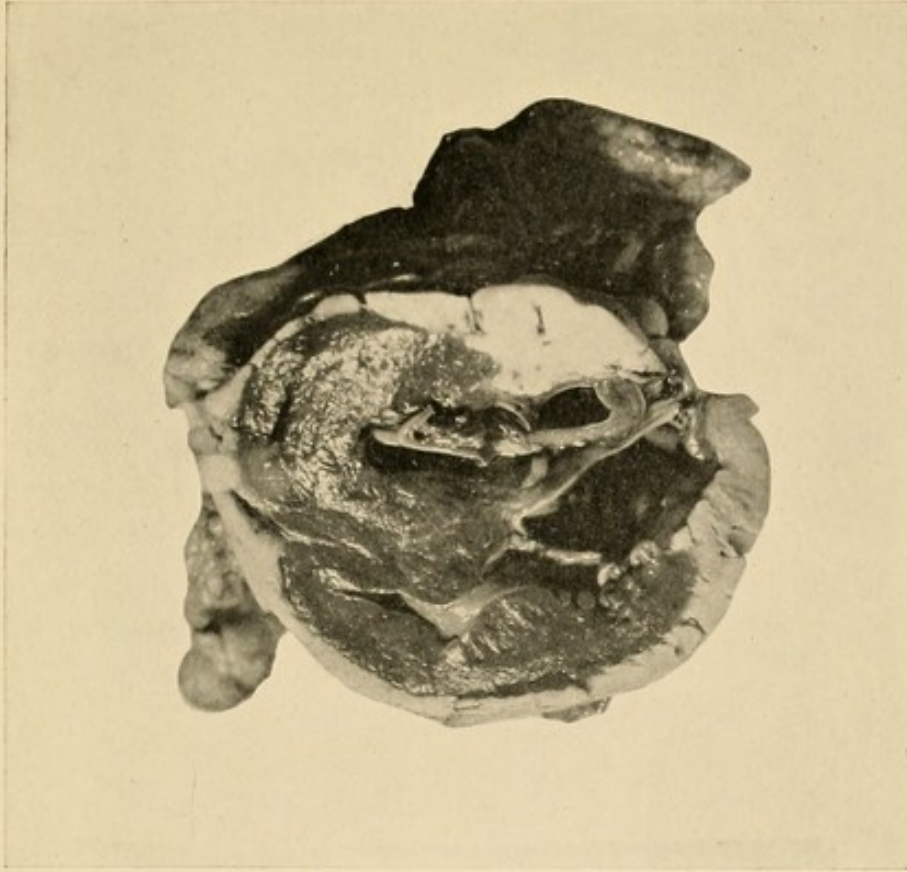
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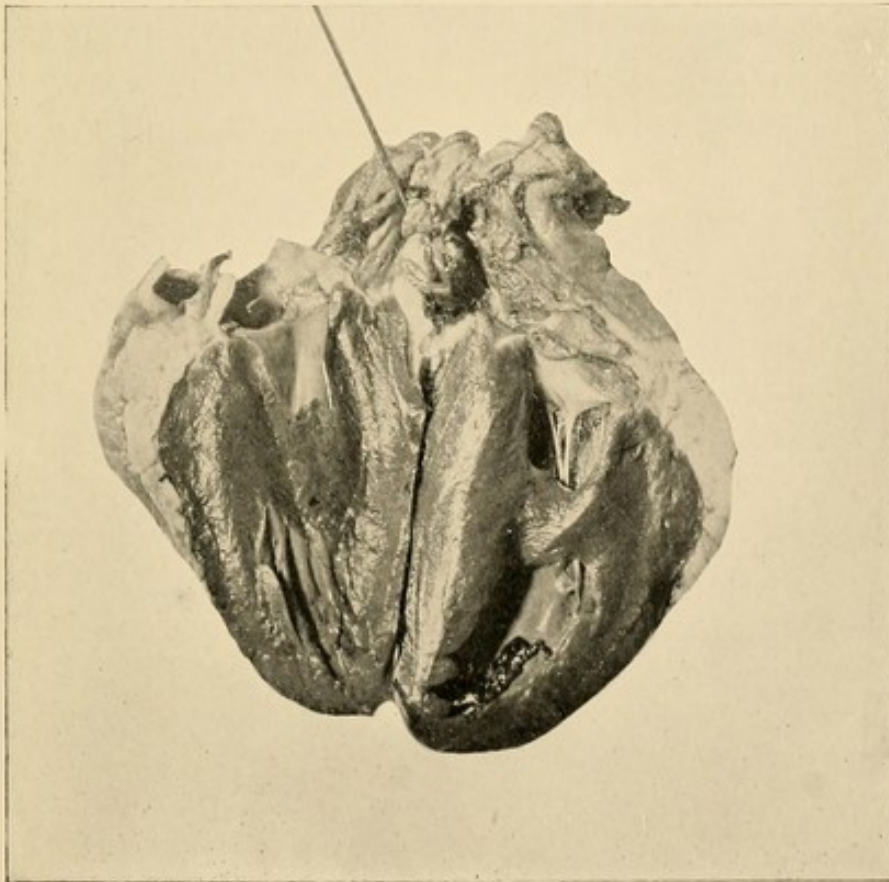
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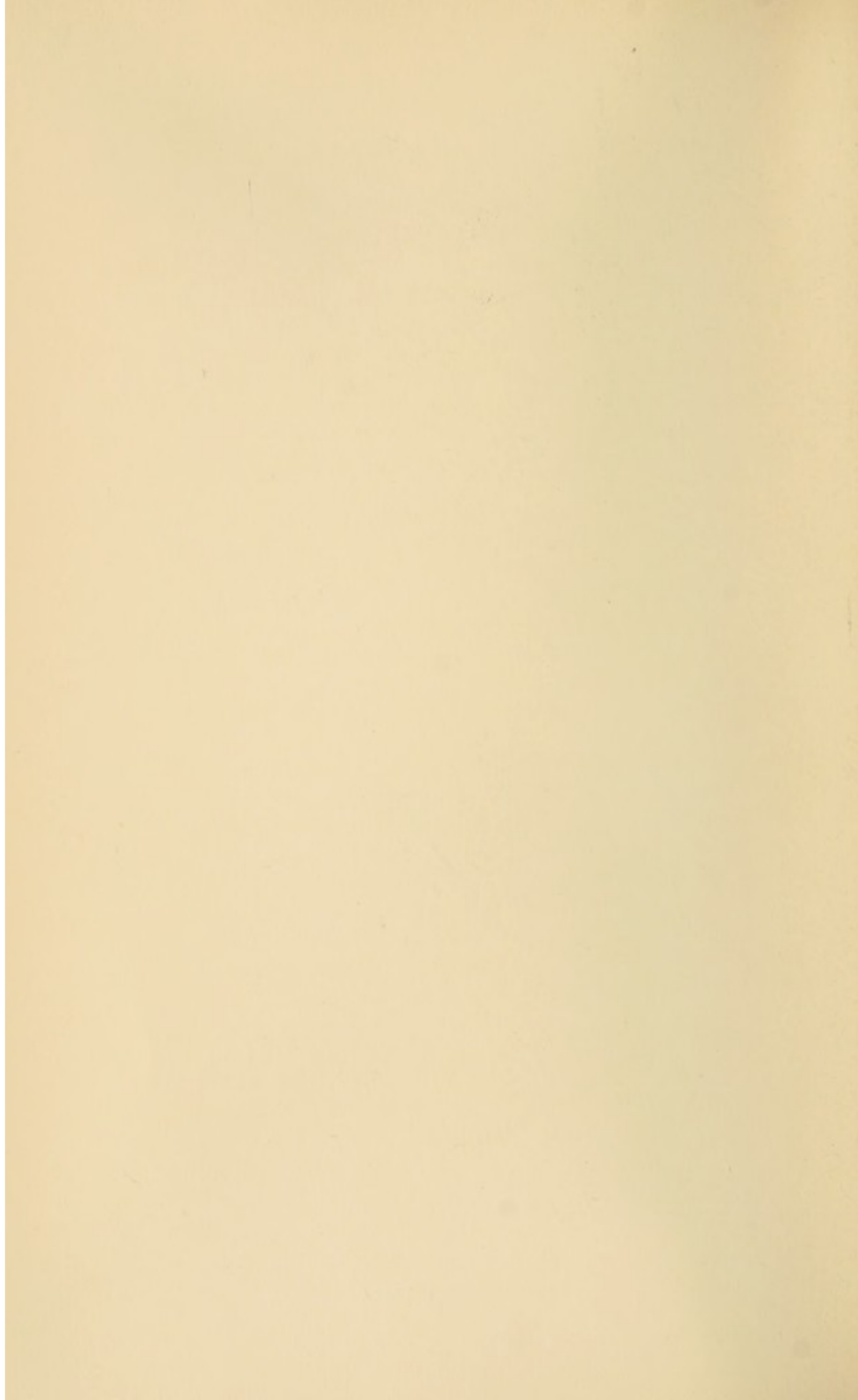
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TRANSVERSE SECTION OF HEART, $4\frac{1}{2}$ INCHES FROM APEX.



LONGITUDINAL SECTION OF HEART, DIVIDING THE RIGHT
AND LEFT HEART.



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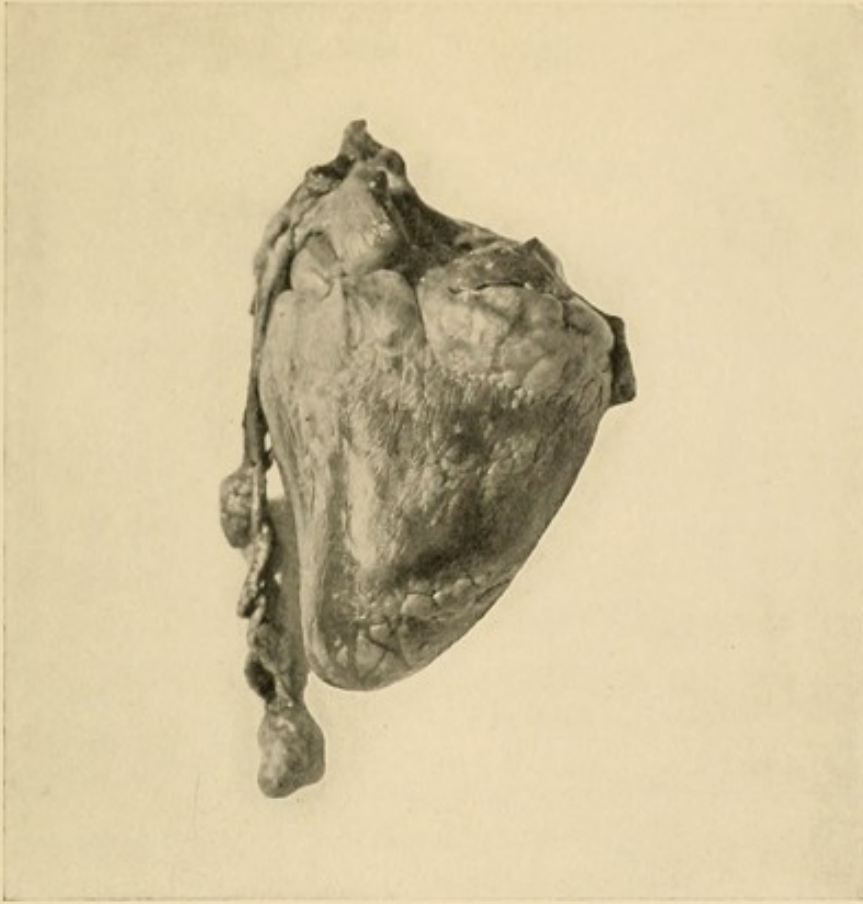
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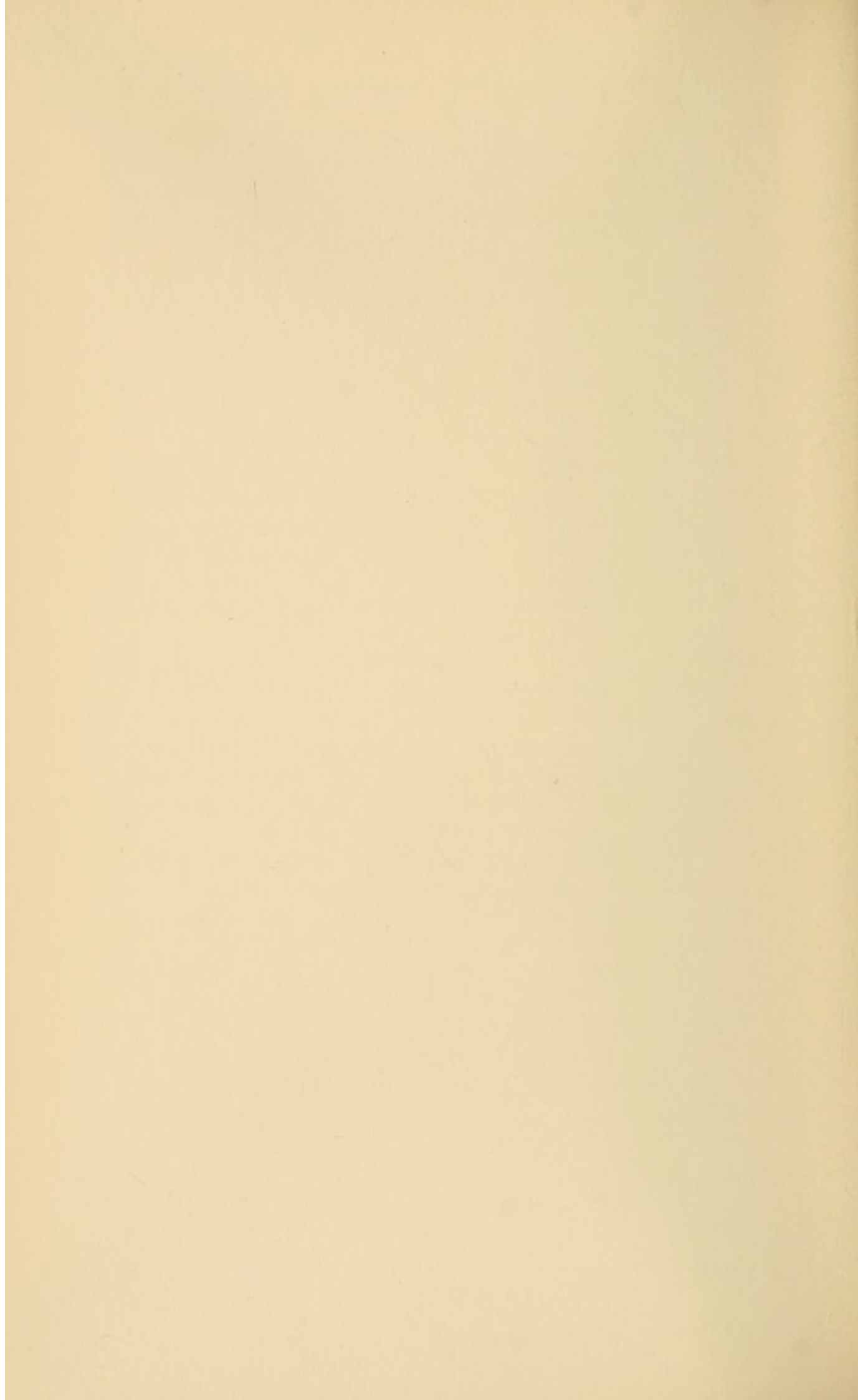
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VIEW OF RIGHT HEART.



INCISION IN RIGHT VENTRICULAR WALL SHOWING ITS
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CHAPTER IV

ECTOCARDIA

DISPLACEMENT—a putting out of place; applied to various organs. **Malpositions**—*Malus*, bad, *ponere*, to place—the improper or abnormal position of any part or organ.

Displacement may be congenital or acquired, or it may be due to change with the movements of respiration or bodily posture.

Historical (1797-1903).—Congenital. The heart may occupy any portion of the thoracic cavity of man. It has, in two cases, been found in the abdominal cavity, the deviation from the normal type being greater and more diversified in the congenital displacements.

The heart may even protrude through the chest wall, several such cases having been recorded. Abernethy, in 1793, reported an unusual case of transposition of the heart and distribution of the blood-vessels together with a very strange and singular formation of the liver. Lippington (1834) recorded a case of transposition of the heart with complete obliteration of the gall bladder. Lyons (1836) reported a case of malposition of the heart with imperforate vagina, and O'Bryan a case of partial ectopia cordis with umbilical hernia.

Smith (1808) recorded a case in which the heart was on the right side without transposition of other viscera. Bramwell (1881) reported a rare form of congenital misplacement of the heart in which the organ was situated on the right side of the body, and in which the liver remained on the right

side of the body in its natural position. Robinson (1881) reported a case of transposition of the heart with abnormal and imperfect development, there being only one auricle and one ventricle. Babcock (1884) recorded a most remarkable case of dexiocardia. Augyan (1888) gave an interesting account of a case of dexiocardia with insufficient bicuspid valves. Huchard (1888) and Holt each report a case in which the apex beat was in the abdominal cavity, the heart being there also.

François-Franck (1889) mentions a novel case of congenital cardiac ectopia. Sandhoff (1890) reports a case of congenital dextrocardia and transposition of the thoracic viscera. Abrams (1900) professes to have discovered a new physical sign in dislocation of the heart. He states that gastroectatic dyspnoea and pseudoangina indicate a displaced heart. Droog (1894) reports a case of congenital dextrocardia with hernia of the lung. Perregaux (1894) records a case of displaced heart in a new-born infant. There was apparent absence of the right lung. It died of suffocation. MacLennan (1896) speaks of a case in which there was dexiocardia without displacement of other viscera. Gerrard (1896) reports a case of dextrocardia with the apex beat four inches and a half to the right of the ensiform cartilage, with no impulse at its normal position.

Pic (1897) reported a case of pleural effusion in which the differential diagnosis involved congenital dextrocardia. Morgagni recorded a case of ectopia cordis congenita. Barnardo (1897) recorded a case of ectopia cordis with a fissure in the sternum.

Oki (1898), of Tokio, gave a unique description of a misplaced heart, and Duchamp reported a case of dextrocardia with general visceral inversion in which he applied the x ray to determine the diagnosis. Stockton (1897) recorded a case of phrenic paralysis with transposition of the heart. Dalton (1898) reported a case of dextrocardia with left superior

vena cava. Michael (1900) mentions a case of dextrocardia complicating chorea. Fitzgerald's (1900) case was one in which the apex beat was below the angle of the right scapula.

Murrell, D. E. (1901), in a personal communication, reports the case of C. F. Smith, twenty-four years old, five feet ten inches high, with the chest well developed and of even conformation, measuring thirty-nine inches on inspiration and thirty-five inches on expiration. The apex beat of the heart was two inches to the left of the right nipple and the same distance below that point, the impact being most distinct at the lower border of the sixth rib. This condition was discovered several years ago in examining his chest for an attack of pneumonia, at which time he said he had known for some time previous that his heart did not beat where other people's did. There was no effusion then to account for the displacement and no previous history of any trouble about the chest. His health was good and the dextrocardia, no doubt, was congenital. He was a bolt-maker by occupation.

Acquired Malpositions.—The position of the heart may be changed suddenly (as by trauma) or the change may be gradual, most frequently the latter. If sudden, it is due to the sudden change in the shape of the chest, or hæmorrhage into it, or both.

If slowly changed, it may be due to numerous causes, such as aneurysm of the arch, empyema or hypertrophy, direct or indirect pressure from the accumulation of hard or soft fluids within the thoracic, mediastinal, or abdominal cavity, or tumor growth of the hard or soft tissues entering into the formation of either of these cavities or their contents.

A frequent cause in changing the position of the heart is found in curvature of the spine. Stokes (1831) records a case of probable dislocation of the heart from violence. Curran (1862) reports one of malposition of the heart resulting from collateral disease or visceral derangement; Green-

ough one in which the heart was displaced to the right side as a result of disease of the right lung.

Brackenridge (1880) gave a clinical lecture on pulmonary phthisis with fibroid contraction of the right lung, displacement of the heart upward and to the right, angular bending of the aorta, and dilatation of the angle, simulating a considerable aneurysm. Lambert (1880) recorded a case of traumatic cardiac hernia. McSherry (1886) recorded a case of displacement of the heart to the left due to contraction of the lung on that side. Nedwill (1887) records one of extreme displacement of the heart from the left to the right, from purulent effusion into the left pleura. Kukharski (1888) mentions complete transposition of the heart to the right half of the thorax, following atelectasis of the right lung. Lannelongue (1888) wrote of ectocardia and its cure by autoplasty. Hawkins (1890) mentions a case of displacement of the heart to the right side, the other viscera being normal in position. There was pulmonary stenosis with regurgitation. McGee reports a case of acquired dextrocardia. Hall (1898) reports one due to lung disease. Satterthwaite (1899) reports one due to lateral curvature of the spine; Wilson, one with functional irregularity due to pleuritic effusion. Barbier (1900) reports a case of dextrocardia resulting from pulmonary tuberculosis. Leusser (1902) considers movable heart and offers various suggestions for its relief. Lannelongue (1901) reports his observations on a successful operation for ectocardia performed in 1888. Beeson, C. F. (1903), records a case of displacement of the heart due to aneurysm of the descending aorta.

Cardiaptosis.—Abrams (*N. Y. Med. Journal*, Sept. 5, 1903, p. 484), considers the downward falling of the heart (non-congenital) due to: 1, increased size and weight of the heart; 2, aneurysms and new growths that displace the heart downward; 3, adhesions pleural and pericardial.

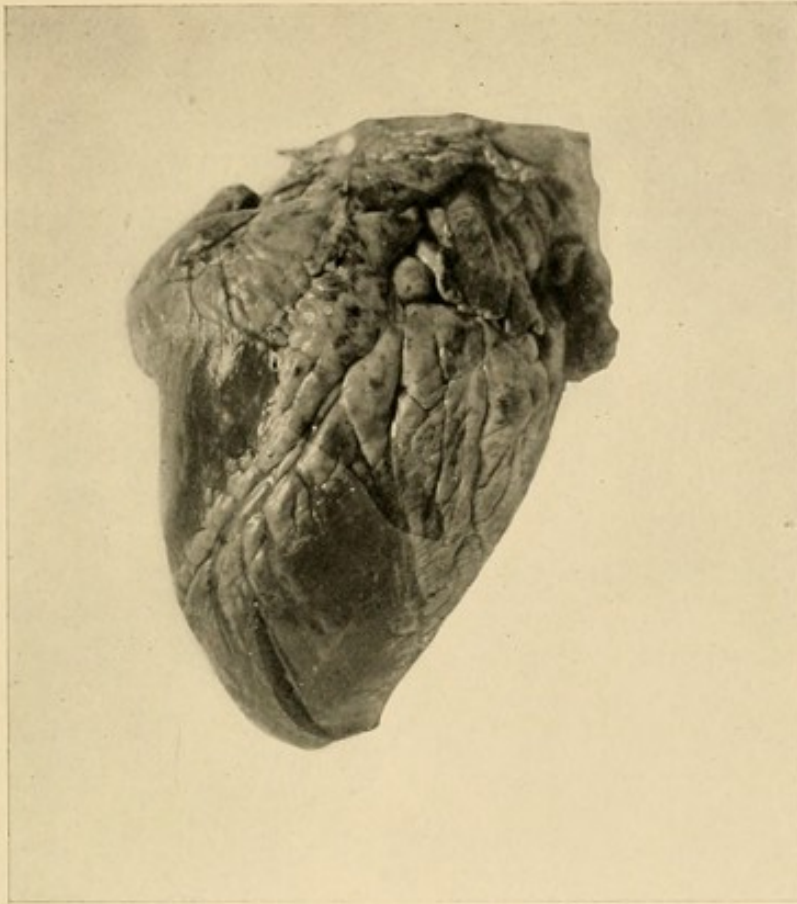
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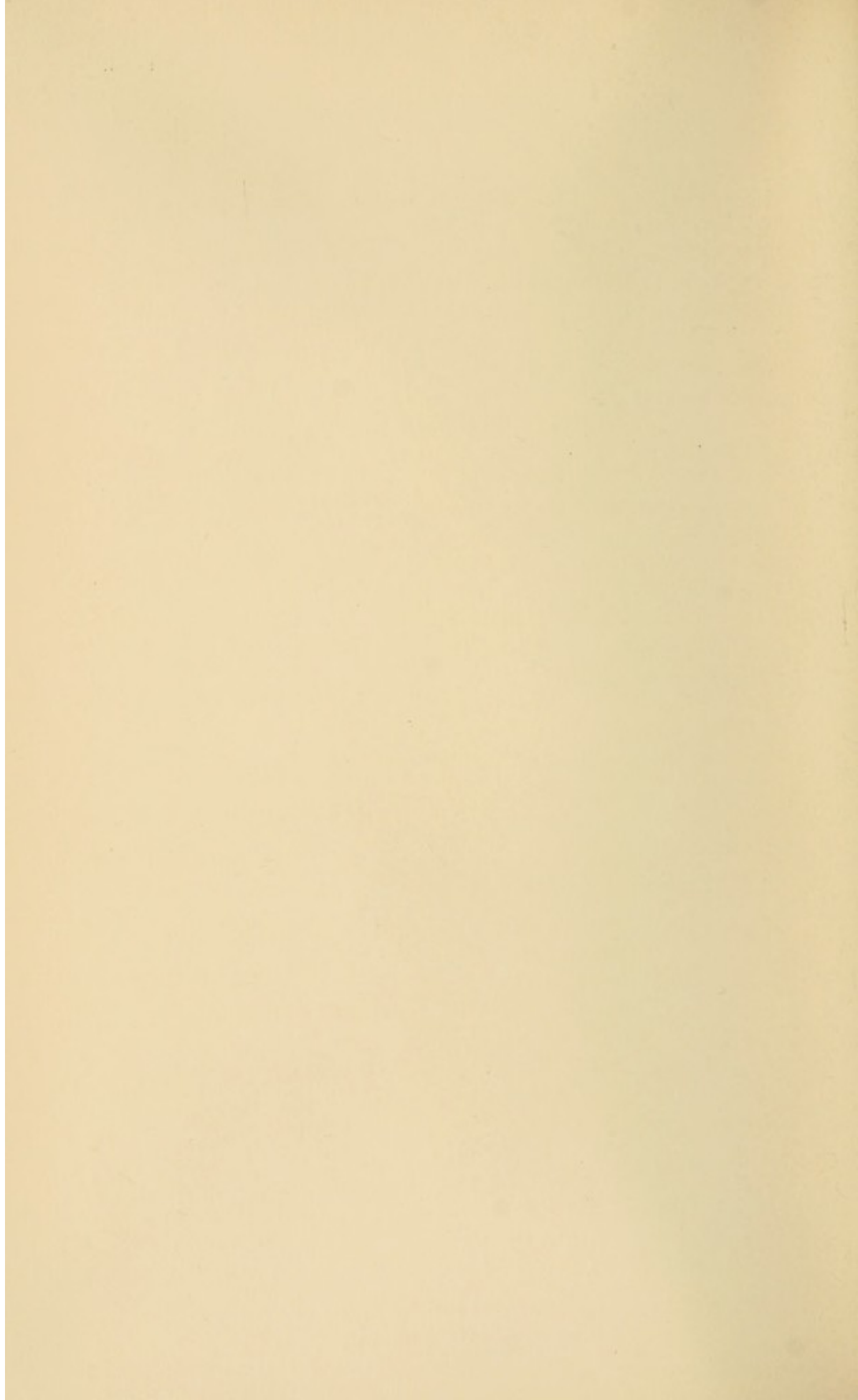
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ANTERIOR VIEW OF LEFT HEART SHOWING INCISION IN
APEX.



PENETRATING INCISION OF LEFT VENTRICULAR WALL
SHOWING ITS THICKNESS.



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CHAPTER V

GUNSHOT, LACERATED, AND INCISED WOUNDS

WOUNDS of the heart are of many characters and degrees. Before the use of firearms, daggers, spears, and arrows were most common, but since the introduction of firearms it is probable that injuries of the heart are more frequently due to their use.

Historical (1552-1903).—Paré, in 1552, was one of the first to refer to the statement that heart wounds must result in instant death. He saw a duelist run two hundred paces before falling with a sword wound in his heart large enough to admit the finger. In the meantime he fought his antagonist in a most vicious manner.

Senac, in 1749, attributed the sudden death to profuse bleeding, while Morgagni thought it due to obstruction of the circulation dependent upon the distention of the pericardium from bleeding. The latter author reports the case of Valsalva, in which death occurred on the eighth day following a wound of the right ventricle.

Aprilis wrote concerning a case of sword wound of the right auricle, resulting in death five days after. (This report is in the first medical journal ever published, 1680, Obs. X, a copy of which is now in possession of the Surgeon-General of the United States Army.) In the case reported by Courtial (1705), in which there was a wound of the left ventricle, the patient walked five hundred paces and lived five hours. Chastanet (1783) collected many cases of gunshot wounds of the heart from the records of Bonetus, Morgagni, and others,

and recorded five interesting cases of his own. Lerouge (1792) reports the case of a soldier who resumed his vocation on the ninth day after receiving a stab in the right auricle, and died suddenly on the eleventh day at a cabaret.

The case of Durande (1798), in which there was a sword wound of the right ventricle, did not terminate fatally until the end of the fifteenth day. This patient lived longer than the usual time after the infliction of such a wound. If life is prolonged to this extent recovery usually ensues. In Babington's case of the same year (1798) the patient lived but nine hours after having received a bayonet thrust through the entire heart. In the case of Frisi the patient lived ten days after having received a wound of the left ventricle. Fournier (1834) reports the case of a soldier who received a gunshot wound in the breast followed by profuse hæmorrhage. He was thought to be dead; however, he rallied and in three months recovered, dying three years later, when the ball was found buried in the apex of the heart.

One of the most curious cases on record is that of Holmes (1845), who reports an accident in which there was a gunshot wound of the heart without perforation of the pericardium. This ball entered from above, passing through the base of the heart, clearing the pericardial attachments. Lavender (1851) mentions a case of recovery following a penetrating wound of the right ventricle. Carnochan (1855) reports a case of gunshot wound of the heart in which life was protracted for eleven days. The bullet was found encysted in the heart's substance.

An interesting complication of gunshot wounds is reported by Prichard (1855), in which a ball, after having entered the chest, passed through the heart and stomach. Purple (1855) reports twelve cases of gunshot injuries of the heart in which the patients survived from forty-four hours to six years.

Grant (1857) reports a case of gunshot wound in which the ball after entering the chest, passed through the heart and stomach.

In the case of Bullock (1858) the patient lived four days and eighteen hours with a bullet in the left ventricle. Andrew (1860) showed a case coming under his observation in which a fish bone, after having lodged in the œsophagus and perforated it and the diaphragm, entered the heart. Croly (1864) reports the finding of a musket ball in the pericardium.

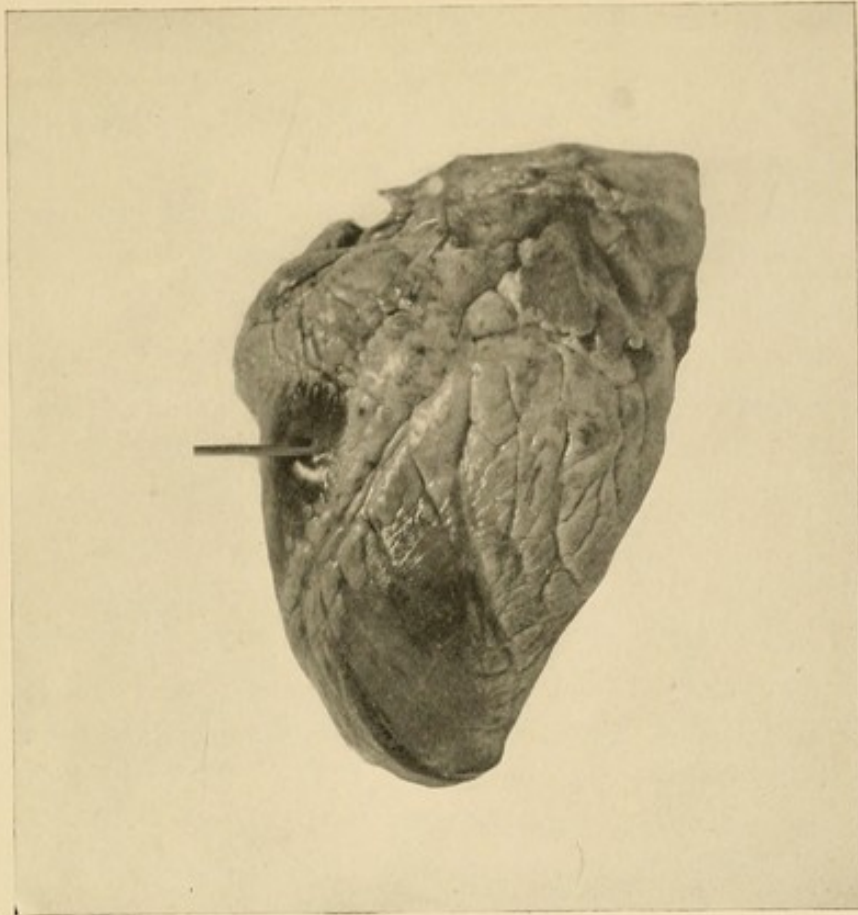
The reports of heart injuries in the American civil war, 1861-65, are very indefinite and unsatisfactory, so much so that they will be given but passing mention. No attempt, it seems, was made in any case to adopt surgical measures. U. S. A. Report, 1865 to 1871, No. 3, S. G. O. P. 91, Medical Museum, U. S. A., Spec., 1,837, shows a gunshot injury to the left ventricle and right auricle. The patient survived seventy-five minutes. Medical Museum, U. S. A., Spec. 2,639, shows a gunshot injury, an anteroposterior perforation of the left ventricle near the sæptum, with instant death. Medical Museum, U. S. A., Spec. 5,688, shows a laceration of the right ventricle by a pistol ball, with instant death. Medical Museum, U. S. A., Spec. 5929, shows an oblique perforation of the anterior wall of the left ventricle by a small Derringer ball; cavity not open. The patient, a suicide, lived twenty-seven minutes. Medical Museum, U. S. A., Spec. 5,949, shows a pistol shot through the right ventricle. The patient lived fifteen minutes. Medical Museum, U. S. A., Sec. 1, Spec. 1,052, shows a gunshot wound of the left ventricle. Medical Museum, U. S. A., Spec. 5,648, shows a gunshot wound of the right ventricle and auricle causing instant death. Medical Museum, U. S. A., Sec. 1, Spec. 4,870, shows a stab in the apex of the right ventricle by a jack knife. The wounded man ran thirty yards and lived twelve minutes. Medical Museum, U. S. A., Sec. 1, Spec. 504, shows a mus-

ket ball imbedded between the innominate artery and the descending aorta.

Hart reports a wound of the heart of a deer with recovery. Robert mentions the case of a man who ran sixty yards and lived one hour after having been shot through both lungs and the right auricle of the heart. Dudley (1871) records the case of a man who lived four days with a pistol ball in his heart. Ford (1875) speaks of a case of recovery from buckshot wound of the heart. Vite (1876) in his minutes speaks of the tenacity of life of a person who lived four days with a knife wound penetrating the chest into the pericardial sac and passing through the left ventricle of the heart into the opposite wall.

Among the cases of recovery from gunshot wounds of the heart is that of Mellichamp (1876). Then a similar case resulting in recovery is reported by Heil (1878). This patient lived twelve months after having received a stab wound penetrating the aorta. West (1878), of Birmingham, reports a case in which a man lived four years and a half. The autopsy revealed a linear scar, half an inch long, in the anterior part of the right ventricle. Gibney (1878) reports a case of a pistol ball passing through the right ventricle, sæptum, and aorta. Holly, during the same year, reports a case of pistol shot through the right ventricle, sæptum, and aorta. There was apparent recovery at the end of the fourteenth day, but sudden death occurred on the fifty-fifth day. The autopsy revealed the ball lying in the left ventricle.

In the case of Boileau (1879) there was a penetrating wound of the heart, involving the transfixion of both ventricles, but death did not ensue for several minutes. Dunham's patient (1879), after having received a bayonet wound implicating both ventricles, the sæptum, and the auricle, walked several yards after the injury and died at the end of forty-six hours. In another case death did not result until the end of fifty-four days. Death resulted from rupture

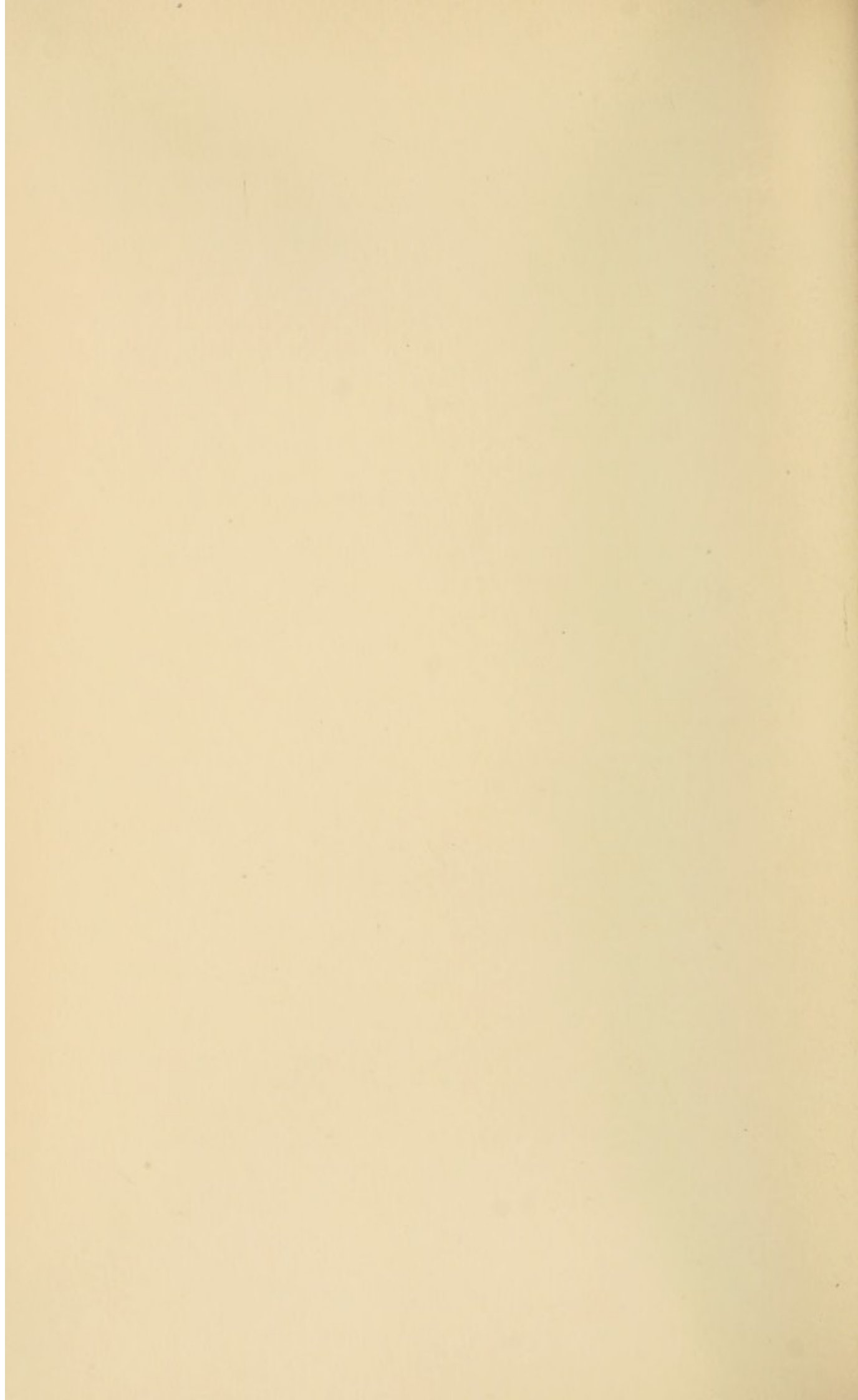


SHOWING SKEWER PENETRATING THE TWO VENTRICLES
FROM RIGHT TO LEFT.



A DIRECT PENETRATING KNIFE WOUND OF LEFT VEN-
TRICULAR WALL.

(Chapter on Wounds of Heart.)



at the point of lodgement in the case of Robbins, on the eleventh day. Sayre (1881) reports a recovery from a laceration of the pericardium and contusion of the heart.

Simmons (1882) reports a case in which a pistol ball, after having entered the heart, had fallen into the inferior cava. Randall (1882) reports the case of a negro boy who died sixty-seven days after having received a gunshot wound of the chest, from overeating. There were no signs of heart wound. The autopsy revealed three shot in the base of the ventricle and two in the auricle. The wounds in the wall of the organ were all firmly healed.

In the case of the author (1882) there were numerous perforations of the chest by buckshot, one having passed through both auricular walls and the left lung, one through both ventricular walls and the left lung, and one through the liver and the abdominal aorta, all from right to left. With all these wounds the patient walked ten paces. Ward (1883) mentions a wound of the chest. The ball was found lodged beneath the two layers of the pericardium. There was laceration of the wall of the right ventricle and of a branch of the anterior coronary artery, causing fatal hæmorrhage into the pericardial sac.

"I have in my possession the heart of a man, named John Kelly, containing a round ball which lies encysted in the apex of the right ventricle and which was received twenty years before his death. There is conclusive evidence, however, that during the first five years it lay near the right internal jugular vein and that, having at length made its way through the coats of this vein, it dropped into the ventricle and finally became imbedded in the walls of the heart at its apex. It remained in the heart, therefore, fifteen years, and was not then the immediate cause of death." (Hamilton, "Principles and Practice of Surgery," 1886, page 90.)

Kravkoff (1887) reports a wound of the left ventricle with recovery. Peebles (1892) reports a pistol wound of the heart

with recovery. Bell (1894) cites a case of recovery following a puncture of the cardiac wall without suture after the clots had been removed from the pericardium by incision.

Sloan (1896) speaks of a case in which paracentesis was undertaken to relieve pericardial effusion, and the right ventricle was penetrated and 300 grammes of liquid blood were removed. There was rapid improvement for twenty-four hours, slower after that until recovery. In the case of Nelson (1896), who was shot, the x ray showed the ball in the heart moving with each pulsation. Spencer and Tippet (1896) report a case of punctured wound of the right ventricle of the heart through the second intercostal space, with severe primary and secondary hæmorrhages. The wound healed and the patient died of disease. The autopsy revealed the location of the wound.

Fisher (1896) shows, in a case he reports, that a rupture of the right ventricle of the heart may result from a blow in the epigastric region. That rupture of cicatricial tissues of the heart may occur is shown in the case of a soldier (a Michigan sharpshooter) who received a bullet wound in the heart at Spottsylvania, Va. He died suddenly, two years later, in such a way.

Williams (1897) reports a stab wound of the heart and pericardium. Suture of the pericardium was performed, with recovery. The patient died three years afterward.

Hennen states that a case came under his observation in which a bayonet had been thrust through the colon, stomach, diaphragm, lung, and right ventricle, and the man lived nine hours; while in the case of Jackson the patient lived three hours and a half and made depositions to the name of his assassin, after having received two shot wounds in the chest, one passing through the right auricle. Diemerbrock states that a patient walked sixty paces and lived ten days after having received a wound of the right ventricle.

Needle wounds of the heart are quite common. Among

those reporting such accidents are Peck (1852), and Pridborn (1856), also Wright (1869). Thomas (1887) reports a case of suicide with a needle, while Thompson (1888) reports one with a pin. Peabody during the same year (1888) found a pin imbedded in the heart of a cadaver. Meacham (1899) also found a needle in the heart upon autopsy.

A Sardinian prince met instant death from the puncture of the right ventricle by a gold needle in the hands of his wife.

Paget (1897) reports the case of a man, aged thirty-one, who, while in a struggle, received a needle two inches long in the cardiac region. He had pain on the following day, and worked nine days with continuous pain from the nipple to the axilla and down the inner side of the arm to the elbow. An operation exposed the eye of the needle, which moved with each pulsation of the heart. The needle was withdrawn and recovery ensued. In the case of a girl eleven years old, a knitting needle entered the chest, breaking. An operation found it penetrating the heart. The removal was followed by recovery. Callender's patient (1897), in attempting to commit suicide, drove a needle into the heart. Indications were those of a disturbance by a foreign body. By an operation the pleura was opened, as was the pericardium also; a gauze sponge was lost in the pleural cavity and was not recovered. The needle head was brought to view, but by strong motion of the heart had been thrown completely into the ventricle and was upright. Pneumothorax occurred six days later. The patient left the hospital in four weeks in perfect health.

Among those to compile tables concerning heart wounds was Purple (1855), who reported forty-two cases that were immediately fatal. Twelve of these were due to gunshot. Otis reports twenty-one cases of injuries of the heart in the United States Army, 1865-1870. Eighteen were gunshot, two incised, and one an arrow puncture. Holmes and Fisher (1881) report a series of 452 wounds of the heart, with 104

immediate deaths, 219 not immediate, 72 recoveries, and 57 uncertain as to time of death; 123 right ventricle, 101 left ventricle, 26 both ventricles, 28 right auricle, 13 left auricle, 7 sæptum ventriculorum, 17 apex, 2 base, 16 whole heart, 4 right heart, 5 left heart, 2 coronary artery, 57 uncertain, and 51 pericardium. He also reports a series of cases of foreign bodies in the heart, such as needles. One entered through the sternum, eight by the œsophagus, thirty by the thorax, and eight by an uncertain route.

Fisher enumerates 452 cases, of which 44, with 10 recoveries, were punctured wounds; 260, with 43 recoveries, were punctured incised wounds; 72, with 12 recoveries, were gunshot wounds; and 76, with 10 recoveries, were contusions and traumatic rupture. Olliver and Sanson state that, out of twenty-nine cases of penetrating wounds of the heart, only two proved fatal in forty-eight hours. In the others death took place in from four to seventy-eight days after the wound.

Hill records a case in which he extracted a needle that had been forced through the skin into the heart. Fouck and Pramm (1901) report a case of suicide in which a man stabbed himself in the left thorax with a long knife, the weapon penetrating the pericardium and entering the left ventricle, after which he drew out the knife and laid it on a table near by. The weapon was apparently perfectly clean, but microchemical examination of a tiny rust fleck on the blade revealed the presence of hæmin crystals.

Roswell Park (1902), in attempting to remove what he supposed to be pericardial fluid with an aspirating needle, removed pus from an abscess cavity in the wall of the heart. (See Chapter on Abscess of the Heart.)

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heart.

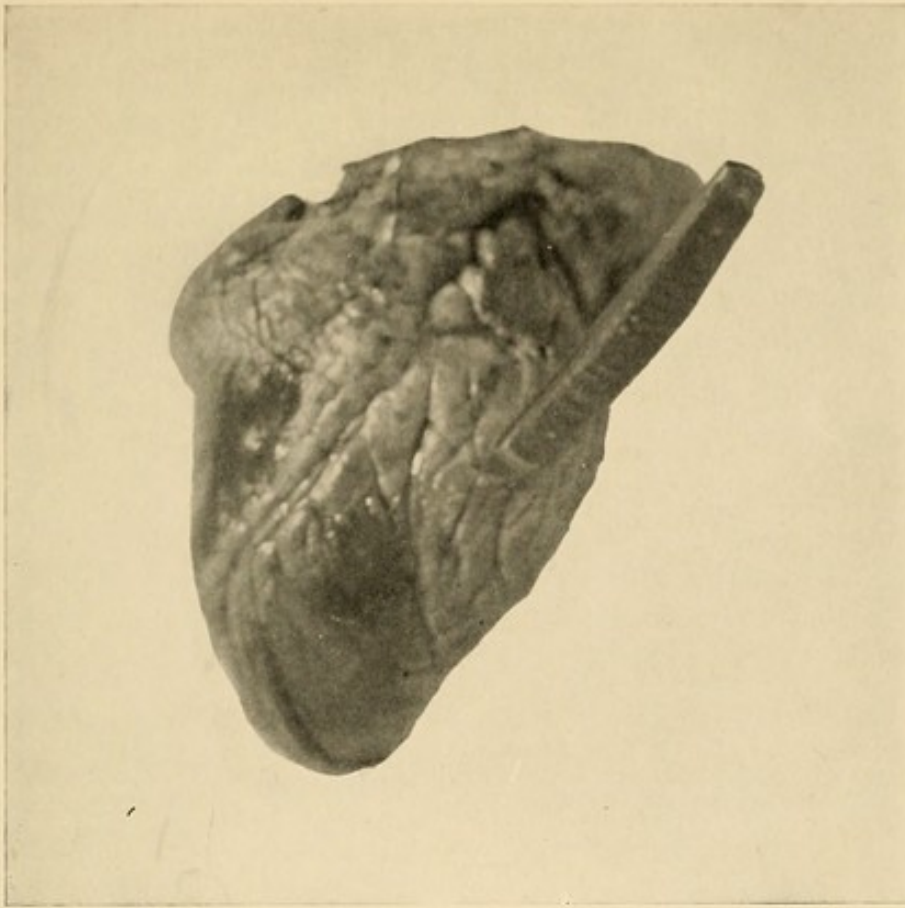
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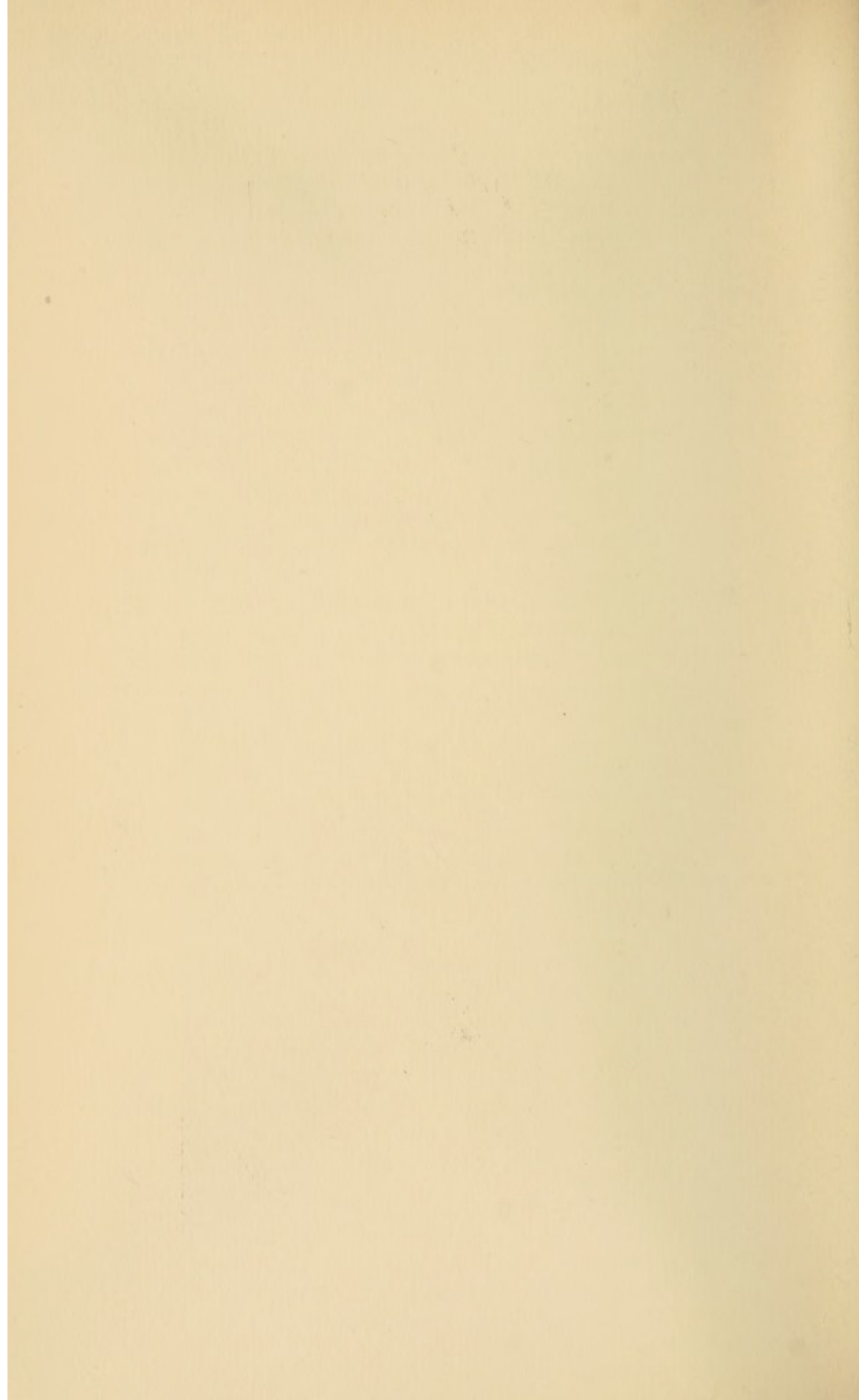


AN OBLIQUE PENETRATING KNIFE WOUND OF LEFT
VENTRICULAR WALL.



A LONGITUDINAL PENETRATING WOUND OF THE HEART,
SHOWING HOW WOUNDS OF THE HEART
MAY BE EXTRA PERICARDIAL.

(Chapter on Wounds of the Heart.)



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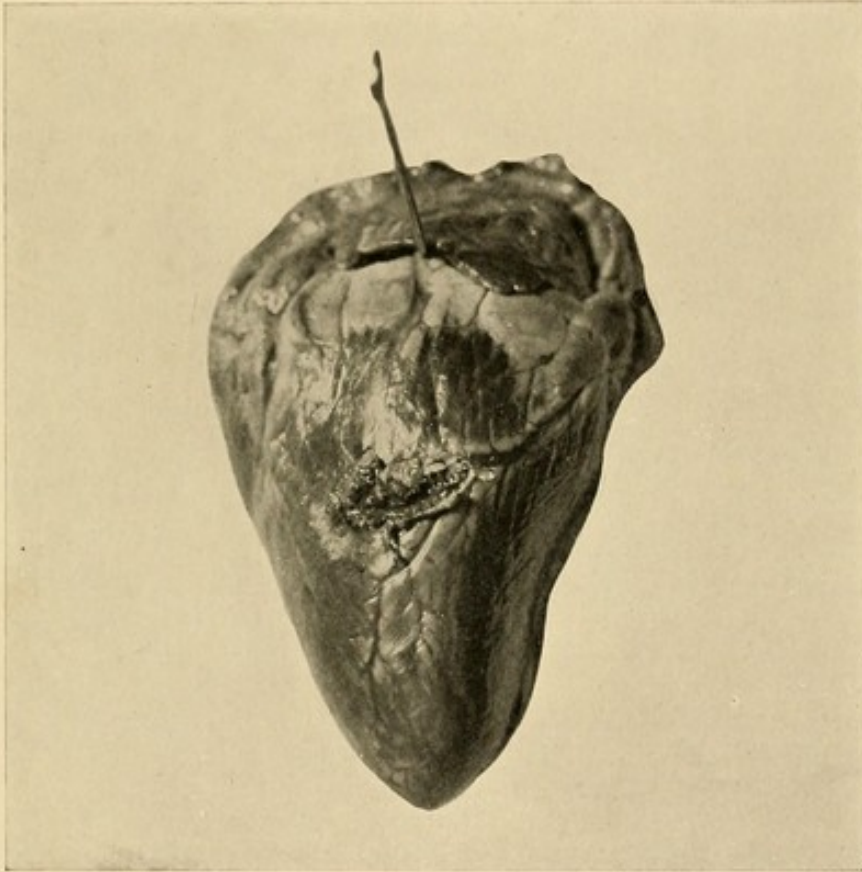
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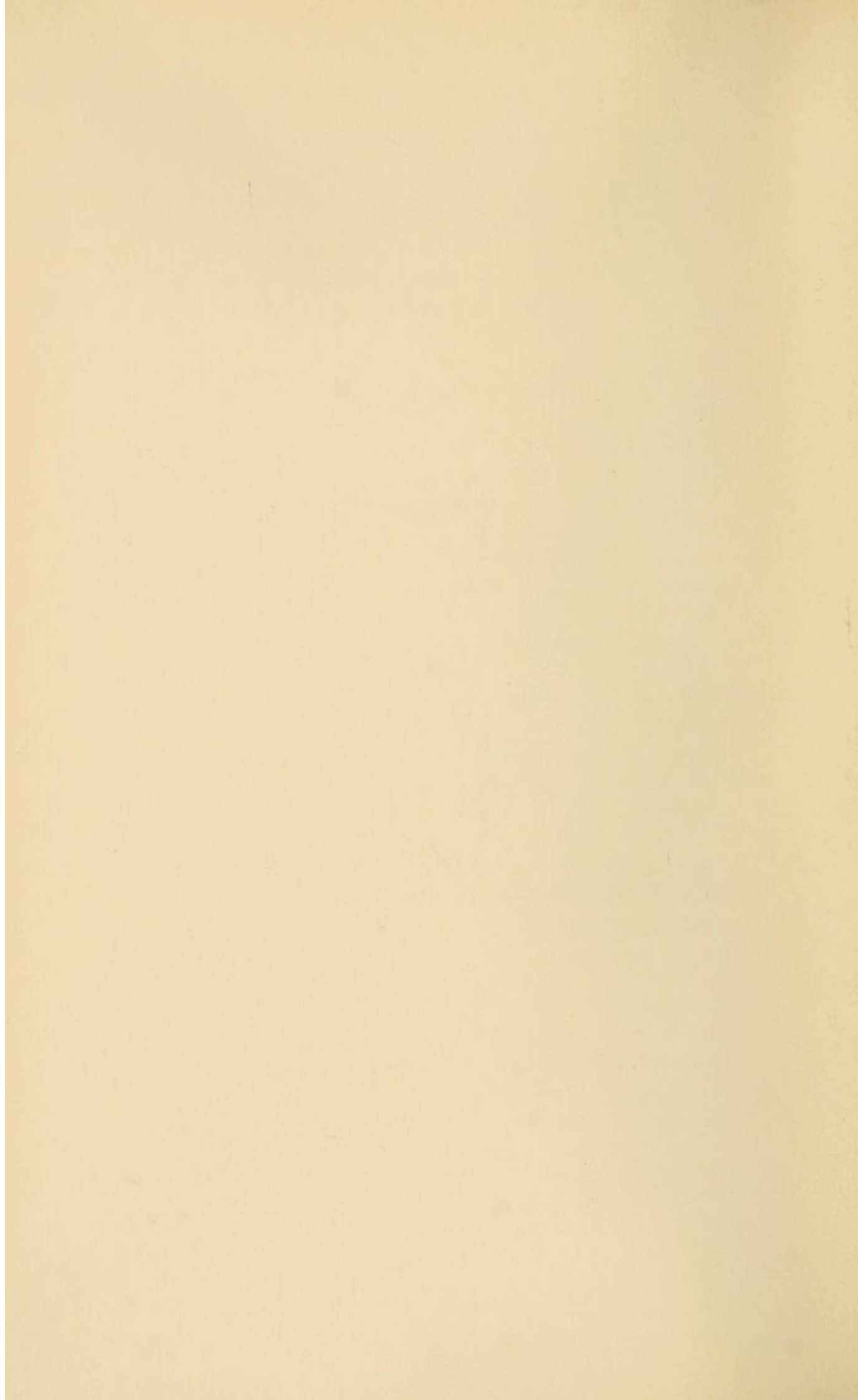
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CHAPTER VI

CARDIOCLASIA

Ætiology.—Rupture of the heart may be due to injury or disease or both. Disease is conducive to traumatic rupture, and rupture may occur without trauma at any time in disease. Fatty degeneration is the most frequent cause in advanced life, two-thirds being beyond sixty years of age, the proportion being about the same in each sex.

It may be complete or incomplete and the opening of any size, single or multiple, which may or may not communicate with each other. The fissures are usually parallel to the muscular fasciculi, unless abscess be present, when the opening may be of a perforating character. The edges are irregular and materially aid in the formation of clots, which have frequently been found in the opening. George II. and the Princess of Brunswick each succumbed to rupture of the heart.

Historical (1758-1903).—Townsend (1832) found in twenty-five cases of rupture of the heart that three were of the right ventricle. Bayle found in nineteen cases that three were of the right ventricle. Reports of rupture of the various chambers of the heart indicate that the left ventricular wall is most frequently involved, spontaneously or by traumatic influence.

Portal (1788) cites a death due to spontaneous rupture of the left ventricle. Matt (1815) states that the death of a young woman was due to rupture of the left ventricle; verified by autopsy.

This class of rupture was recognized by Watson (1828) in a case revealed by autopsy. Crass during the same year gives the notes of two cases shown by autopsy to be rupture of the left ventricle, as does Adams (1828) also.

It would appear from Smith's (1836) case that fatty degeneration plays an important rôle as a factor in producing such a lesion. In his case of rupture of the left ventricle there was not only fatty degeneration of the heart, but free oil was abundant in the blood.

Bodington (1843), Walshe (1844), Crisp (1846), Quain (1846), Fletcher (1847), Amry (1848), Coulson (1848), Benberg (1850), and O'Conner (1850), each report interesting cases of rupture of the left ventricle. The last-named gentleman found rupture of the pericardium in addition to rupture of the ventricular wall. This, no doubt, was due to trauma.

Quain, White, and Hill each report a case of rupture of the left ventricle, the cause in each being attributed to aneurysm of the ventricle.

Godden (1854), Fuinell (1857), Popham (1857), Coote (1861), Wilks (1864), Ramskill (1866), Meyer (1871), and Thomas (1883) each report a case of rupture of the left ventricle. The case of Meyer terminated in recovery. This is indeed a unique case and one from which many important deductions may be drawn.

Blauvelt (1883) reports a case in which both ventricles were ruptured. In the case of Fraser (1897) the rent in the left ventricular wall was quite extensive. Thus it is shown that many varieties of rupture of the left ventricular wall may take place spontaneously and that fatty degeneration is probably the causative factor. Konsoff states that rupture of any of the heart fibres is rare, and that he found but three cases in 8,000 autopsies.

Rupture of the right ventricle spontaneously or from trauma is very rare, as shown by the few recorded cases,

among the first of which are those of Ashburner, in which both ventricular walls were ruptured spontaneously. Chalice (1843), Leaming (1844), Johnson (1851), Davis (1859), Duka (1862), Fennell (1869), and Prudden (1888) each report a case of spontaneous rupture of the right ventricular wall. In the case of Prudden the rupture was the result of general fatty degeneration from atheroma of the coronary arteries.

Squire (1891) reports a case of rupture of the right ventricle with death at end of twenty-five hours, revealed by autopsy. Green (1894) reports a case of thrombosis and rupture of the right ventricle in a child nine and one-half months old. Hunter (1897) reports a death from an incomplete rupture of the right ventricle with adherent pericardium. Thomas (1825), Rutherford (1828), Thomas (1830), Lankaster (1849), and Hall (1852), each report a case of spontaneous rupture of the *right auricular wall*. In the case of Hall there was an aneurysmal cavity in the substance of the ventricular septum of the heart. The rupture in the right auricle was sudden and fatal.

Hudson (1859) mentions a case of rupture of the right auricle during labor. Cregen (1859), Finnell (1869), and Shearer (1872), each report a case of such a rupture. The case of Finnell is especially interesting in that autopsy revealed a small saccular aneurysm of the ascending aorta with hypertrophy and fatty degeneration of the heart.

Armory (1873) found by autopsy that compression of the thorax had ruptured the right auricular wall. Tennison (1879), Duffy (1881), and Thompson (1884), each record a case of rupture of the right auricle. Vase (1849), Clapton (1870), and Johnson (1877), each report a case of *rupture of the left auricular wall*. There was an aneurysm of the ascending aorta in the case of Johnson.

Allen (1880) reports rupture of the left auricular appendage of the heart. Mackintosh (1890) reports a case of spontaneous rupture of the left auricle.

Rupture of one or all of the cardiac walls from violence may occur at any age, and there are fewer cases reported than those of spontaneous rupture. Gariel (1835), Salluce (1839), and Geoghegan (1839), each report heart rupture due to violence. Fenner (1846) mentions a case of rupture of the heart with a compound fracture of the thigh in which the patient survived twenty-eight and a half hours. In the case of Carter (1847) it was the interventricular sæptum of the heart that was ruptured by violence. This was so in the case of Beith, except that in addition the rent extended through the walls of the right ventricle. In the case of Stanley the rupture involved both auricular walls.

Leared (1852) mentions a similar case, while Hewitt records a case of traumatic rupture of the ventricular sæptum of the heart without any laceration of the pericardium. Ward (1862), in reporting a case of heart rupture by external violence, states that it was without break of the skin.

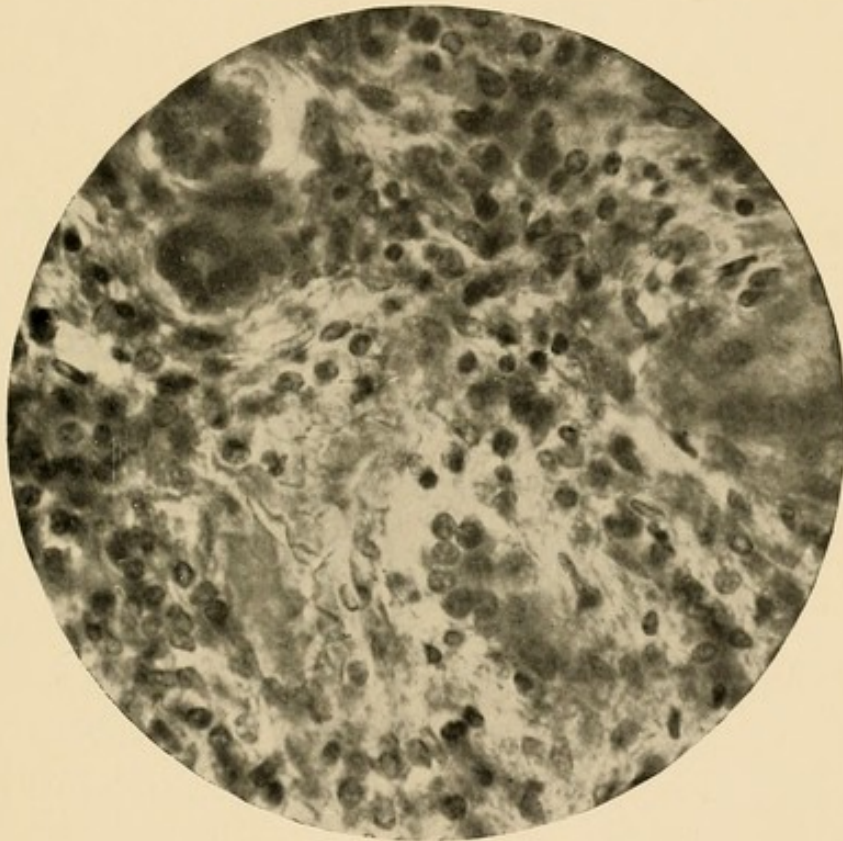
Both Ellis and Oyler, during the year 1863, report cases of traumatic rupture in fatty degeneration of the heart without external manifestations. In the case of Oyler the laceration occurred in the wall of the left auricle, which contained fibrous concretions undergoing softening in the same auricle. Mackenzie (1866) reports a case of rupture of the heart in a child, complicated with fracture of several ribs. This class of rupture is well established.

The *aorta may rupture independently*, or it may be *associated with rupture of any one or all of the cavities of the heart traumatically or idiopathically*. Curling (1838) reported a case of rupture of the heart and aorta. Davy (1839) gave notice of a fatal case of rupture of the heart and aorta, with an account of some experiments on the power of resistance of the heart and great vessels. Hewitt (1846) gave cases of rupture of the heart and large vessels resulting from injury. Lewis (1883) reports a case of rupture of the aortic valves during severe muscular strain. Biggo

(1890) reports a similar case, due to a fall. Hektoen (1892) reports such an injury with aneurysm of the right auricular appendix. Rolleston (1890) reports a rupture of the aortic arch in connection with heart rupture, while Baylac reports rupture of the aortic arch. Williams (1896) records a case of rupture of the cardiac vessels. Eshner (1900) reports a case of rupture of an aortic leaflet in a case of right hemiplegia with aphasia due to cerebral hæmorrhage.

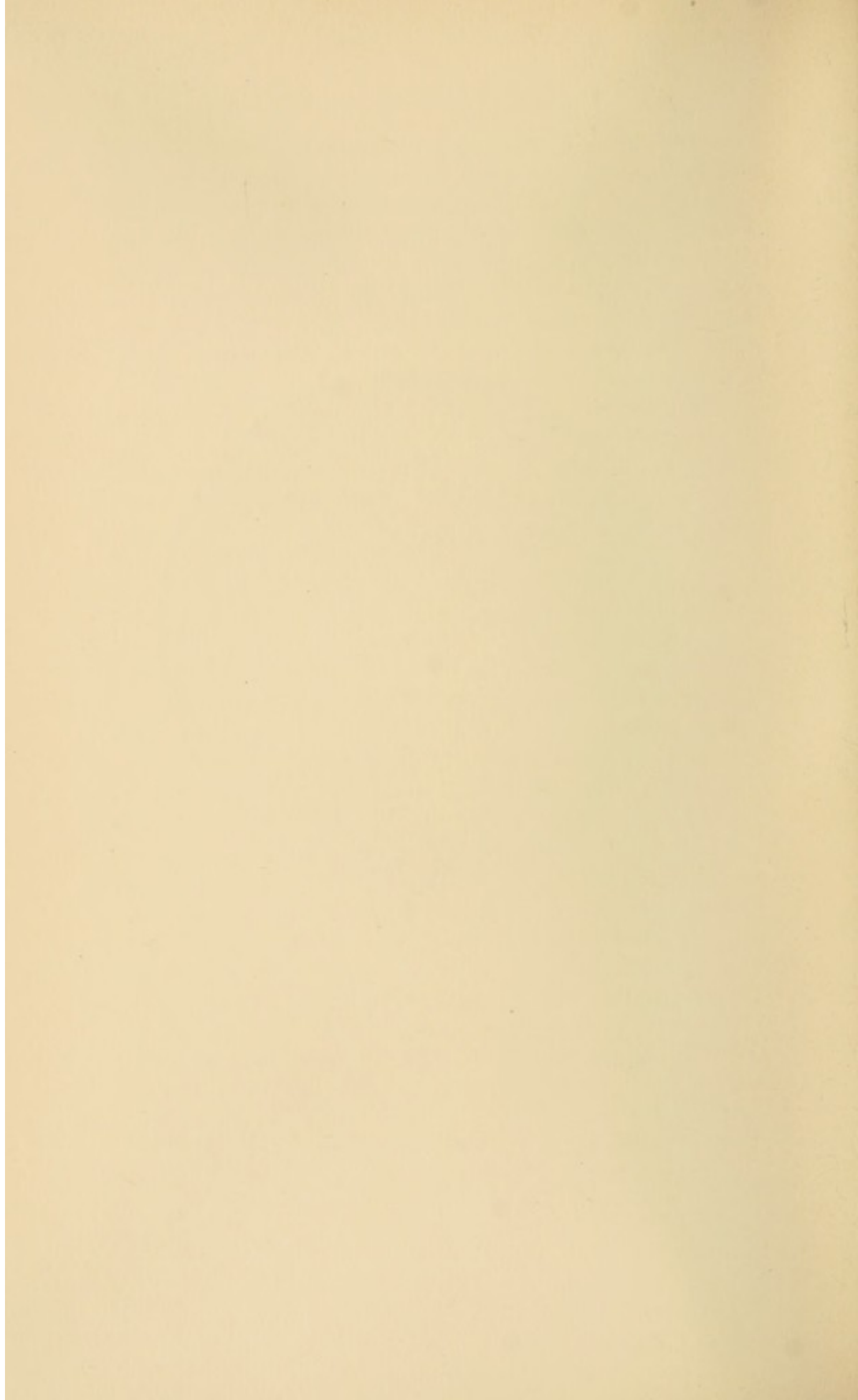
Rupture of the coronary arteries may be due to injury or disease and may involve any part of one or more vessels. Lally (1862) reports a case of rupture of the coronary artery with obscure symptoms and death, and Cutler (1880) reports a case of embolism of the coronary artery with rupture of the heart. Josiasis and Betremeux (1884) report a case of atheroma of the coronary arteries. Steven (1884) reports a case of fatty degeneration and disease of the coronary arteries with cardiac rupture. Saivin (1887) reports a case of thrombosis of the coronary artery with rupture of the heart. Armand (1889) reported spontaneous obliteration of the coronary artery in a case of Hodgkin's disease. Milan (1897) reports thrombosis of the coronary artery with cardiac rupture.

Sherman (1871) cites a case of cardiac *rupture due to violence*. In the case of Shearer (1874) the patient died at the end of eight hours. Clayborn (1874), Wharton (1874), Hielt (1875), Packard (1877), Deheune (1878), and Finnell (1880) each report traumatic cardiac rupture, the case of Finnell being due to indirect violence. Hanford (1880) reports a rupture from external violence without perforating wounds. Draper (1879) mentions a case of rupture of the interventricular sæptum of the heart in consequence of external violence. Bennett (1890) records a case of cardiac rupture complicated with fracture of the sternum and costal cartilages. O'Brien (1893) reports a similar case. Nibling (1896) writes on a case of heart rupture due to



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trauma, as does Bennett (1896) also, while Gibbons (1897) speaks of a case due to a blow by a stick, with survival for three hours. Oscar and Voelker during the same year report rupture of the ventricular sæptum. Ghedini (1897) also reports such a case. Newton (1899) mentions a case of a man twenty years old who was thrown upon a bicycle handle, fracturing and pushing the sixth costal cartilage into the apex of the right ventricle.

Among other causes of heart rupture is tetanus, cases of this character having been reported by Ferguson (1883) and Duclaux (1878). There was one in a case of arsenical poisoning (?) reported by Lewis and Adams (1887) and one by Glikman (1893) during the act of defæcation, and one due to cold bathing.

Several cases of heart rupture have been reported as having occurred in the insane during violent periods. Among them are those of Mickle (1883), Pichenot (1888 and 1889), also Nash (1892) and Beadles (1892).

Rutchinski reports a spontaneous rupture of the heart. Hamilton (1903) records eight cases of heart rupture in insane subjects, six in the left ventricular wall, one in the right ventricular wall, and one in the right auricular wall. There were two openings in the right ventricular wall.

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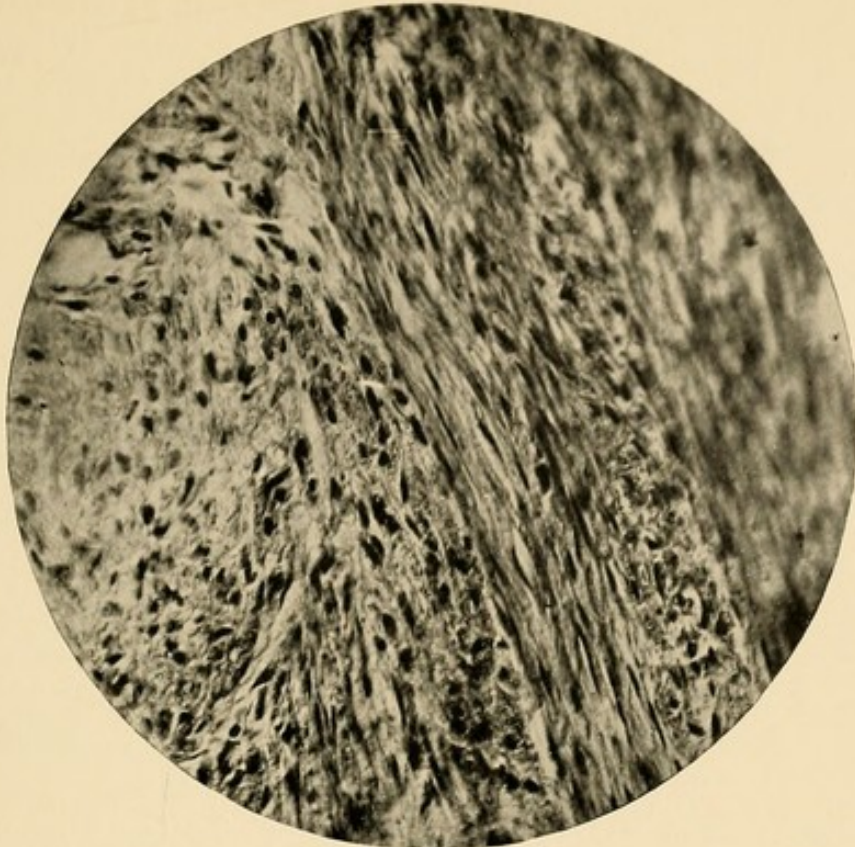
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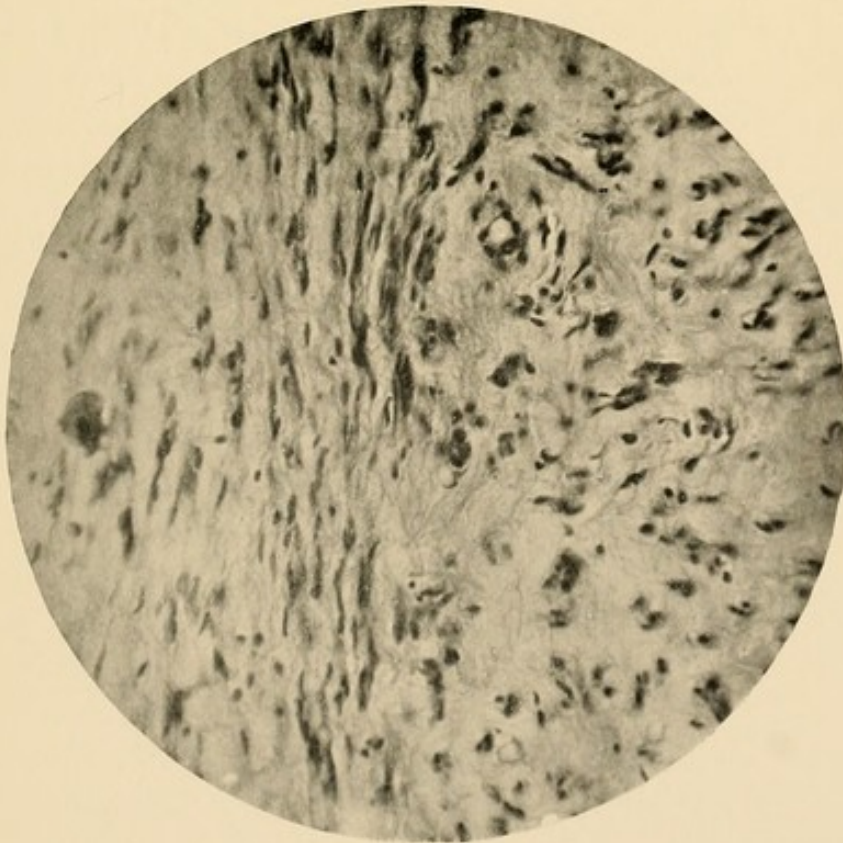
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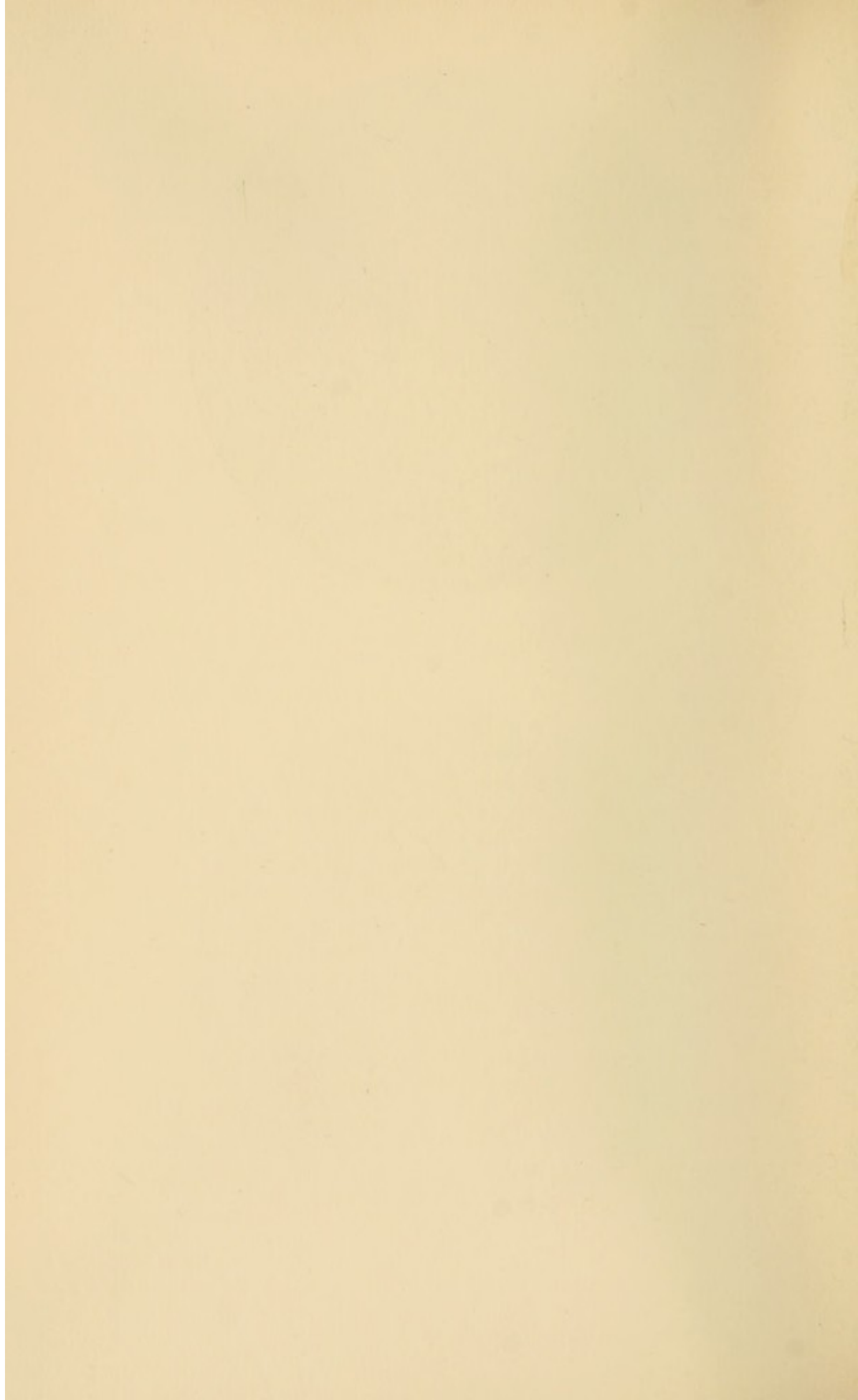


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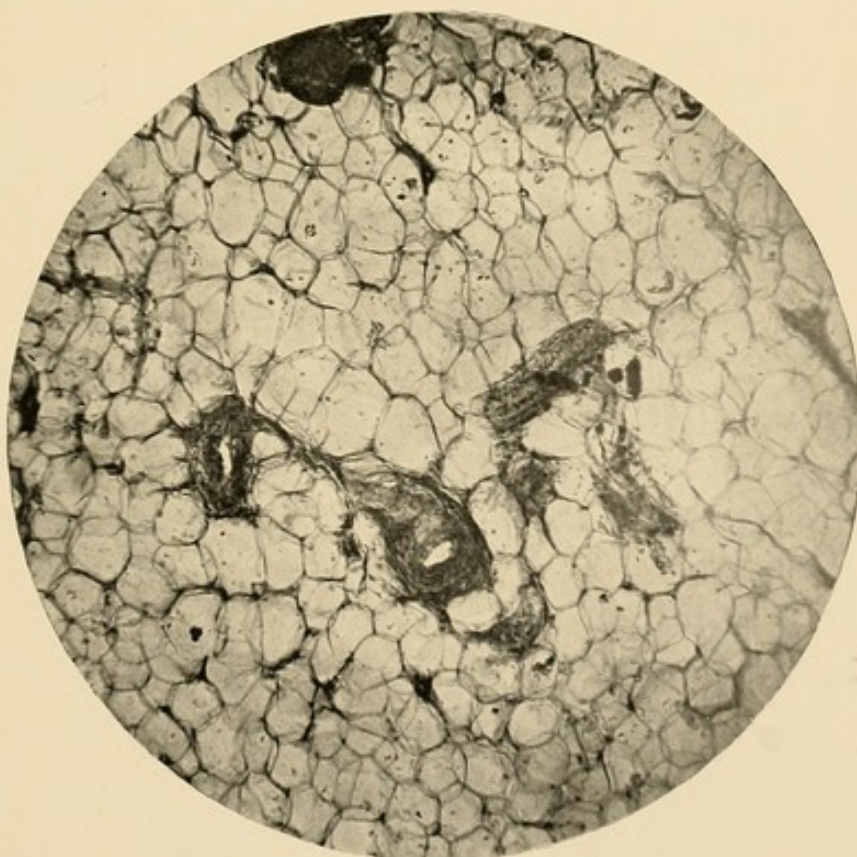
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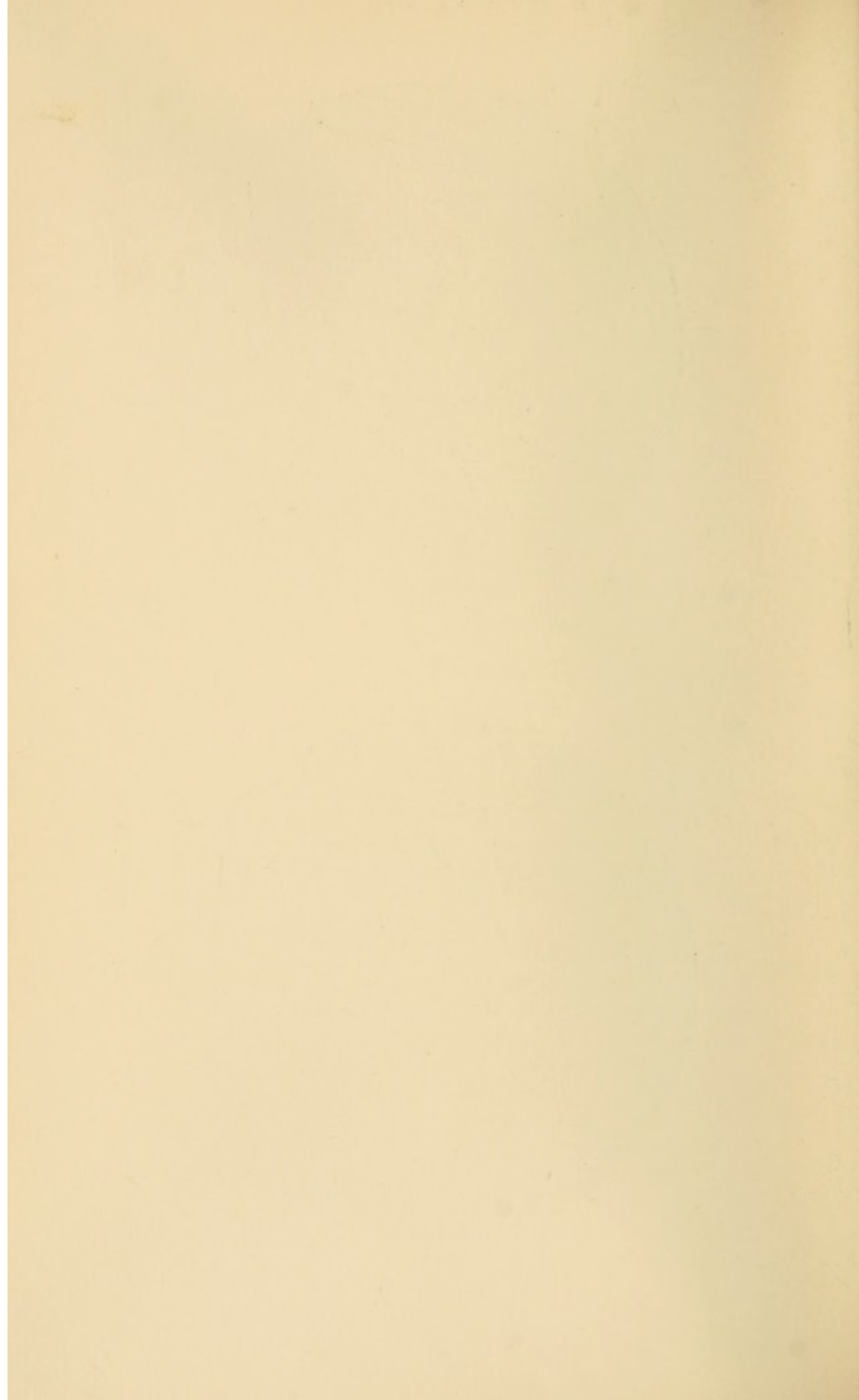
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CHAPTER VII

CARDIORRHAPHY—CARDIOTOMY—HEART SUTURES

THERE is probably no organ or disease about which so much has been said and written, with so little accomplished, as the heart with its diseases.

Historical (1871-1903).—Until 1871, when Callender removed a needle from the heart, there is no recorded case of human heart injury in which anything surgical was attempted. He was succeeded by Goodheart, who cured a case of hydatids of the heart by a surgical operation in 1876.

The heart may be injured even to the point of laceration without injury to the pericardium, and *vice versa*. Both, however, are found wounded in either event, whether by direct or oblique contact. A penetrating wound of the heart may occur in its base from above, without injury to the pericardium. The right ventricle is more frequently injured than the left, and the mortality greater in the left. The auricles are protected by the sternum.

Loison says that death varies with the position, size, and character of wound, and in general 85 per cent. of all heart wounds are fatal.

It is said that a large proportion of deaths are due to effusion of blood into the pericardial sac, causing over-distention. This is hardly probable when the pericardium is incised or lacerated. Reports of death from heart injury are very untrustworthy unless verified by autopsy.

Billroth condemned any attempt to suture wounds of the heart. Riedinger (1884), Tillmanns, Rosenthal, Del

*He did the work
correctly*

Vecchio, Solomoni, and Bode each discouraged any attempt whatever at suturing wounds of the heart.

Stevenson (1887), concerning heart wounds in war, says that no method of treatment is likely to be of permanent service towards their cure.

Druitt ("Surgery," 1867, page 456) says that "opium is the only available remedy" in injuries of the heart, while Stephen Smith, as late as 1887 (page 257 "The Principles and Practice of Operative Surgery"), says the first aim is clot and to induce it, and that fluid should be drawn off with a trocar. He does not mention suturing or anything surgical, but says (page 277, "Operative Surgery") that "the only operation on the heart and pericardium is undertaken for dropsy."

Ashhurst (International Encyclopedia, Vol. VII, page 813) says that there is nothing to be done in wounds of the heart. This statement was made as late as 1889.

Wharton and Curtis ("Surgery," 1898, page 878) say, concerning foreign bodies in the heart, that their removal should be attempted if their position can be located and their presence causes marked disturbances. Da Costa says that suture in case of laceration of the heart should be attempted and that fine silk should be used. Paget ("Surgery of the Chest," page 373, 1897) says small wounds do not need suture and large ones give no chance for it.

Makins (1901, "Surgical Experience in South Africa," pages 383, 384) says that perforating wounds of the heart were probably fatal in all instances, but that several cases occurred in which the surface of the heart was scored by bullets, and that in the case of Cheatle death resulted from suppurative pericarditis; both the auricular and ventricular walls had been scored. Makins believes that death was often due to sudden stoppage of the heart and not hæmorrhage from it. He reports six interesting cases of gunshot wounds of tissues in close proximity with the heart, as shown by autopsy,

demonstrating their influence upon the action of both the heart and lungs.

The history is of more or less importance, and while there is but little time, if any at all, to secure a history in cases of emergency, it should be accurately detailed in cases of election. To know the position of the body, whether erect or recumbent, at the time of injury, will often enable the character of the injury to be more accurately determined, as the heart changes its position materially with these postures.

Weapon, Knife or Gun.—In the case of wound with a knife, the characters of the blade, whether sharp or blunt-edged, pointed or rounded at the end, narrow, thin, wide or thick, are all of the greatest importance. The size of the gun, the character of the ball, one or more in number, whether of lead or steel, soft or hard, jacketed or not, the distance it travelled, and the angle at which it entered the body, are of importance. Age, sex, and general physical condition at the time of injury are to be noted, also whether other injuries have been inflicted upon the body at the same time. Note, too, exposure (if any) of the body to the sun, heat, cold, rain, or wind, and the time of injury following the eating of a meal.

Complications such as new growths, disease, deformity in general, or of the chest in particular, are quite common.

Symptoms.—External signs of injury may or may not be present. If present, there may be puncture, laceration, contusion, or slight or extensive ecchymoses.

Crepitus may be present; if so, it may be due to a fractured rib or cartilage or to emphysema. These may exist without external manifestations. A foreign body may induce crepitus.

Hæmorrhage may be of an oozing character, it may pulsate or flow steadily, mildly or excessively, and its character, whether venous or arterial, cannot, as a rule, be determined. If pulsating, it may be due to the escape of blood from the heart or the internal mammary or intercostal artery

or one or more of the pulmonary vessels. One or all of these may be injured at the same time, with or without pulsating hæmorrhage. The hæmorrhage may be exposed or concealed (external or internal), single or combined, with or without dulness in either event. If there is dulness upon percussion, the area increases with increased hæmorrhage, which may escape into a cavity of the chest or that of the abdomen. The heart's action becomes more rapid, irregular, and feeble, threadlike or tumultuous. Its sounds are less distinct, becoming more indistinct as hæmorrhage increases, whether it be concealed or exposed. There is sometimes to be heard a metallic tinkling or whizzing sound, resulting from the air in the pericardium.

Nietert says: "I have observed and operated upon four cases of penetrating wounds of the pericardium in which there was bleeding into the pericardial sac. In these four cases there was a communication of the sac with the pleural cavity, and in each instance the splashing sound was audible. I conclude, therefore, that the absence of the sound is due to increased intrapericardial pressure, produced by an accumulation of blood. This accumulation is due to the absence of an avenue of escape, there being no communication with the pleural cavity. Therefore, the splashing sound audible over the region of the heart, in injuries of this kind, seems to be an important sign in connection with the diagnosis, as it determines whether the pericardial sac communicates with the pleural cavity or not."

Cyanosis is usually present, varying in degree, depending upon the size of the wound and amount of hæmorrhage and interference with respiration.

Dextrocardia.—The heart may not be in its normal position, and for that reason escape injury when it occurs in the heart's normal position, or the position commonly known to be that of the heart. Sometimes the heart is pushed forward as a result of fluid behind it. Orthodiagraphy may be used

to determine the position of the heart or the presence of a foreign body. Moritz mentions sixteen cases in which he could determine the outlines of the heart with the x ray (*Münchener Med. Woch.*, January 7, 1902.)

The temperature is usually subnormal. It may be normal or it may be higher, depending upon the amount of shock from the injury itself, or excitement incident to it, or both, exposure to heat, cold, water, air, the sun, or rough handling. Perspiration may be mild or profuse, or it may be absent entirely. Pallor may vary in degree, or it may be absent, but is usually present.

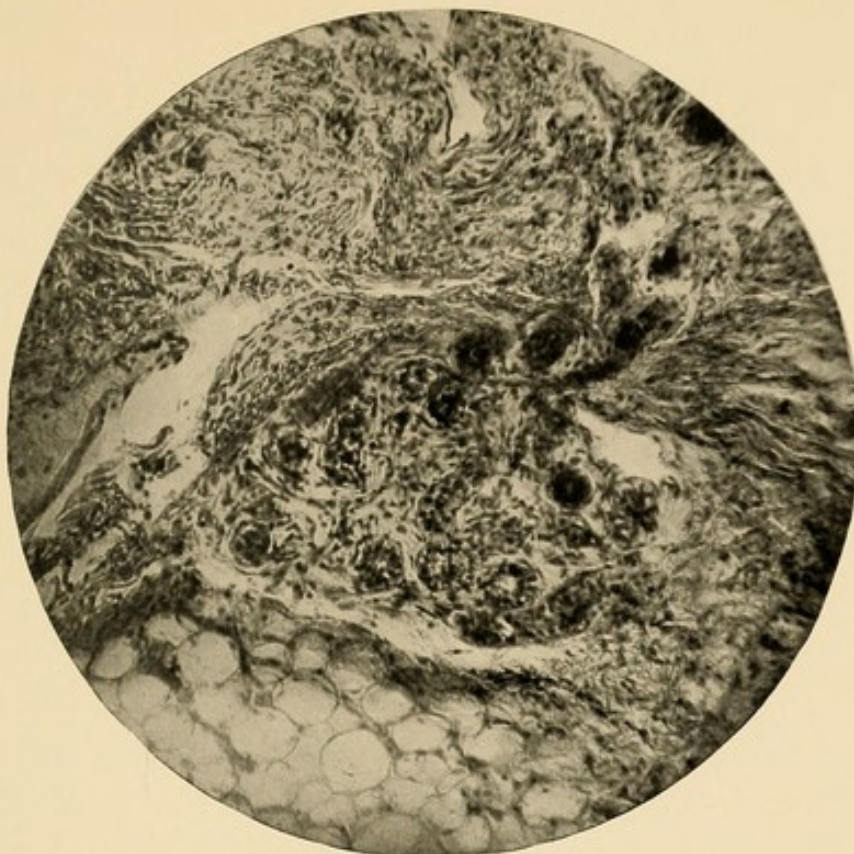
Respiration may be difficult and vary in degree. The difficulty is supposed to be due to pressure upon the lungs by the escape of blood into the pericardial or pleural cavities, but it may be present without these conditions.

Sighing, yawning, and gasping may manifest themselves separately or combined at any time between the injury and recovery or dissolution. Facial expression is markedly changed, indicating great distress and anxiety, and this sign is usually present. Mental excitement varies from a mild degree to that of delirium and unconsciousness. Delirium coming on after a few days indicates pyæmic cardiac abscess.

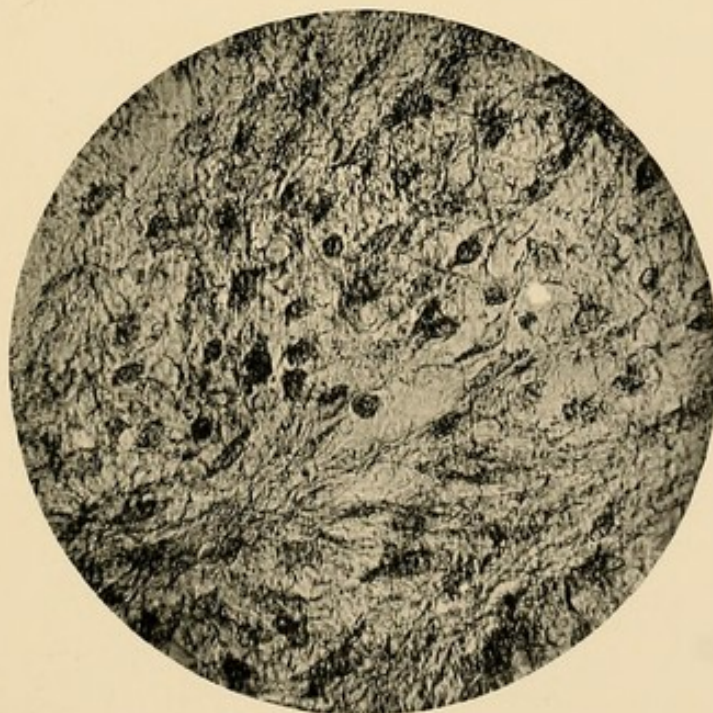
The general nervous system suffers greatly as a rule. There is more or less muscular contraction, with a slight hacking cough and restlessness to the point of general convulsion. The patient will sometimes claw at his clothing or, if lying upon the ground, will pull at the grass, dirt, or weeds, or anything he can grasp.

Treatment. (1) **Sanitary.**—Stimulants should be given with great caution, especially before the opening in the heart is closed with suture. The amount of bleeding from an opening in the heart is greatly influenced by the strength and number of beats. A recumbent position and perfect quietude should be maintained with the patient and his surroundings.

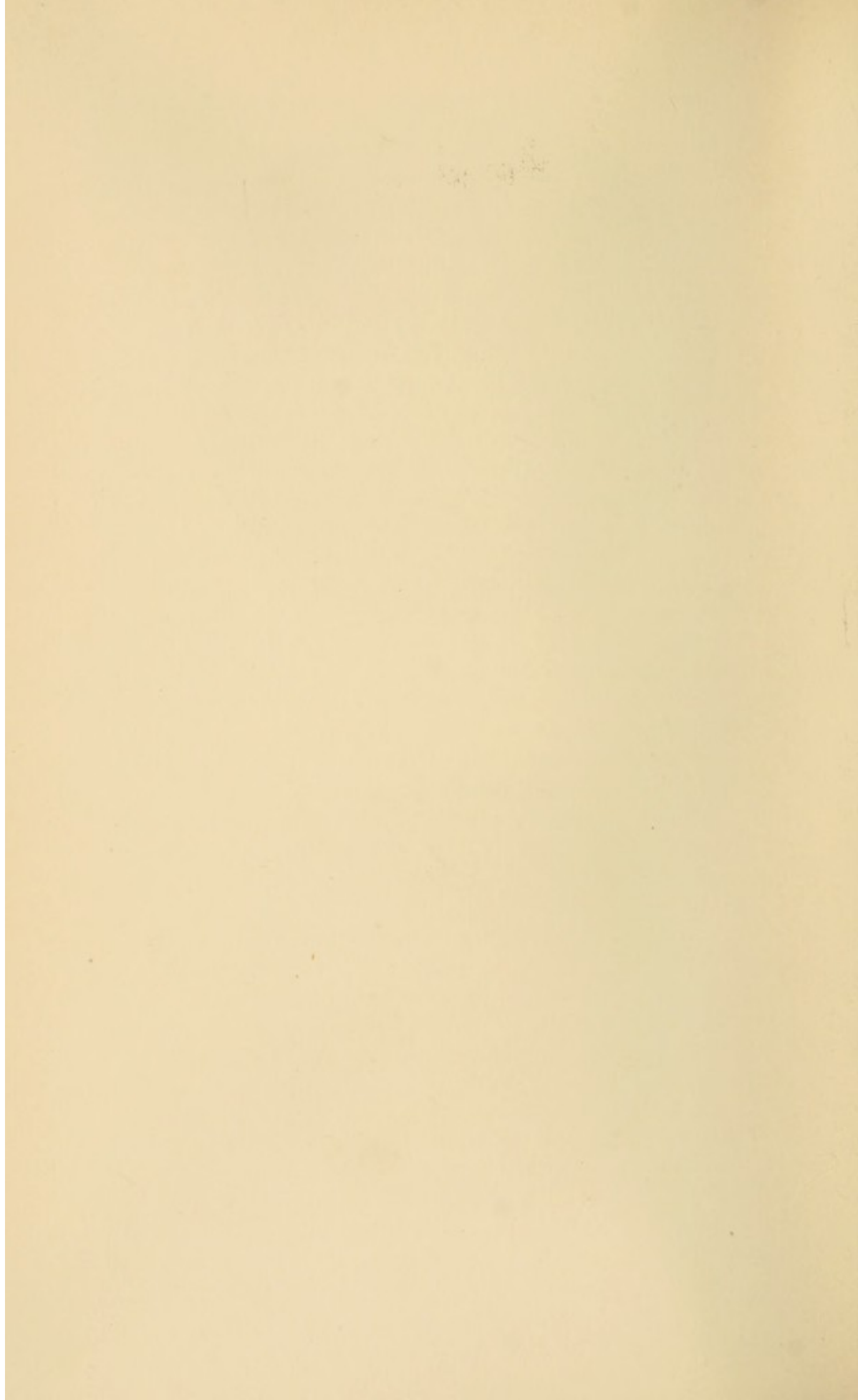
Hot or cold draughts of air, rain, snow, and the sun's



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rays should be excluded. Artificial heat should be applied, and tight, unclean, or superfluous garments removed. Exclude all but necessary attendants and relieve pain with hypodermic injections of morphine. Transportation of the patient should not be attempted. If necessary, it should be done on a stretcher carried by men.

(2) **Surgical.**—Aseptic principles should be applied in every step of the operation and throughout the care of the wound. No time should be lost in deciding upon what is to be done in each individual case. If the patient is unconscious, anæsthesia will not be necessary. In many cases in which the patients are conscious anæsthesia cannot be induced because the loss of time necessary to produce anæsthesia would be fatal. There can be no fixed rule as to whether or not anæsthesia should be produced, each case having its individuality. Morphine given subcutaneously at time of injury will probably prove efficacious in lessening pain and shock in patients who cannot bear anæsthetics.

If possible, reach the opening in the heart without opening the pleural cavity, but if the pleural cavity has been opened by the primary injury, the opening should be enlarged to admit of ample room to expedite suturing.

Giardano advises following the canal of the wound to the pericardium and heart rather than making an osteoplastic flap, as it might be sufficient to stop hæmorrhage through a small opening in this way. If this course is not followed, a semicircular incision is made to divide the soft tissues overlying the sternum. The cartilages of the fifth and sixth ribs on the left side are severed near the sternum, then by means of the rongeur a sufficient portion of the sternum is removed to bring the cut in the pericardium plainly into view. If necessary, the opening in the sternum may be enlarged. The wound in the pericardium may also be enlarged to facilitate the work. Gelatin given subcutaneously, by the stomach, or by the rectum, is said to be beneficial in arrest-

ing hæmorrhage from wounds of the heart as in other localities.

Historical Surgery of the Pericardium.—Baron Larrey (1798) was the first deliberately to plan the removal of, and to remove, fluid from the pericardial space. This he did by introducing a hollow needle between the seventh rib and the ensiform cartilage. (*Mémoires de Chirurgie*, Milan, t. III, page 458.)

The best anatomical route would appear to be between the sixth and seventh ribs, one inch to the left of the sternal margin. The internal mammary artery is a little external to the side of the sternum, and the intercostal artery at the lower margin of the rib.

Romero incised the pericardium in 1801 with a needle, and aspirated it in three cases in 1819, in two of which the patients recovered. Jowett (1827), Wheelhouse (1866), and Tiele (1869), each punctured the pericardium. Goodhart (1876) cured a case of hydatids of the pericardial sac by aspiration. West (1883) collected eighty cases of aspiration of the pericardium for various causes. Leyden (1881) was the first to make an incision in the pericardium to evacuate fluid. In his case the fluid was pus and the patient recovered.

Riolan was the first to trephine the sternum for the purpose of opening the pericardial sac. John C. Warren (1852) was the first American to remove fluid from the pericardial sac with a needle successfully. Trousseau did not give Larrey the credit of being the first to open the pericardial sac with a needle. Trousseau not only adopted the method of Larrey and Desault, but the point of puncture also.

The heart is pushed forward in the great majority of cases by fluid within the pericardium. This of itself should preclude the advisability of plunging a trocar into the pericardial sac, for the reason that the needle must of necessity pass through the heart to reach the fluid behind it. ("Surgery of the Pericardium.")

Wyman reports a case in which the bursting of a circular saw tore away a portion of the fifth costal cartilage and fifth rib. There was an opening in the pericardium and apex of the heart. The latter protruded. He sutured the pericardium with catgut and the patient recovered. (*Deut. Med. Woch.*, August 11, 1898.)

Reed R. Harvey, during the year 1887, had a case of stab wound in the left chest over the apex of the heart. He removed a section of the sixth rib and the clots in the pericardial sac and sutured the pericardium and cutaneous structures. The patient is acting as a policeman in Shelby, Ohio. (Personal communication.)

Dalton, H. C. (1891, September 6, *Annals of Surgery*), sutured the pericardium for a stab wound, with recovery.

Resuscitation.—There are numerous ways suggested to induce return of the heart's action. Among those most commonly practised are pressure, manipulation, subjecting the heart to a saline solution, cold or hot air, needling, aspiration, electricity, and the exhibition of adrenalin.

Pressure.—This may be accomplished by compressing the chest wall or diaphragm when the abdomen is open.

Manipulation is done with the fingers or hand when the chest is open. A part or all of the heart may be held in the palm of the hand and gently pressed with each systole. If the opening in the pericardium is not sufficient to permit of the entire heart being grasped in the palm of the hand, the apex alone may be grasped by the thumb, index, and second fingers and gently compressed with each systole, or about eighty times a minute.

Saline solution.—The immersion of the heart in a normal salt solution has been known to stimulate the cardiac fibres to contraction. It may be injected into the pericardial sac through a hollow needle or it may be introduced with a syringe through a rent in the pericardium.

Cold or hot air has also been known to stimulate the

heart's action when once it has become quiescent. The blowing of air with the mouth or bellows has, in a few instances, also stimulated cardiac action, when once it had ceased.

Needling.—The introduction of a small needle into the wall of the heart has been shown to cause the heart to renew its contraction after it had ceased for several seconds.

Aspiration.—Westbrook (*New York Medical Record*, 1882, Vol. II, page 705) abstracted blood from the right heart for simple distention and to excite a return of its action.

Maag had a case of death from chloroform narcosis, but before the patient died he made use of the pressure method of resuscitation, *i.e.*, manual compression of the heart and artificial respiration. For the latter purpose air was blown into the lungs through a tracheal cannula. Half an hour elapsed before they could perceive natural respiration. For one hour the breathing was deep and regular, the heart beats were powerful, seventy per minute. An hour later, the patient, apparently saved, was put to bed, although still unconscious. In a few minutes respiration ceased and could not be restored. The heart continued to beat for eight hours after, and then stopped suddenly; the temperature fell gradually during this time. Maag resorted to the pressure method in this case ten or fifteen minutes after all pulse and respiration had stopped; the patient was cold and cyanotic. Resuscitation was successful, even though the patient died.

A personal communication from E. Lanphear states that he resuscitated a patient from chloroform narcosis by manual compression of the heart. The patient was brought to consciousness and was able to converse, but died one hour later.

Electricity.—The negative pole of a faradic current applied to any portion of the vagi will stimulate the heart's action. Muhlberg and Crile believe that adrenalin is a most powerful cardiac stimulant, in fact the most powerful of any

known at the present time. (See Chapter on Experimental Heart.)

Causes of Death.—*Primary.* Shock, hæmorrhage.

Secondary. Carditis, endocarditis, pericarditis, pleuritis, pneumonitis, embolism (air or clot), abscess, aneurysm, exhaustion.

Primary shock is the term applied to that class of heart injuries which produce instant death without much if any loss of blood.

Hæmorrhage is the cause of death in the greater number of cases. Life may be maintained several hours after the heart has received a fatal injury. In such a case the probabilities are that the laceration is limited to the external surface of the heart. Hæmorrhage may also result from an injury to a small branch of one or both of the coronary arteries or a small puncture through the endocardium, regardless of the size of the opening on the external surface of the heart.

Secondary carditis frequently results from lacerations or contusions and may be local or general, varying in degree of seriousness.

Endocarditis occurs perhaps more frequently, and is many times associated with carditis. It may be the result of carditis or it may cause it. If there is endocarditis without injury to the endocardium, it is the result of carditis, but it more frequently occurs as the result of direct injury.

Pericarditis is probably the most frequent complication, and it may follow cardiac injury of any degree, at any time, in a circumscribed or general way. If it is present at the time of operation, the pericardium should be left open and provided with a strip of gauze for drainage. In such cases the pericardium will become adherent to the heart.

Pleuritis resulting in empyema is of frequent occurrence. The pleura may be involved without empyema. In either case inflammation of the pleura may be a complication with-

out the pleura having received direct injury. It may be circumscribed or general.

Pneumonitis is a serious complication, resulting from direct injury or secondary to injury to the heart. The left lung is more frequently involved than the right, and the extent of involvement may be of any degree.

Embolism (air or clot) may be fatal at any time during convalescence. It is to be especially feared in all cases in which the injury has extended to the cavity of the heart; otherwise it is not likely to occur.

Air entering the heart during the closure of a heart wound is not so much feared in later years. It is, however, to be considered and guarded against. Its entrance into the heart may cause immediate or subsequent death. It may enter the heart before the closure of the opening or it may enter subsequently, if the sutures should tear out or become absorbed or break before union has been complete.

Abscess may occur in the wall of the heart within the pericardial, pleural, or mediastinal space; wherever it may exist, free drainage should be resorted to.

Aneurysm has been observed in the cicatrix of cardiac wounds. It may occur and terminate fatally at any time, or it may develop slowly and may or may not result in dissolution.

Exhaustion is usually due to one or more of these complications of any degree to that of fatal termination.

The accompanying fifty-six cases of heart suture with twenty successes are a glowing tribute to the many achievements already attained during the nineteenth century, and, coming as it does so near its close, one is led to believe that the twentieth century will not be far advanced before the problems of surgery of the heart will be determined and become fixed.

That incisions, lacerations, and puncture of the heart from any cause will be successfully sutured, superficial ab-

scesses and cysts evacuated by incision, foreign bodies, clots, and pathogenic organisms removed from the wall or the cavities of the heart, there can be but little doubt.

Callender (1871) extracted a needle imbedded in the human heart, and Roswell Park (1877) unintentionally aspirated a myocardial abscess. These are probably the first recorded cases in which anything surgical has been done with the human heart.

Farina (1896) reports the first recorded case in which sutures were applied for a traumatic opening in the cardiac wall, and, although the patient died on the fifth day from bronchopneumonia, much credit should be given the operator.

The wound was made with a dagger entering just above the margin of the left sixth rib near the sternum. An opening one-fourth of an inch in length was made in the right ventricular wall. Three stitches were taken with silk.

Cappelen (1896) records a case of stab wound of the heart through the fourth left intercostal space in the middle axillary line, inflicting a penetrating wound four-fifths of an inch in length, not into the left ventricle. The operation was done one hour later. Death ensued several days after, from pericarditis. A branch of the coronary artery had been accidentally cut during the operation, probably with the needle.

Rehn (1896) also sutured a stab wound of the heart of a man twenty-two years old, the opening being in the right ventricle. The knife entered the fourth left intercostal space near the sternum. Three sutures were applied twenty-six hours after the injury. Although empyema developed, the patient recovered. This is the first recovery to follow suturing the heart for injury.

Parrozzani (1897) had the second case to end in recovery from heart suturing for a three-quarter inch incision in the left ventricle five hours after the injury. The knife entered

the seventh left intercostal space in the middle axillary line. No anæsthetic was given.

Parrozzani again records a case in which suturing of a three-quarter inch puncture in the right ventricle was done through the third left intercostal space one-half hour after the injury. Death, on the second day, was due to a cut in the interventricular sæptum. No anæsthetic was given. The heart wound was firmly closed.

Funna (1898) reports a stab wound under the left nipple, the weapon entering the apex of the heart, but not the cardiac cavity. Sutures were applied several hours after the injury. Empyema followed, but recovery took place. No anæsthetic was used.

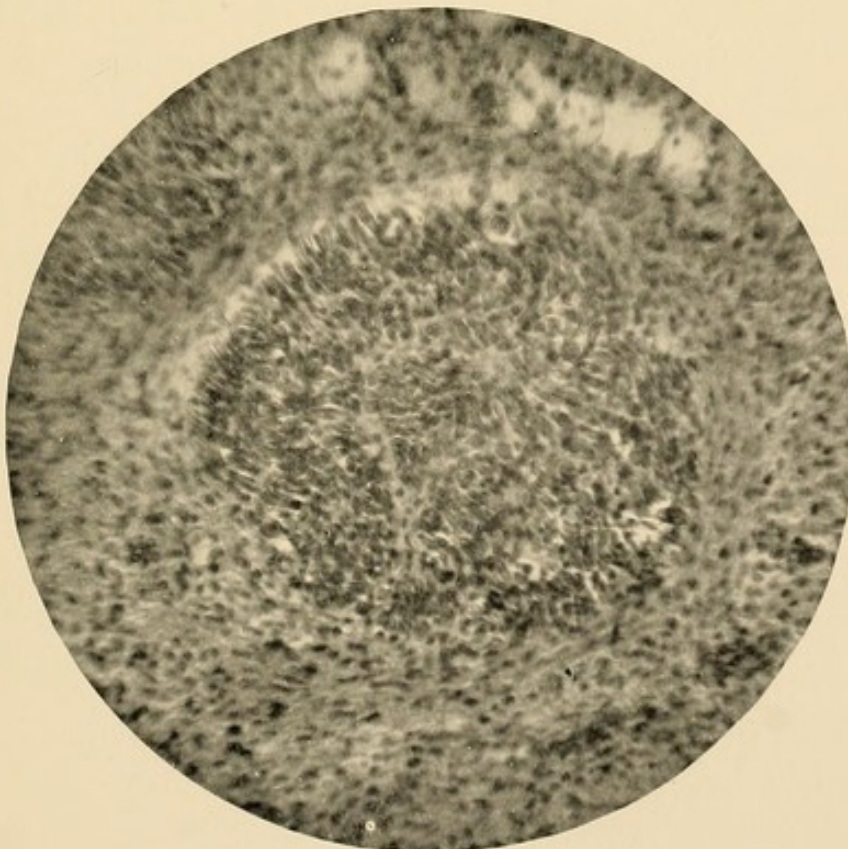
Parlavecchio (1898) mentions the case of a young man who walked a quarter of a mile with a V-shaped penetrating knife wound, three and one-half inches long, in the wall of the left ventricle, through the fifth left intercostal space. Eight hours after the injury the chest was opened and four interrupted silk sutures were applied. Chloroform narcosis was employed, and recovery was uneventful.

Ninni (1898) reports the case of a man thirty years of age who, after receiving a knife wound in the left fifth intercostal space, walked two hundred steps with a wound in the anterior wall of the left ventricle near the apex twenty-five mm. in length. Without anæsthesia the chest was opened and the pleura incised, with the escape of much clotted blood. Two silk sutures were used to close the wound in the heart, and continuous sutures to close the pericardium. The patient died while the pleural cavity was being cleared of clots.

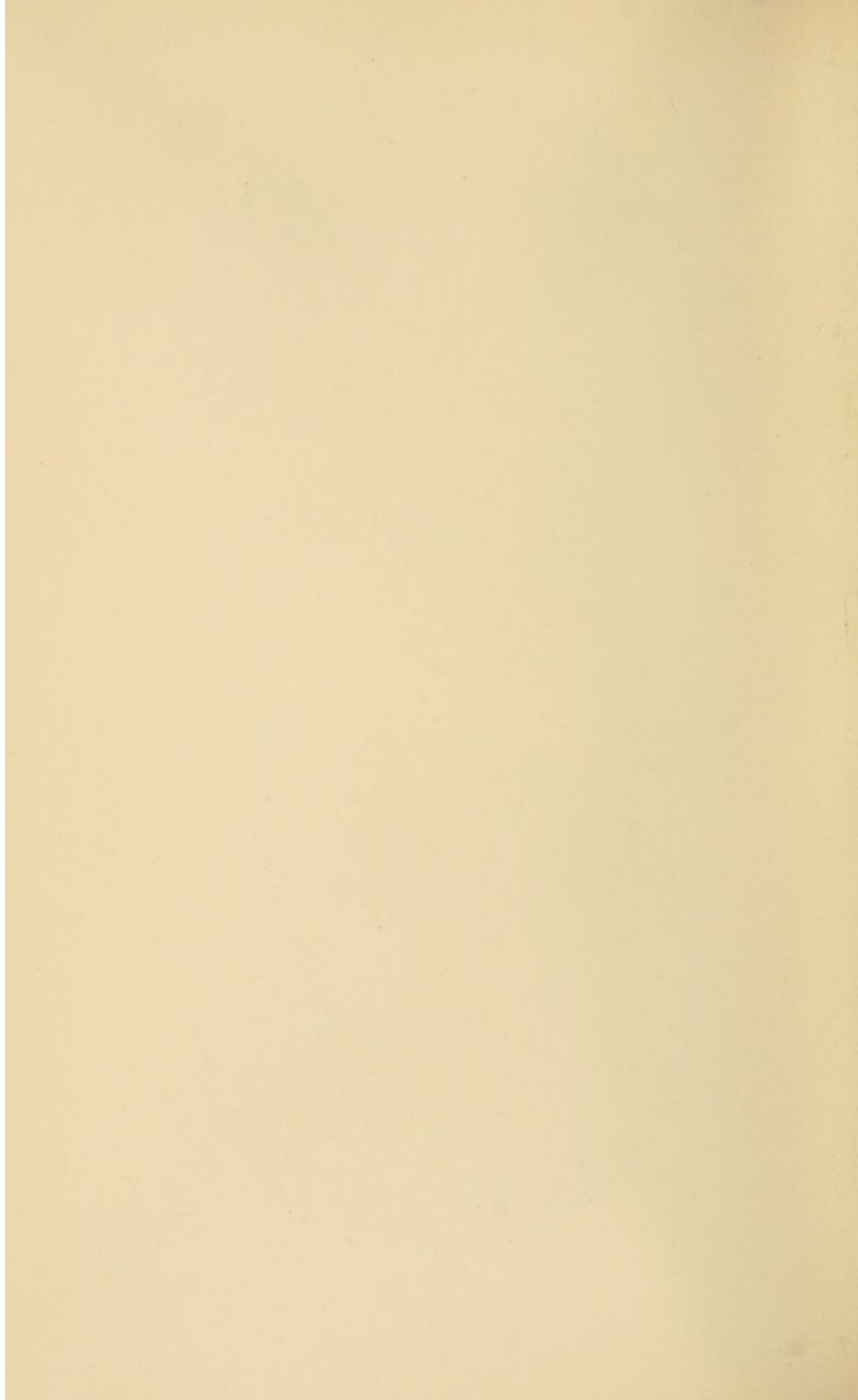
Giordano (1898) records a case of an incision four-fifths of an inch in length in the left auricle in which he applied four stitches one-half hour after the injury. The external wound was in the second left intercostal space. No anæsthetic was used. Death took place on the nineteenth day.



X 440.
MYOMA.



X 160.
RHABDOMYOMA.



Empyema and abscess in the right lung were found, but the wound in the heart had completely united.

Nicolai (1898) took four stitches in a wound of the right ventricle one and one-half hours after the injury. The external wound was in the fourth left intercostal space, midway between the margin of the sternum and the nipple. Chloroform was used. Death occurred twelve hours later.

Tuzzi (1898) records a case in which there were two wounds of the heart, one penetrating and one non-penetrating. The external wound was in the fourth left intercostal space. No chloroform was used, and death occurred on the twenty-second day from empyema and pericarditis.

Longo (1898) records a case of injury through the fifth left intercostal space, two-fifths of an inch internal to the nipple, producing an opening in the left ventricle necessitating three stitches. The operation was done at once without an anæsthetic. Death followed in fifteen minutes.

Williams (1898) reports a discovery following the suturing of a stab wound of the heart. (Da Costa, "Surgery," p. 240.)

Ramoni (1898) applied four stitches in two wounds of the heart, one penetrating and one non-penetrating. The external wound was at the third left cartilage, four-fifths of an inch from the sternum. No anæsthetic was used. Recovery followed.

Marion (1899) sutured a gunshot wound in the heart, with death.

Rosa (1899) was not sure that a stab wound of the left ventricle wall entered the cavity. He sutured a three-fifth inch incision without anæsthesia and with recovery.

Horodimki (1899) sutured an incision one and one-half cm. long in the right ventricle, with death.

Maliszewski (1899) sutured a heart wound, with death.

Maliszewski (1899) sutured another heart wound, with a fatal result.

Bufnoir (1899) sutured a twenty-two calibre gunshot wound of the right ventricle. The ball entered the fifth left intercostal space. Death followed. The necropsy showed perforation of the ventricle, and the anterior opening only had been sutured.

Pagenstecher (1899) records the case of a man seventeen years old in which he applied two stitches in a wound of the apex of the left ventricle, sixteen hours after the injury, without anæsthesia, the point of entrance being in the fourth left intercostal space, beneath the nipple. Recovery took place.

Nanu (1900) applied two interrupted sutures in a wound of the right ventricle two ctm. long, the point of entrance being in the third left intercostal space, four ctm. from the edge of the sternum. Death occurred on the fifth day, from infection of the pericardium and pleura.

Masseli (1900) sutured a wound of the left ventricle, near the apex, one and one-half hours after the injury. The external wound was below and internal to the left nipple, cutting the fifth rib. The patient died twelve hours afterward.

Fountain (1900) sutured a wound twelve mm. long in the left ventricle with continuous and interrupted catgut, six hours after the injury, using chloroform, with recovery. There were six external wounds with scissors between the third and seventh rib in the cardiac region.

Nietert (1901) sutured a stab wound in the heart three-fourths of an inch long. Three silk sutures were used to close the wound in the right ventricle. Death occurred after twenty-five hours.

Vaughan (1901) applied a continuous silk suture, seven stitches, in a wound of the left ventricle two and one-half ctm. long, forty-five minutes after the injury. Ether was used. Death of the patient took place on the table from hæmorrhage at the time of the completion of the operation, from external wounds in fifth left costal cartilage divided.

Nietert (1901) applied two sutures in a wound of the left ventricular wall. It was doubtful whether the cavity had been opened. Recovery took place.

Zerlehner (1901) reports a case of a man who had been stabbed in both chest and abdomen. The chest wound penetrated the heart. He sutured the incision in the wall of the left ventricle. The patient bled to death by reason of the five sutures being torn out almost immediately. The general condition of the patient was such that he would have undoubtedly died even if the sutures had not given way.

Ninni (1901) had a case of wound of the right auricle, the entrance being in the chest left of the sternum; the patient died in four days, from sepsis.

Mignon and Sieur (1901) sutured a wound of the right ventricle; death followed.

Fontan (1901) sutured a wound of the left ventricle with catgut. Empyema followed; its evacuation was made, followed by recovery.

Brenner (1901) had a case of injury to the left of the sternum, near the sixth cartilage, the right ventricle being injured. The patient was operated upon on the following day. Death took place on the table. Degeneration of the heart muscle was found.

Watten (1901) records a case in which the missile entered the fourth right intercostal space, injuring the right ventricle, producing a wound from three to four ctm. in length. The right pleura was wounded. Pneumothorax followed, but recovery took place.

Lastaria (1901) had a case in which the left ventricle was injured, and was sutured. Death occurred in a few days.

Launay (1902) reports a case of a pistol ball entering the left ventricle, perforating both the anterior and posterior walls of the heart. He used catgut sutures in each wound, and recovery took place.

Ransohoff (1902) had a case of non-penetrating pistol wound of the left ventricle. Death took place on the table.

Stewart, G. D. (1902, personal communication), had a patient with an injury of the heart, which he sutured. It was followed by death.

Nietert, H. L. (Surgery of the Heart, "American Journal of Surgery and Gynæcology," St. Louis, 1902, xv, 151-153, "Philadelphia Medical Journal," 1902, ix, 790-793, 1 fig.) had a case in a male, aged 27, penetrating wound of left chest. A hurried examination showed an incision wound in the sixth interspace, a little to the right of the left papillary line; superficial area of cardiac dulness was somewhat increased toward the left; there was absolute flatness posteriorly over the area normally occupied by the lower lobe of the left lung. A normal vesicular murmur was heard over the entire right lung and upper portion of the left lung. The finger being introduced into the wound, it was found that the pericardium had been cut. The finger was then introduced through the incision in the pericardium and it was found that the heart also had been entered by the knife. In order further to explore the wound and ascertain its true nature a flap was made including the fifth and sixth ribs on the left side of the sternum. The outlines of the flap were as follows: The first incision was made along the lower border of the fourth rib, extending for two inches outward from the left border of the sternum. A second incision was made along the lower border of the sixth rib to a point about two inches to the left of the sternum. The outer extremities of the two incisions were united by a third incision. The fifth and sixth ribs were divided in the line of the outer wound, as were also the intercostal muscles and pleura. The entire flap, composed of skin, muscles and ribs, was forcibly pulled toward the right side, partly breaking the cartilages near the sternum. (The flap was a modification of that devised by Rotter, and is fully described above.) Through this opening an excellent view could be obtained of the pericar-

dium and the cut in it. A cut about three-quarters of an inch in length was seen in the left ventricle, located far back. Two interrupted silk sutures were introduced by means of a highly curved gut needle. The wound was treated as an infected one and drains were introduced; one in pericardium back of the heart and the opening in the pericardium only partly closed; another drain was placed in the pleural cavity. The osteoplastic flap was then allowed to fall back into position and sutured, except at point of drain. Patient was unconscious for several days after the operation. During this time he was given frequent hypodermic injections of strychnine and whiskey. The drains were removed on the fourth day. Patient made an uninterrupted recovery. The conclusions are: 1. That gentle manipulation may be applied without producing shock; 2, that the introduction of the suture produces but a slight irregularity in the heart's action; 3, that heart wounds heal rapidly; 4, intrapericardial pressure is increased even if hæmorrhage occurs during diastole alone; 5, that all heart wounds in which there is danger of fatal hæmorrhage should be sutured; 6, if the wound does not involve the pleura the extrapleural route should be employed as described above; 7, if the pleura has been injured the intrapleural method should be employed, and the flap devised by Rotter is the best; 8, although it is advisable for the surgeon to familiarize himself with the methods of operation and the flaps devised by the different operators a thorough knowledge of the anatomy of the region is most essential, and each operator should modify the flaps as best suits his case.

REPORTS OF CASES OF SUCCESSFUL SUTURING BY DIFFERENT OPERATORS WITH VARIOUS TERMINATIONS, AND THE CONCLUSIONS

By L. L. Hill, M.D., surgeon to the Hill Infirmary, Montgomery, Alabama. Personal communication.

Henry Myrick, a negro, thirteen years of age, of rather delicate appearance, was stabbed at five o'clock on Sunday

afternoon, September 14, 1902. About six hours after the injury Drs. Parker and Wilkerson were called, and, perceiving the nature of the case, advised that I should be sent for, and upon my arrival I urged an immediate operation. To this the parents readily consented, and I was assisted in the operation by Drs. Wilkerson, Parker, Michel, R. S. Hill, Robinson, and Washington. The knife blade entered the fifth intercostal space, about a quarter of an inch to the right of the left nipple, and, penetrating the apex of the heart, passed into the left ventricle. The wound was about three-eighths of an inch in length, and from it came a stream of blood at every systole. There was no external bleeding, but his general condition was very unfavorable. The radial pulse was almost imperceptible, and the heart sounds were heard with difficulty. There was a triangular-shaped area of dullness. He had dyspnœa and was very restless. His extremities were cold, as were his lips and nose. When aroused, he answered questions intelligently, though his countenance showed great distress. Securing two lamps, I removed the boy from his bed to a table at one o'clock at night, eight hours after the stabbing, and proceeded to cleanse the field of the operation and place the patient in as favorable a condition as my surroundings in the negro cabin would admit. Commencing an incision about five-eighths of an inch from the left border of the sternum, I carried it along the third rib for four inches. A second incision was started at the same distance from the sternum and carried along the sixth rib for four inches. A vertical incision along the anterior axillary line connected them. The third, fourth, and fifth ribs were cut through with the pleura. The musculo-osseous flap was raised, with the cartilages of the ribs acting as hinges. There was no blood in the pleural cavity, but the pericardium was enormously distended. I enlarged the opening in the pericardium to a distance of two and one-half inches and evacuated about ten ounces of blood. The pulse im-

mediately improved, and this was commented upon by Dr. L. D. Robinson, who so successfully and skilfully administered the chloroform. I had my brother, Dr. S. Hill, pass his hand into the pericardial sac and bring the heart upward, and at the same time steady it sufficiently for me to pass a catgut suture through the centre of the wound in the heart and control the hemorrhage. I cleansed the pericardial sac with a saline solution and closed the opening in it with seven interrupted catgut sutures. The pleural cavity was also cleansed with a saline solution and drained with iodoform gauze. The musculo-osseous flap was brought down and stitched in position. The operation lasted forty-five minutes. The patient's pulse, on reaching his bed, was 145 and respiration 56. I injected strychnine hypodermically and employed hypodermoclysis and autotransfusion. The following morning, September 15, the boy's pulse was 130 and temperature 102° , and he was slightly delirious. On September 16 there was but slight change in the temperature and pulse, though the delirium was much worse. On September 17 he commenced to improve, and his recovery has been uninterrupted. I allowed him to sit up on the fifteenth day. Dr. E. C. Parker, who assisted me in the subsequent management of the case, examined the urine frequently, but was only able once to find a trace of albumin.

Conclusions.—*First.*—Any operation which reduces the mortality of a given injury from ninety per cent. to about sixty-two per cent., is entitled to a permanent place in surgery, and every wound of the heart should be operated on immediately.

Second.—Whenever the location of the external wound and the attending symptoms cause suspicion of a wound of the heart, it is the duty of the surgeon to determine the nature of the injury by an exploratory operation, as is recommended by Professor Vaughan.

Third.—Unless the patient is unconscious, and corneal

reflex abolished, as in Pagenstecher's case, an anæsthetic should be given, and preferably chloroform. Struggling is apt to produce a detachment of a clot and renew the hemorrhage, as occurred in Parlavecchio's patient.

Fourth.—Never probe the wound, as serious injury may be inflicted upon the myocardium.

Fifth.—Rotter's operation renders access to the heart extremely easy, and should be generally adopted.

Sixth.—Steady the heart before attempting to suture it either by carrying the hand under the organ and lifting it up, or, if the hole is not large enough, introduce the little finger, as Parrozzani did, which will serve the double purpose of stopping the bleeding and facilitating the passage of the stitches.

Seventh.—Catgut sutures should be used, as wounds of the heart heal in a remarkably short time. The sutures should be interrupted, introduced and tied during diastole, and not involve the endocardium, and as few as possible should be passed commensurate with safety against leakage, as they cause a degeneration of the muscular fibre with its tendency to dilatation and rupture.

Eighth.—In cleansing the pericardium it should be sponged out, and no fluid poured into the sac.

Ninth.—It hardly seems necessary to accentuate the fact of the necessity of perfect cleanliness in these operations whenever the urgency of the case does not require instant intervention, as in the patients of Longo and Ninni.

The wound in the pericardium should be closed, and should symptoms of compression arise, reopen the wound and drain as Rehn did.

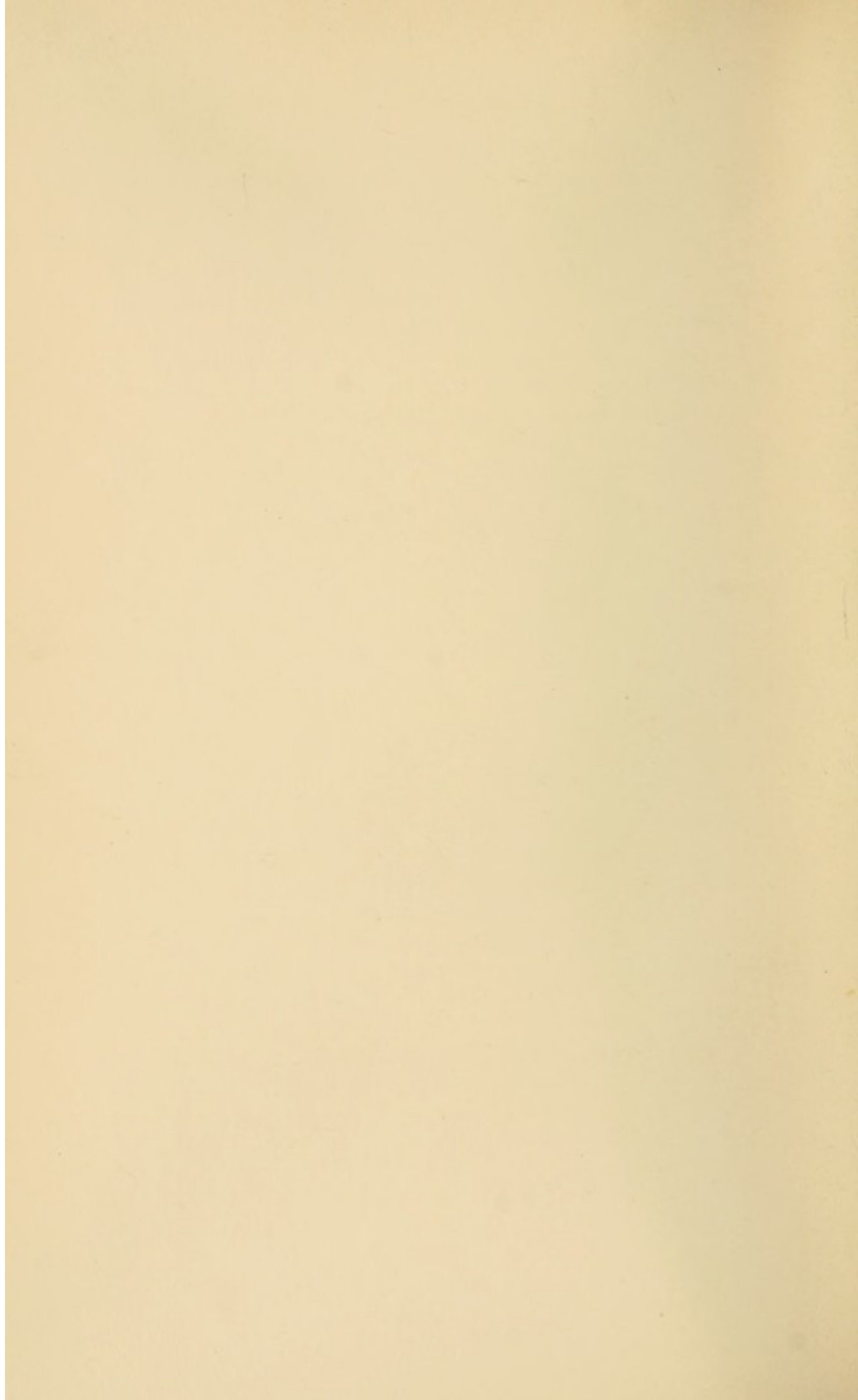
By Louis Rassieur, M.D. Personal communication.

Edward Spilker, white, single, aged nineteen years, nativity, St. Louis, Mo., shot himself with suicidal intent on Sunday, January 18, 1903, at 2.45 P.M. "A Christian Scientist"



X 80.

POLYPUS.



saw him and probed the wound with a lead pencil. A regular physician was then called in. The latter pronounced the wound necessarily fatal, and advised the patient's transfer to the St. Louis City Hospital.

When he arrived, at 3.45 P. M., his pulse was bad, his abdomen board-like. A powder-burned pistol wound was in the fourth interspace, just below and internal to the left nipple. The chest showed, on physical examination, signs of a slight hæmothorax.

There were none of the many symptoms so clearly classified by the various writers which are pathognomonic of gunshot wound of the heart. The patient looked pale and was very indisposed.

The senior physician, who first saw the case, in fact, reported it to me as one of gunshot wound of the chest, with the bullet ranging down toward the peritoneal cavity, not at all divining the fact that the bullet had struck not only the heart, but the left lung also.

I ordered the patient prepared for operation. The preparation, *et cætera*, took about two hours. During this time he bled about a pint and a half from the gunshot wound.

When the patient was placed on the table for operation, he presented a different picture. He was now well-nigh depleted, almost indifferent, and covered with profuse perspiration. He was anæsthetized with chloroform. The operation began at 5.45 P. M.

Operation.—An incision three inches long, parallel to the left papillary line, was made, extending through the gunshot wound. One inch of the fourth and fifth ribs was resected, one-half inch of the cartilaginous and one-half inch of the bony portion of the respective ribs. The intercostal vessels were secured by silk ligatures. The chest was now full of blood. I turned the patient on his belly to let the blood run out of the chest. Then I turned him on his back, and found

on examination a hole in the pericardium, which was also powder-stained.

I enlarged the hole two inches. The heart-sac was full of blood. I mopped out the heart-sac with sterile gauze, and with the left hand drew the heart forward, grasping the heart at the apex. There was a ragged laceration of the wall of the left ventricle midway between the base and the apex. The laceration bled freely and was half an inch wide, three-eighths of an inch deep, and an inch and a half long. Three silk sutures, of medium-sized silk, were introduced into the heart muscle. The approximation was ideal. The hæmorrhage from the heart muscle ceased.

On further examination of the pericardium, the wound of exit was found in the bottom of the sac. I washed the sac with physiological saline solution. I then cut out the burned portion of the sac and now approximated the sac incision with eight medium-sized silk sutures, thus using no drainage in the pericardium.

I now drew forth the lower lobe of the left lung. The lower lobe had been perforated by the bullet and was bleeding freely. About a square inch and a half of the lower lobe was infiltrated with extravasated blood. I raised this portion of the lung, and then tied around it a silk ligature of the heaviest silk. Thus the lower portion of the lower left lobe was ligated *en masse*; treated as if it were but a single vessel. The ligature was drawn very tight, crushing the lung tissue. The part beyond the ligature was cut away. In this way the bleeding of the lung was disposed of in three-quarters of a minute.

During the operation I had the median flap of the chest wound raised with a retractor. While sewing the heart I held it with my left hand against the median side of the chest, and introduced my silk sutures with a gut needle. I used a Halsted artery forceps as a needle holder. I now turned the patient on his belly to rid the chest of the blood.

Now I rolled him on his back. I introduced a single strand of gauze into the left pleural cavity as a drain. The gauze in the mouth of the pleural wound had an additional motive, in that it kept the mouth of the wound open and permitted filtered air to rush into the pleural cavity, thus forming an air cushion or splint about the left lung, preventing the expansion of the lung and the occurrence of pneumonia.

The bullet was somewhere in the muscles of the back. The pectoral muscles were approximated with medium-sized silk, the skin with silkworm gut. The operation ended at 6.45 P.M.; duration, fifty-five minutes; anæsthesia with chloroform (Squibb's).

No stimulants were given save a hypodermoclysis of physiological saline solution, 250 c.c., just before the operation.

Post-Operative Course.—When the patient was put to bed his chart was 99.2° F.; respiration, 28; pulse, 100. He complained of severe incessant pain over the region of the heart. The temperature, respiration, and pulse grew rapidly higher. The highest point was reached the next morning at 3 A.M. (January 19, 1903). Temperature, 103.4° F.; respiration, 36; pulse, 152. Then it receded. At 9 P. M., temperature, 100.2°; respiration, 38; pulse, 132.

January 20.—102.8°; respiration, 30; pulse, 128. Severe heart pain continued. At 6 P. M. the patient got up and walked sixty feet, and went to bed again. His walk did not harm him. He wished for a great deal of nourishment. He was given four ounces of water, milk, or beef-tea hourly if awake. (For twenty-four hours after the operation he was fed entirely per rectum.)

January 21.—Temperature, 101°; respiration, 36; pulse, 106. Resting easier. Drain removed from the pleural cavity, none returned. A slight amount of bloody fluid (three ounces) came from the chest on turning the patient on his abdomen.

January 22.—Temperature 100° ; respiration, 33; pulse, 106. Continues in fine condition. A slight systolic murmur heard best over the base of the heart; no physical signs of pneumonia.

January 23.—Temperature 99.4° ; respiration, 36; pulse, 106. Continues in fine condition.

Patient is dressed once every two days. He sleeps well. He receives five saline enemata every twenty-four hours and an occasional hypodermic of morphine sulphate, grain one-sixth. Up to the present time he has received nine-sixths of a grain of morphine sulphate. Absolutely no other form of medicines and no other stimulants, not even alcoholic, have been resorted to. The morphine was the only drug used.

(This is the third case under my observation. I saw Dr. Neitert's two cases daily.)

ANALYSIS OF FIFTY-SIX CASES OF HEART SUTURE

Character of the Wound.—The majority of the wounds were single and non-penetrating. However the percentage of recoveries from penetrating wounds that had been sutured was quite as large as from those of non-penetrating wounds.

Probably two-thirds of the wounds of the heart that had been sutured had been produced by dagger-like instruments; some accidental, some with suicidal, and still more with murderous intent.

The greater number of subjects of heart injuries operated upon, and the surgeons operating upon them, have been Italians. This probably accounts for the frequency of wounds, stiletto-like in character. The mortality is greater in gunshot wounds.

In one case operated upon death was due to the failure of the operator to close the endocardial opening with the external opening in the heart. This is one of the greatest dangers, and should, therefore, be carefully guarded against.

Anæsthetic.—Surgical anæsthesia by any means is not always necessary to suture the heart. Many such operations have been done without it. The greatest judgment should be exercised in the use of chloroform, ether, or nitrous oxide. Both ether and chloroform have been used, and, again, the operation has been frequently done without their use, sometimes while the patient was unconscious and sometimes while he was conscious.

Many of these injuries will not admit of sufficient time to produce artificial unconsciousness, others will, however, especially in non-penetrating wounds of the heart, a condition that cannot be determined without opening the pericardium.

External Location of the Wound.—This may be at any point upon the chest, abdomen, or neck, in any of the soft or bony tissues. About eighty-five per cent of those operated upon have been on the left chest, ranging from the axillary line to the anterior median line, from the third to the seventh intercostal space. The fourth and fifth intercostal spaces are the most frequent locations of entrance.

Time of Operation After Injury.—This depends upon environments and the aggressiveness of the attendants in whose hands the life of the patient is intrusted. In two or three instances the operation was done immediately, in fifteen to thirty minutes, and in one as late as twenty-four hours after the injury.

The wounds have been non-penetrating in the majority of cases operated upon late. In a few there was a very superficial non-penetrating wound with severance of one or both of the coronary vessels, vein and artery.

Accidents During Operation.—In one a branch of the coronary artery was severed, probably with the needle while suturing. In another an injured sæptum was overlooked, and in still another a perforation of the ventricle, posterior, was not closed with the external opening in the heart.

Kinds of Suture.—Silk and catgut have been the only material employed. Interrupted silk sutures have been most frequently employed, from one to seven in number in each individual case. Continuous sutures were used in but two or three cases. Catgut has been very infrequently employed. In one case in particular both interrupted and continuous sutures of this material were employed, with recovery of the patient.

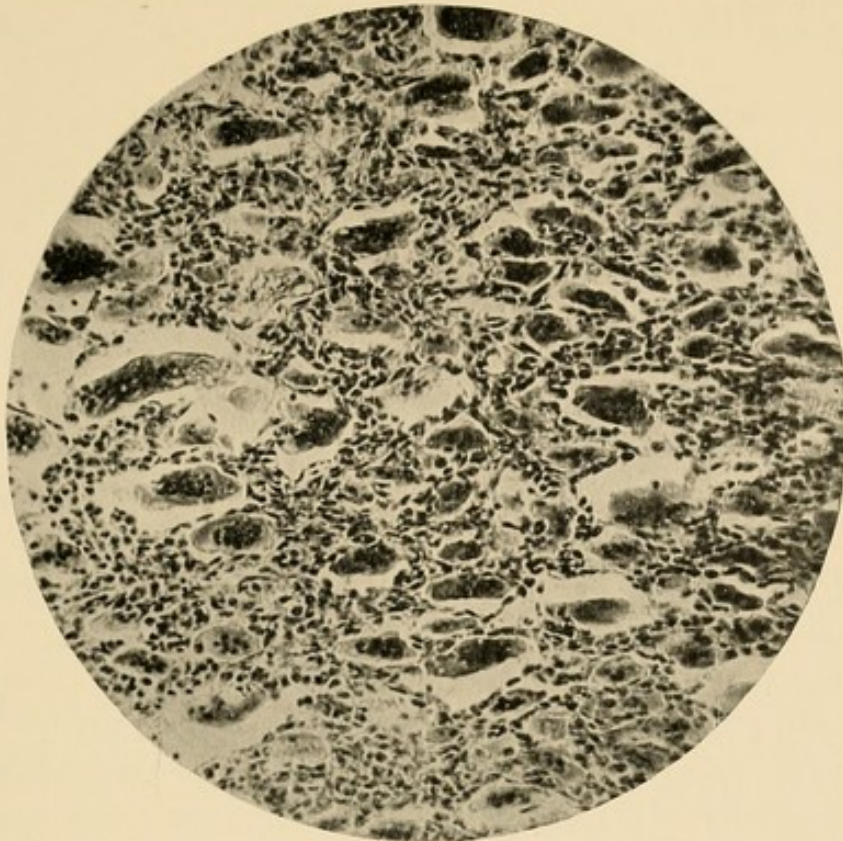
Deaths and Duration of Life After Operation.—Several have expired on the table during or at the completion of the operation; others from fifteen minutes to several days after the operation. Unconsciousness prevailed in a few at the time of operation, so that anæsthetics were not required for the operation.

Causes of Death.—Exhaustion from hæmorrhage or infection is most common. Hæmorrhage is the more common. It may result in instant death or it may be slow and gradual. Death may occur from loss of blood resulting from a penetrating wound of the heart, its great vessels, the mammary, intercostal, pulmonary, or coronary arteries, one or all, singly or combined.

Empyema, pleurisy, bronchopneumonia, carditis, and pericarditis each has contributed to the causation of death in this class of cases.

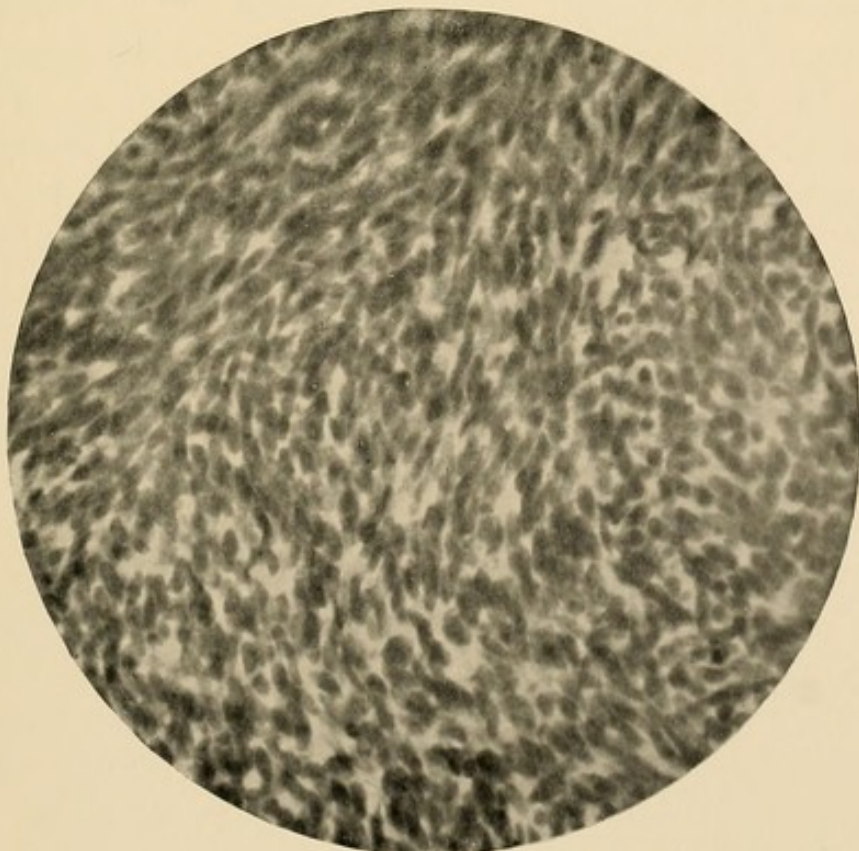
Mortality.—Fifty-six operations; twenty recoveries..

Age Most Favorable for Recovery.—From twenty to forty-five the blood-pressure is comparatively high, and the stress of blood-pressure on the arterial walls causes an increase in diameter of the large arteries. There is also a progressive increase in the size of the heart, year by year, at a nearly uniform rate. But after forty-five, although the arteries continue to increase in size, there is a fall in the blood-pressure. At the same time, almost suddenly, the heart begins to diminish in size. The widening of the arterial trunks and fall of blood-pressure, the reduction of mechanical stress



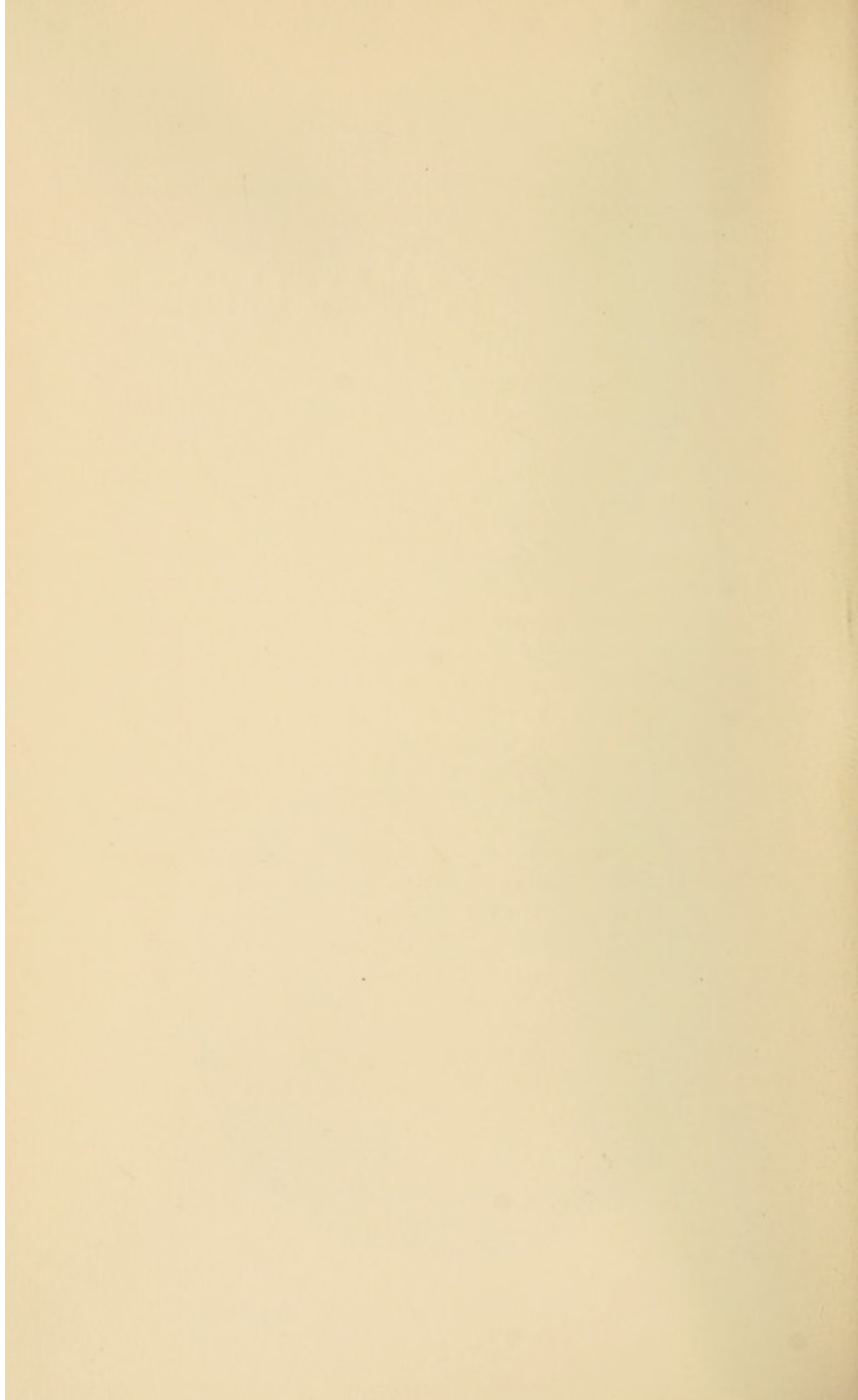
X 165.

SARCOMA, (Giant Cell).



X 360.

SARCOMA, (Spindle Cell).



from bodily relaxation, the loss of tone in the vasomotor mechanism of the splanchnic area, are all factors in producing this diminution in the size of the heart. Any chronic disease which usually afflicts men at this age may perhaps have some influence in this, too. There is also a change in the quality of the blood. It becomes more venous. At sixty-five a large portion of the capillary network becomes obsolete because of lowered metabolic and functional energy of the tissues caused by this decline of circulatory energy and the effects of age on the cell contents of the body.

These changes increase the peripheral resistance, which causes a rise in the blood-pressure. This in turn produces an increase in the size of the heart, so that the heart at fifty-five is as large as it was at forty-five. At the same time the hæmoglobin value of the blood becomes higher. There is no reason why the heart should not remain structurally sound until the most advanced years of life; that is, there is no physiological reason for structural degeneration unless there is some disease present; hence all cardiac and vascular damage that occurs in the second half of life must be produced by physical stress caused by sudden and violent exertions or from some severe laborious occupation. Care must be taken to see that men of middle age who are advised to take physical exercise do not overdo it.

Depressing emotions originating in worry, anxiety, etc., no doubt also are factors in producing cardiac troubles. Then, again, nervous depressions which may cause the foregoing are due to disease, such as gout, influenza, malaria, tuberculosis, and syphilis.

Overwork, worry, and nervous troubles are often held responsible for causing cardiac failure, when in fact the true cause is alcohol. All disturbances of metabolism in middle life are apt to cause heart troubles, especially in the so-called middle and higher classes of society.

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CHAPTER VIII

CARDIAC ANEURYSM

ANEURYSM of the heart may involve any portion, or the whole, of the cardiac wall, the left ventricle and upper portion of the interventricular sæptum being most frequently involved. The causes are those which produce aneurysm in any part of the arterial system. Heart strain and syphilis are the most frequent, but in some cases fatty degeneration may be a prominent causative factor.

There are no definite symptoms by which cardiac aneurysm may be recognized, nor is there any curative treatment. Little indeed can be accomplished in the way of palliation.

Historical (1843-1903).—In 1843 Craig published his observations and reported cases, illustrating the false consecutive aneurysm of the heart. Billingham (1850) reported a case of aneurysm in the apex of the left ventricle, followed by pericarditis. Bristowe (1853), Elliott (1857), Habershon (1862), Arnott (1868) and Girdlestone (1869), all report cases of aneurysm of the left ventricle. In the case of Arnott there was partial ossification of the heart-wall, winding around the root of the aorta.

Gore (1872) reported an aneurysmal tumor of the aorta forming in the walls of the left ventricle. Barlowe (1875) mentions an aneurysm in the base of the left ventricle, and Janeway (1875) a double one in the same cavity. Hughes (1883), Allen (1883), Handford (1885), Haig (1885), and Sharkey (1885), each reported cases. In Sharkey's case there was also an aneurysm of the aorta.

In 1888 Yonge reported a case simulating aneurysm of the descending aorta. In 1898 Sangree had a case of aneurysm of the left ventricle, and Burgess in the same year, one terminating in sudden death.

Georgiades (1894) mentions a case in a man sixty-five years of age, in whom there was found an aneurysm about the size of a walnut, at the apex of the left ventricle.

Hewett (1849) reported an aneurysmal dilatation of the left auricle, with thickening and contracting of the left auriculo-ventricular opening. Dawes (1875) reported a case of aneurysm of the base of the pulmonary artery. Irwine (1878) mentioned a case of displacement of the aortic valve by an aneurysm in the ventricular sæptum.

Newcomb (1884) reported a case in which all of the signs and symptoms of aortic aneurysm were simulated by an enormously dilated heart.

Williams (1890) reported an aneurysm of the pulmonary artery. In 1892 Hebb gives a case of atheroma of the pulmonary artery, and Kidd an embolic aneurysm of the pulmonary artery with aortitis, pulmonary endarteritis, and patent ductus arteriosus.

In 1895 Gaffon records a case of aneurysm of the coronary artery due to its obliteration, and Claude an aneurysm in a case of obliteration of the anterior coronary artery.

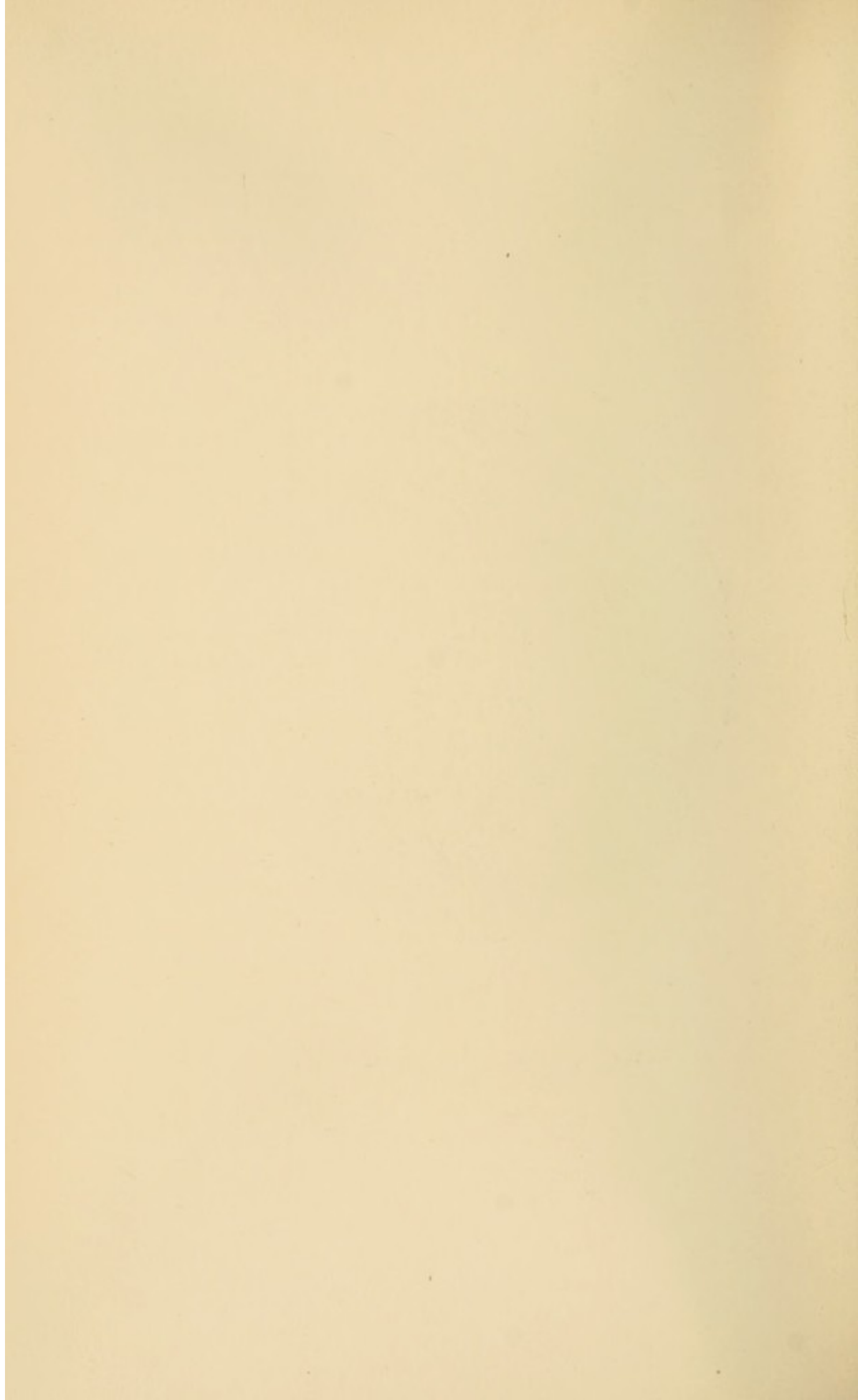
Turney (1896) reports a case of intra-pericardial aneurysm of the aorta. Callett and Steele (1898) report a case of aneurysm of the right pulmonary aortic sinus of Valsalva, with rupture.

Salvilli (1885) reports a case of aneurysm of the inter-ventricular sæptum, and Taylor (1886), Maguire (1886), Pert (1889), Northup (1888), and Klein (1889), each mention cases of like character.



X 270.

SARCOMA, (Small Round Cell).



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CHAPTER IX

FOREIGN BODIES

It has been shown that many kinds and sizes of foreign bodies may form within, or enter from without the heart, and yet life be maintained indefinitely. Foreign bodies in the hearts of bipeds are usually found in the floor of one of the two ventricles. The heart of quadrupeds is in a different position. It falls backward when man is upon his back, and forward as the dog walks about, or lies down.

Historical (1814-1903).—Wood (1814) wrote an interesting account of a dissection of a patient in which a foreign body was found within the heart. Sheward and Davis also report such cases.

Leaming (1843) mentions a case of a needle entering the right breast, and finally lodging in the heart, causing death. Graves (1847) relates a remarkable case of suicide, and extraction of a needle from the substance of the heart. Neill (1849) also relates such a case, resulting in death. White (1853) reports a case of aneurysm of the left axillary artery, with ligature of subclavian artery, and lodgement of a musket-ball in the heart.

In the case of Greene, a needle that had lodged in the right bronchus, and perforated the heart, produced death. Hamilton (1867) reports a gunshot wound of the heart, the ball being embedded in the wall of the right ventricle for twenty years. Death resulted from pneumonia. Balch (1867) also had a case in which the ball remained in the heart for twenty years. Ambrose (1870) recorded a case of a pin, that had become encysted in the wall of the heart.

Callender (1871) successfully removed a needle that had entered the heart, and the patient made a perfect recovery. This seems to be the first surgical operation successfully performed upon the heart.

Ryerson reported a needle in the heart. Halley (1878) reports a case of a ball, fifty-five days in the heart, causing death while the man was working in the field. Fayrer (1879) reports an interesting case of a dissection of a case, in which a foreign body was found within the heart. Murdock (1880) mentions a case of a thorn in the heart. Balch (1882) had another case in which a ball remained in the heart for eighteen years. He recovered from effects of wound in six weeks. Ferris (1882) reports a case of a man living twenty days, with a skewer traversing his heart.

Pool's (1889) case survived eleven days, with a bullet embedded in the apex of the heart. Pollard alludes to a case in which a lad lived five weeks, with a piece of wood in the right ventricle. Agnew cites another case, in which the patient survived three weeks with a watchmaker's file in his heart, the tool having passed through the left ventricle and right auricle. Haller reported (Agnew) the case of a needle being found in the heart of a bullock. Iverhardt reported twenty-two cases of needle in the heart (nineteen of which were discovered post-mortem), which were not suspected.

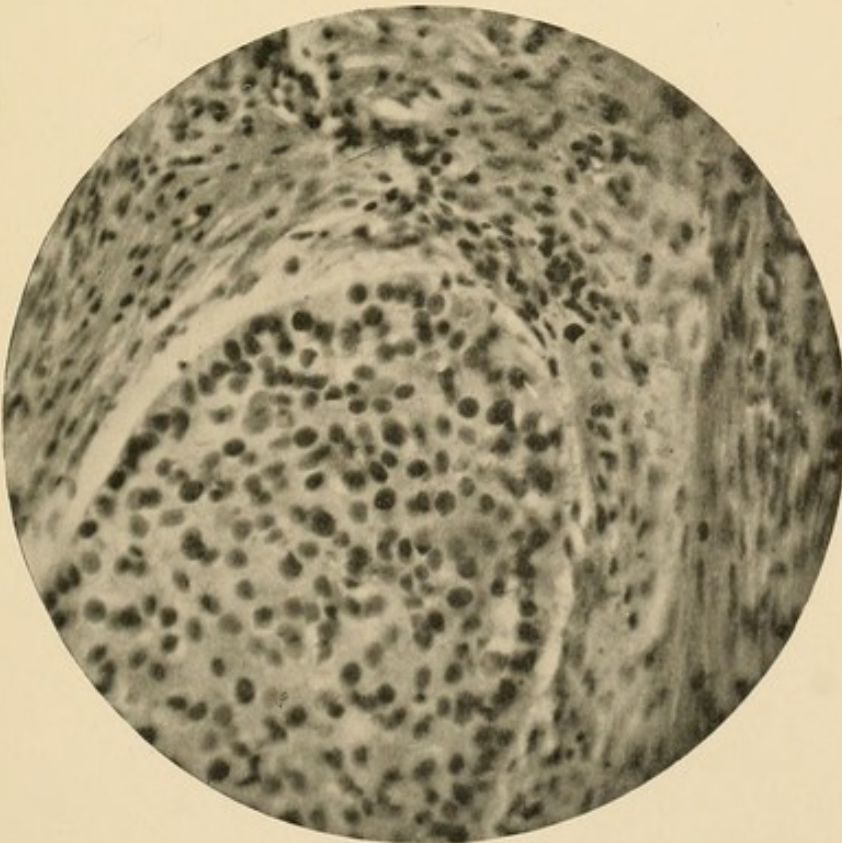
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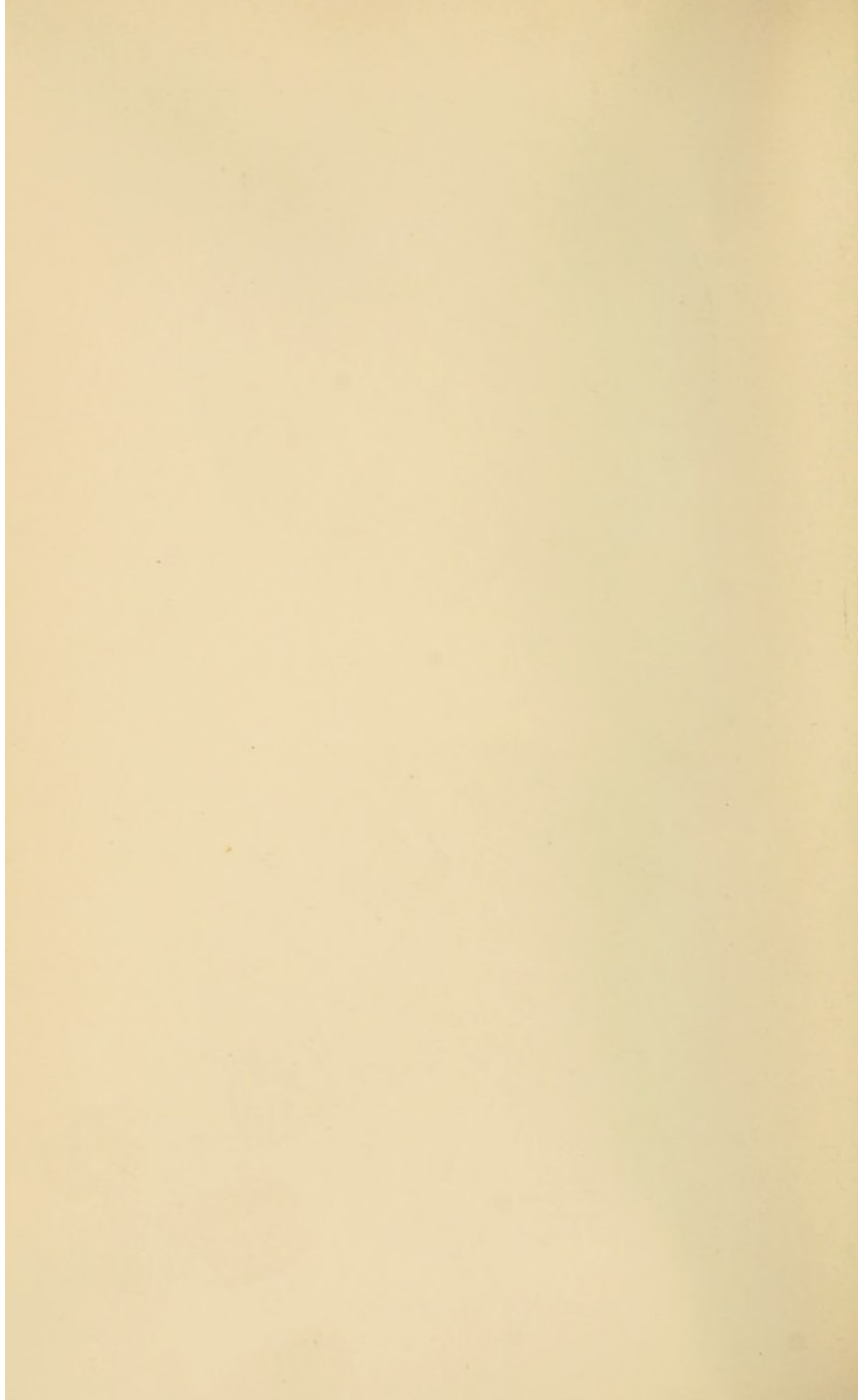
X 97.

CARCINOMA, (Epithelial).



X 260.

CARCINOMA, (Deep-Seated).



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CHAPTER X

CARDIOLITHS

CARDIOLITHS and concretions are quite common, and originate from the blood, polypoid growths, clots, or microorganisms. If a nucleus be present, it may be any foreign body that may have entered the substance of the heart, or any of its chambers. Cardioliths may enter any chamber after having formed in any portion of the cardiac substance, and at once become foreign bodies, and might be so classed.

Historical (1700-1903).—Goodwin (1700) recorded a case of polyform concretions of the heart. At the same time he reported several cases of stones in the heart. Vernon (1826) gives quite a lengthy report of a case of obstruction to the passage of blood through the right auriculo-ventricular opening of the heart, from a fibrous concretion, which was entangled under the tendinous cords of the tricuspid valve. Bricheteau (1834) reported a similar concretion of a fibrous character. Hache (1832) found such concretions in a tuberculous subject. Aubrey (1836) observed fibrous concretions, causing obstruction to the circulation. He thought them to be due to microorganisms. Hardy (1838) attributed their formation, in his case, to a vegetable ferment. Hughes (1838) reported his observations on fibrous concretions, in eleven cases.

Bouilland (1839) believed that the concretions found in his patient were from the blood alone. In the case of Sprague (1848) there were fibrinous concretions in the heart, extending into the pulmonary artery and aorta with extensive hepatiza-

tion of both lungs. Garstang (1852) mentions a case of death, due to a fibrinous concretion of the heart. Barbieri (1852) of Milan reports a case, in which a fibrous polyp extended from the ventricle through the aortic orifice.

Richardson (1855), it seems, was among the first to write upon the diagnosis of fibrous concretions in the heart. Blondet (1857) wrote voluminously upon the subject, but could offer nothing definite in determining their cause or presence. Hausley (1858) reported a death from a fibrous concretion in the right heart. Its presence in the right, is less frequent than in the left heart. It remained for Ogle (1862) to report the largest cardiolith. It was globular, and one inch in diameter, "lying loose" within the left auricle of the heart. It was fibrous in character. There was induration of the suprarenal capsules.

During the year 1864 Faure made an experimental research concerning fibrinous clots and the products of inflammation. In 1866 he reported upon a case of extensive fibrinous concretions in the heart. Monard (1867) wrote an interesting paper on the general considerations of concretions found in the blood. Faure and Monard deserve much credit, as they were among the first to explain the character of these bodies.

Barbancy (1869) appears to be the first to report fibrous concretions as being due to pneumonia. Fayrer (1870) states that death was due to fibrinous concretions in the right side of the heart, in a subject suffering from urethral fever. It is possible that in each of these cases the presence of concretions was coincidental. Fayrer (1873) reports another case, in which a fibrous concretion was found in the right heart. Lawson (1873) reports two such cases. Baker (1874) found them in the heart and large vessels. Hattute (1875) and Rendue (1875) each report concretions found in the heart of tuberculous subjects.

Chaffey (1887) mentions a case, in which fibrous deposits were found in the heart of a patient having diphtheria. May-

cock (1888) states that he found peculiar deposits in the heart and aorta, while Delepine (1889) describes a cardiolith.

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CHAPTER XI

CALCIFICATION

CALCIFICATION is a deposit of calcium carbonate or phosphate often found associated with some of the salts of magnesium. It may be deposited in the endothelium on the intermuscular fibres. It is usually preceded by fibrosis and due to weak circulation, and chronic irritation.

Gibson says "the nature of the process which leads to the deposition of lime salts is absolutely unknown," and that no more definite hypothesis can be assumed at present than that soluble become altered into insoluble salts.

Historical (1822-1903).—Rost (1822), Rainy (1827), Richardson (1830), Pierson (1834), Douglas (1838), Wood (1850), and Pierce (1852), have found ossific formations in the heart, the last named having also observed them in a hog. Wilks (1856), Cleveland (1860), Gay (1872), and Egan (1876), also mention cases. In the case of Eskridge (1884), the ossification was at the aortic orifice.

Emmet (1855) reports a case of calcareous deposits on the surface of the heart, with reference to the manner in which the blood is propelled from that organ. Ogle (1859) had a case in which such deposits surrounded the heart substance. Coats (1871) had a similar case, and reported two cases of calcareous infiltration of the muscular fibres of the heart. Harduch (1880) observed a similar one, and O'Toole (1880) found infiltration in the apex of the heart, at the same time writing extensively on the ætiology and pathology of such infiltration.

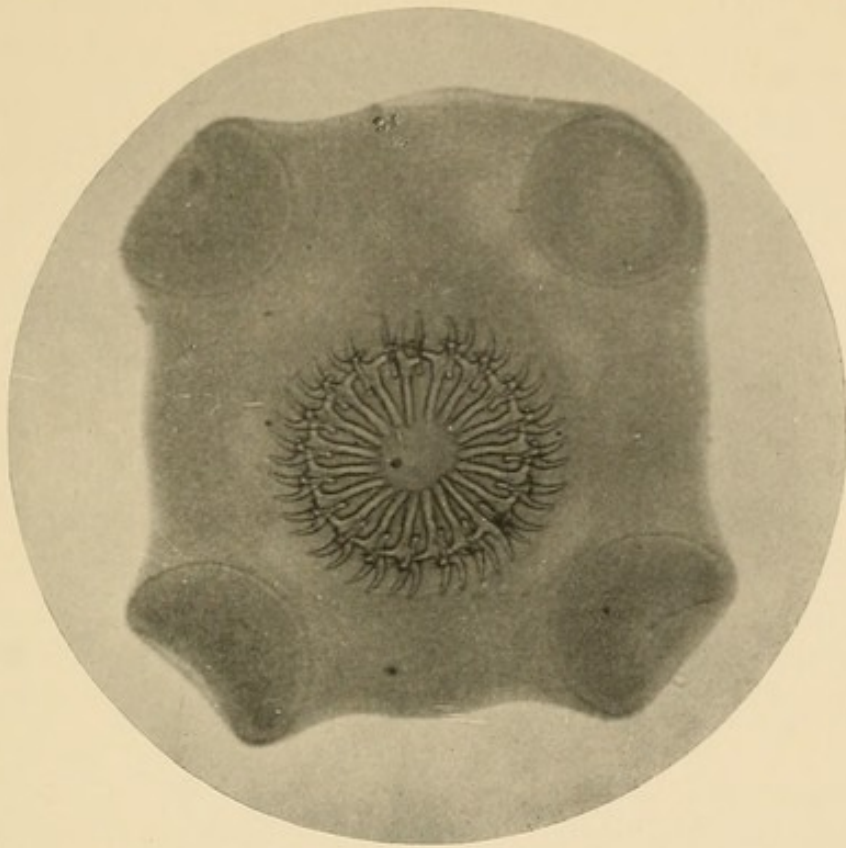
Réchardière (1883) recognized these deposits about the

aortic valves and ventricular walls. Robin (1885), Guinou (1885), Drummond (1888), Wolff (1891), Bromwell (1895), and Bromwell and Gulland (1896), and Faitout (1896), all report interesting cases of this character.

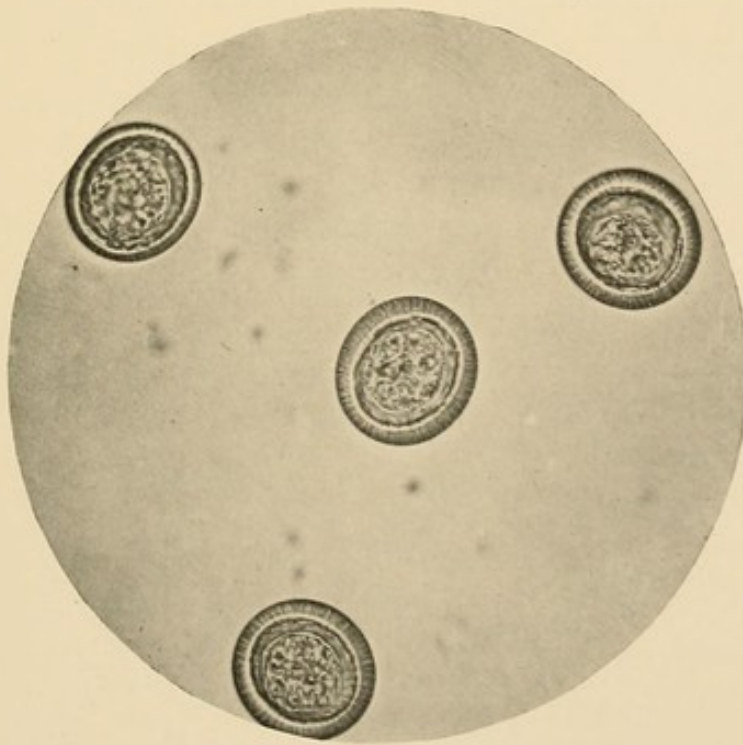
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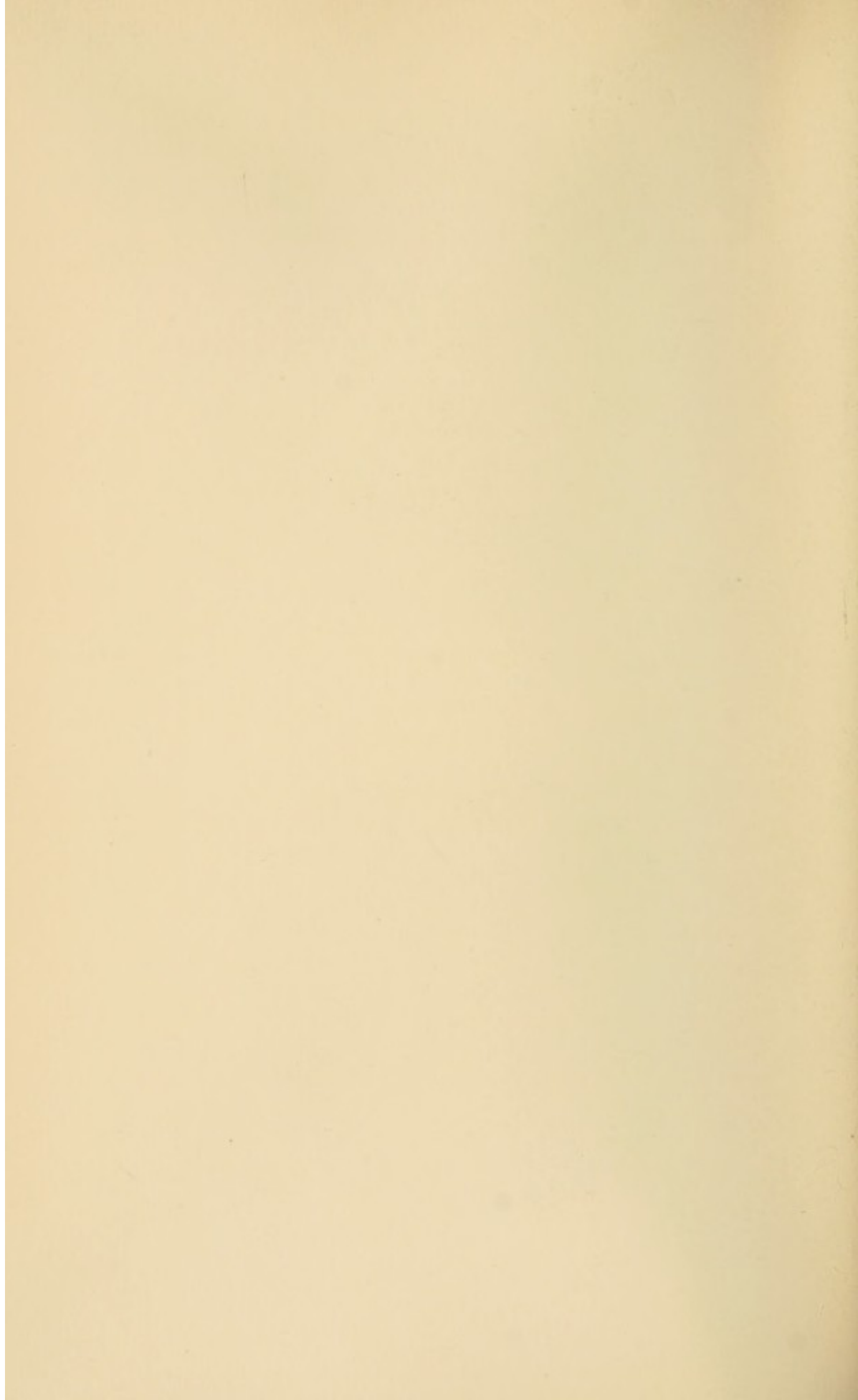
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X 47.
CYSTICERCUS.



X 75.
EGGS OF CYSTICERCUS.



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CHAPTER XII

ABSCESS

ABSCESS of the heart is usually pyæmic, and associated with disease of the bones and joints, cancer, phlebitis, myocarditis, and chronic ulcers, especially about the genito-urinary tract.

Cardiac abscesses occur as multiple yellow spots under the pericardium or endocardium, varying in size from a millet-seed to a bantam's egg, and situated, as a rule, at the base of the left ventricle in the papillary muscles. They may remain semi-solid, or they may contain fluid and rupture into the pericardial space, or into one or all of the chambers of the heart, and so finally enter the general circulation. Death may not ensue from either kind of rupture, the result depending upon the character of the fluid, its amount and the condition of the patient at time of rupture.

Historical (1833-1903).—One of the earlier reports of abscess of the human heart is by Broussais (1832). Such a condition was found in the heart of a horse by Parry (1835).

Hewitt (1846), mentions a remarkable case of abscess of the heart, with pain in the leg as the only symptom during life. Chance (1846) gives an account of abscess of the heart found post mortem, as does Stallard. Mayne (1847) speaks of a purulent cyst of the heart; McCormick (1851) of an abscess of the right ventricle; Rankin (1852) of an anomalous case of scrofulous abscess; Banks (1852) of purulent cardiac cysts.

Holmes (1857) mentions a secondary cardiac abscess from pyæmia in the heart-wall, and Maxon (1869) reports a case of abscess of the heart bursting into the left ventricle.

Wooster (1872) reports a case of abscess of the heart-wall with disease of the valves, incompetence of left sigmoid valves, physiological tricuspid incompetence, and anasarca, with painless death by gradual asphyxia from super-carbonized blood.

In 1872, Langhurst mentions a scrofulous abscess in the wall of the left ventricle, as does Crisp during the same year. The case of Crisp was due to pyæmia. Maxon (1872) reports a case of abscess of the heart and kidneys with suppurative periostitis, and Dennis (1895) records a case of abscess in the wall of the left auriculo-ventricular valves, about the size of a walnut, which had opened into the ventricle. The duration could not be determined from the symptoms.

Following is a case reported to me direct.

“DEAR DOCTOR: With regard to my own case of cardiac abscess, I briefly reported it in a Chicago medical journal I think for 1877. As I have not access to its files I cannot give you the references. My recollection of the case is to this effect. A hospital patient was suffering from dyspnœa, and proved to have a very much dilated pericardium, which at the time was considered to be full of serum. One night in his extremity of distress, I decided to try to relieve him by use of the aspirator. You will recall that this was in the early day of the aspirator and this was almost my first experience with it. I pushed a needle in and withdrew, not serum, but to my surprise, three or four ounces of pus. The man was temporarily relieved but died a few hours later. Autopsy showed a pericardium with considerable serum and an abscess cavity of the heart-wall nearly emptied, into which my needle point must have penetrated.

“Whatever else may be said about the case, I think I may certainly claim accidental priority in tapping an abscess in this locality.

“Very truly yours,

“ROSWELL PARK.

“Buffalo, N. Y., October 4, 1902.”

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CHAPTER XIII

SYPHILIS

It has been conclusively demonstrated that syphilis causes a large proportion of the more serious cardiac affections, especially after middle life, an age when chronic valvular disease is not due to endocarditis. Syphilis is often associated with other factors in the production of heart troubles, especially strain and alcoholism. (Bruce, *British Medical Journal*, March 23, 1901.)

Description (1862-1903).—Syphilis is an exciting and predisposing cause of muscular and valvular lesions of the heart.

Cohn believes that the condition of the heart muscle is the most important point to consider therapeutically, and for the purpose of prognosis, in all cardiac diseases, except mitral stenosis (*Philadelphia Medical Journal*, Vol. 7, No. 3, p. 106, 1901); "many of the changes in the heart-muscle are dependent upon pathologic changes in the arterial system."

Many cases of myocarditis, especially acute cases, are due to syphilis. The pain in cardiac diseases is due to the fact that the various visceral nerves are connected with the nerves of the corresponding parts of the body. The greater frequency of myocarditis in negroes is on account of syphilitic infection. (Bishop, *Philadelphia Medical Journal*, Vol. 7, No. 3, 1901, p. 106.)

These conditions do not generally begin until ten to twenty years after the initial lesion, and are more common in men than in women; they are slow as a rule in manifesting themselves and the prognosis is grave.

Fibrosis and gummatous deposits constitute the two forms of syphilitic affection of the heart. It is, however, only the gummatous form that will be considered.

Ricord, Virchow, and Lancereaux were among the first to observe gummata in the heart. They showed that these lesions may be diffuse or circumscribed, dry and yellow, or of a caseous character. Such infiltrations may occur in any portion of the cardiac tissue and undergo fibrous transformation. These masses do not soften and discharge except in the superficial heart muscles.

Haldane in 1868 reports a case in which he found a syphilitic deposit in the substance of the heart. Pick during the same year recorded one of fibroid degeneration of the heart with aneurysm in the right ventricle and the interventricular septum in a syphilitic patient. There are several cases of syphilitic heart affections reported during the ten years following that of Haldane. Pepper mentions a case of extensive syphilitic disease of the pericardium, pleura, and peritonæum, in which a paracentesis of the chest and abdomen was made. Gummatous infiltration of the muscular wall of the heart leading to aneurysmal pouching and rupture has been recorded by Pitt, and also by Pelletier.

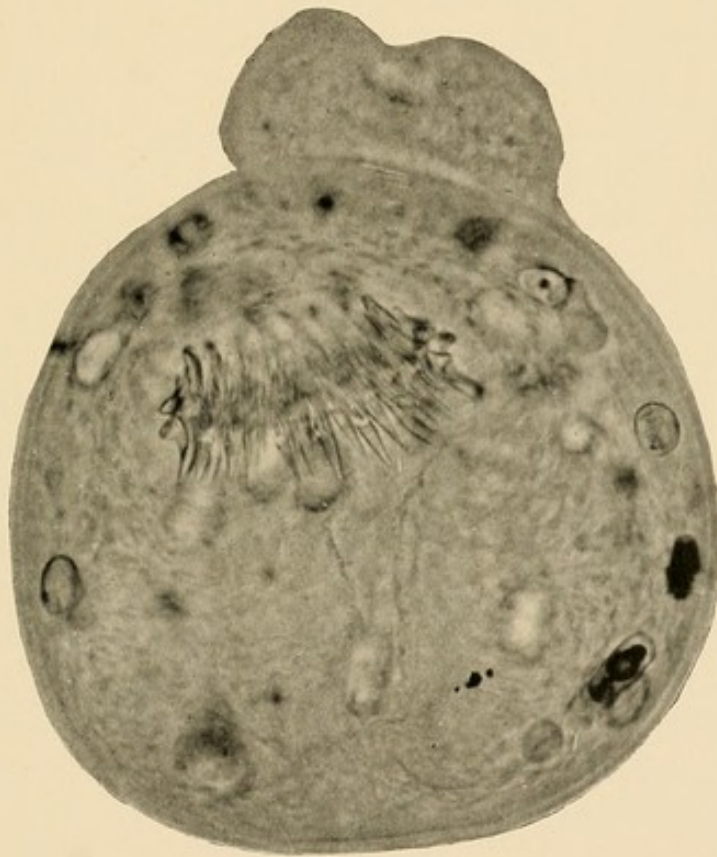
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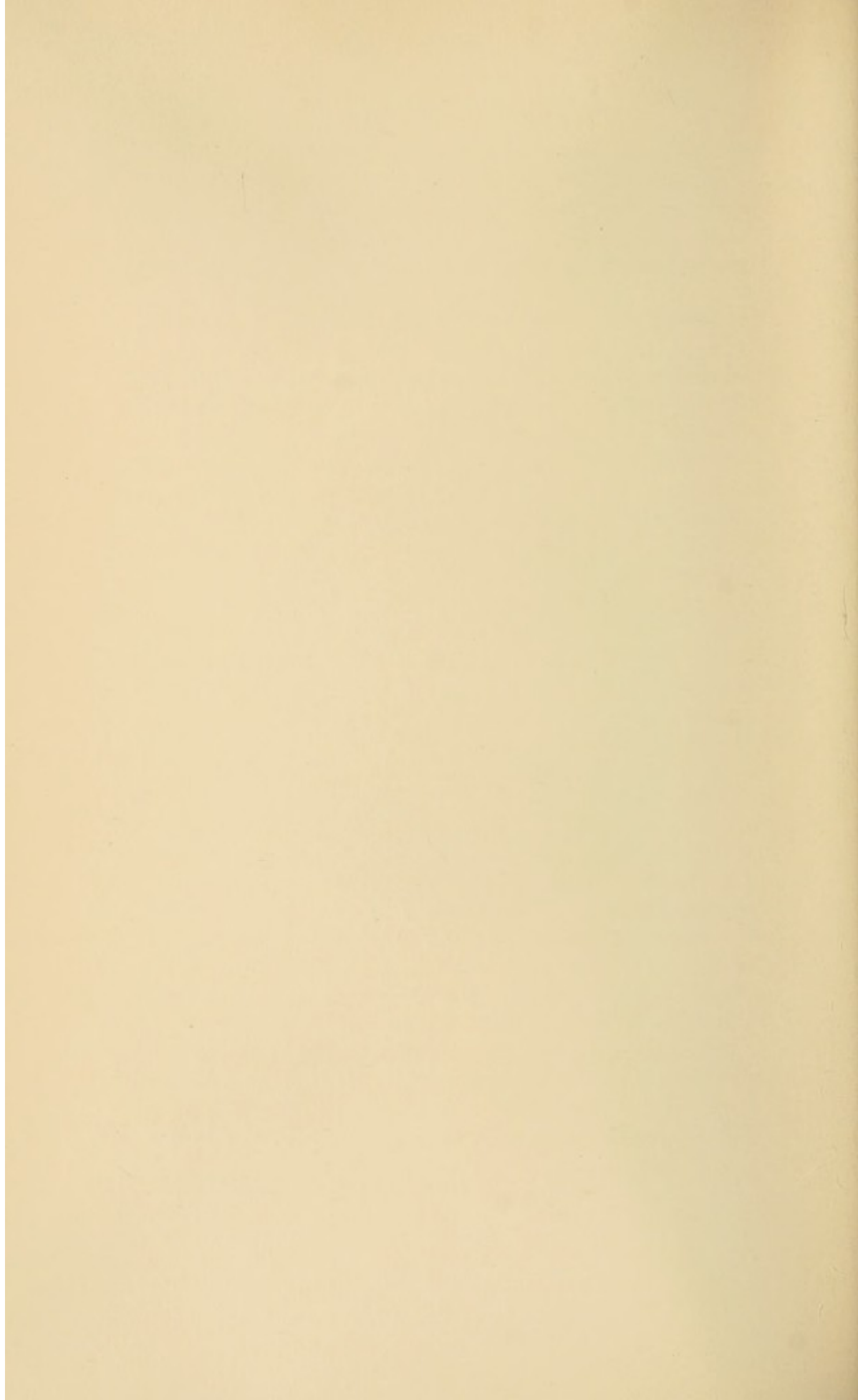
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CYSTICERCUS, (Bladder Stage).



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CHAPTER XIV

GANGRENE

GANGRENE of the heart is the least frequent of the diseases herein mentioned.

Historical (1850-1903).—The first case reported is by Gaullay, 1807; it is hardly more than a casual mention. Kennedy (1824), however, is more explicit in his report of a case of acute carditis terminating in gangrene of the heart, with illustrations of the same lesion determined by other forms of disease.

Cruveilhier (1850) made some interesting observations upon its pathology and maintained that it could occur as an independent disease. Young (1868) reported a case of gangrene of the heart and Oulmout mentioned an eruption simulating rubeola, cyanosis, and œdema in a case of gangrene of the heart. Gesland also reports a case of cardiac gangrene.

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OULMOUT.

CHAPTER XV

BENIGN TUMORS—FIBROMATA, LIPOMATA, ANGEIOMATA, RHABDOMYOMATA, MYXOMATA, POLYPI

FIBROMATA.—Of tumors of the heart, the most common are the fibromata, but while fibroid degeneration of the heart is frequent and may involve a part, or all of the muscular structures, it rarely, if ever, takes the form of a tumor. The latter may develop in any of the heart's structures, principally in the muscles.

Historical (1852-1903).—Gull (1852) found a fibroid tumor attached to the muscular tissue of the left ventricle of the heart of a sheep. Elliott (1856) found one in the right ventricular wall of a human heart. In this case there were a sacculated aneurysm and dilatation of the heart as a result of pressure. Wilks (1856) discovered a fibrous growth in the *sæptum ventriculorum* of the heart. Hitchcock (1856) reports three such tumors in the right ventricular wall, associated with hypertrophy of that wall.

Wagstaff (1871) records cases of cardiac fibroid and Laidley (1879) gave a report of a tumor in the cardiac wall. Meigs (1881) recorded a case in which a heart clot occurred as a consequence of uræmic convulsions and tumors in the heart.

Gairdner (1893) reports a very interesting case of obstruction of the right auriculoventricular orifice caused by a tumor in the auricle acting as a ball valve, during the direct current from the auricle to the ventricle and without other apparent disease of the valve or the heart. He gives clinical comment on diagnosis and prognosis.

Latnella (1896) records a pedunculated fibroid in the heart, and Cesaris-Demie (during the same year) reported multiple fibroids of the heart, while Jachia also made an extensive contribution to the study of fibroid tumors of the heart.

Crawford (1897) records a case of fibroid tumor of the pulmonary valves and Raw (1898), one in the right auricle of the heart with rupture of the inferior vena cava. Knox (1899) records a case of supra-arterial epicardial fibroid nodules.

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LIPOMATA (1886-1903).—Lipomata of the heart are comparatively rare. They may be fibromatous or myxomatous, single, multiple, or diffused. They are connected, as a rule, with the fat about the base of the heart, or form upon its external surface. They may, however, form independently of the fat in the heart, as elsewhere, and may be associated with any other form of new growth, or with general fatty degeneration of the heart. Lipomata may form upon the endocardium or pericardium, either with a broad base or pedunculated. If pedunculated lipomata form upon the endocardium they may swing into any of the cardiac cavities, or into the aortic orifice and occlude one or more of them; if upon the pericardial surface, they will move freely within the pericardial space and if large enough, produce serious or fatal trouble from pressure alone. They may form within the wall of the heart and undergo fibrous or caseous degeneration. Any form of new growth may produce death from pressure alone, or by interfering with the heart's action in general.

Lipomata are benign and rarely, if ever, disappear spontaneously. They are usually found after middle life, more frequently in women than in men, and do not recur when removed.

Banti and Handford (1886) each record a case of primitive lipoma of the heart, while Kolisko (1887) observed two,

one of which was congenital. Pietroni (1887) and Pelroethi (1897) also contribute interesting studies of lipomatous growths of the heart.

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ANGEIOMATA (1887-1903).—Angeioma of the heart is infrequent. It is formed of blood and is known as an erectile or a vascular tumor. It is cancerous when the alveolar spaces communicate with one another. Angeiomata develop upon the external or internal surfaces of the heart indifferently and in the same manner; they may be interstitial and of any size or number. The projection may be outward or inward; in point of fact their course is similar to that of any other kind of cyst. Angeiomata may rupture in one or all of the chambers of the heart, or into the pericardial sac. If they be large, death will ensue, especially if the rupture be into the heart's chamber, clots being carried into the general circulation. If the rupture of a large tumor be external, the pressure alone may be sufficient to produce death. Smaller ones may rupture in either direction without causing dissolution; usually, however, fatal results ensue because of an impaired heart wall, resulting from a pathologic condition existing prior to, and at the time of rupture. Neoplasms in any part of the body are more fre-

quent in women and therefore, cardiac angeiomata are supposed to be so.

Sussman (1887) reports an interesting case, in which he found cardiac angeioma, as does Mann.

Schmalts (1888), Miura (1889), Preisz (1890), and Von Etlinger (1890), each record a case of angeioma of the heart, while Birchhoff (1893) reports a case of a cavernous angeioma of the heart, and Smith (1894) records one of the right auricular wall, terminating in rupture.

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RHABDOMYOMATA.—Rhabdomyoma is a rare form of primary myoma characterized by the presence of striated muscular fibre. It is found in the muscular tissue of the heart upon the endocardial or pericardial surface or within the cardiac walls.

Rhabdomyoma is single as a rule, but may be multiple,

and in either event causes serious trouble by its presence, like other forms of new growth.

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MYXOMATA.—Myxoma is a mucous tumor composed of connective tissue, gelatinous in character, containing intercellular substance in which are scattered peculiar branched, or stellate cells. It attacks the epithelium and connective tissue, involving one or both, and may be single or multiple, and vary in size and shape.

Its location may be in any portion of the heart, and it may produce serious trouble from its size or location, or it may rupture into the cardiac cavities and thence discharge into the general circulation, or into the pericardial space, and so cause death by pressure alone.

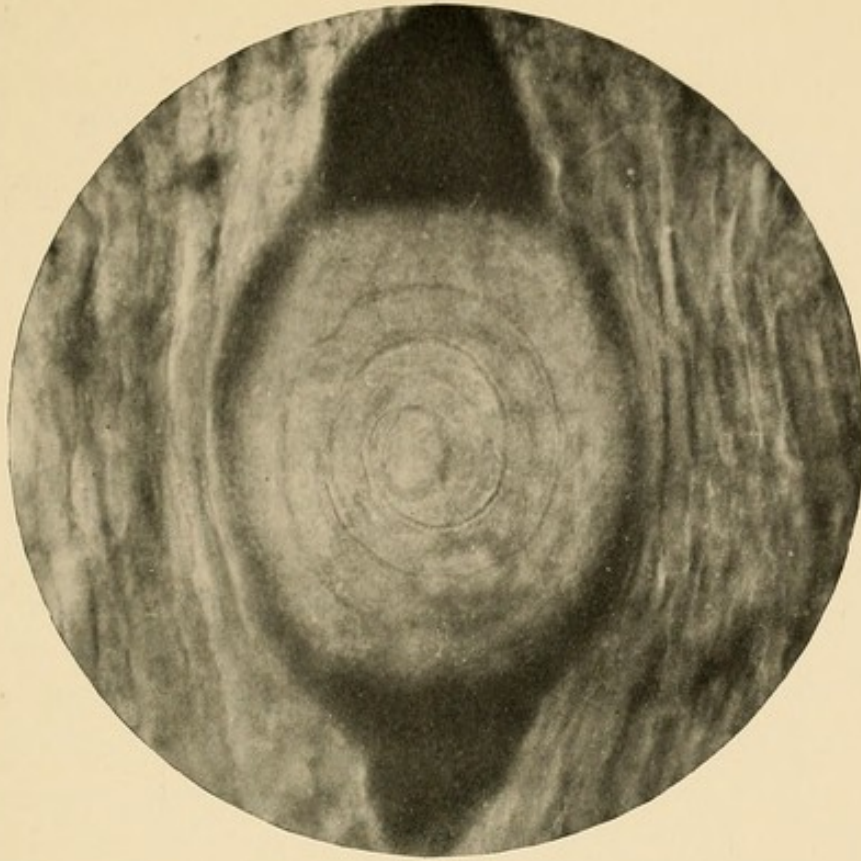
Berteusen (1893) reported a case of myxoma of the left auricle, adding much information as to their formation. Robin (1893) reported a case of myxoma of the heart. His is among the earlier reports of this rare condition; not till 1897 did Petroff report a similar case.

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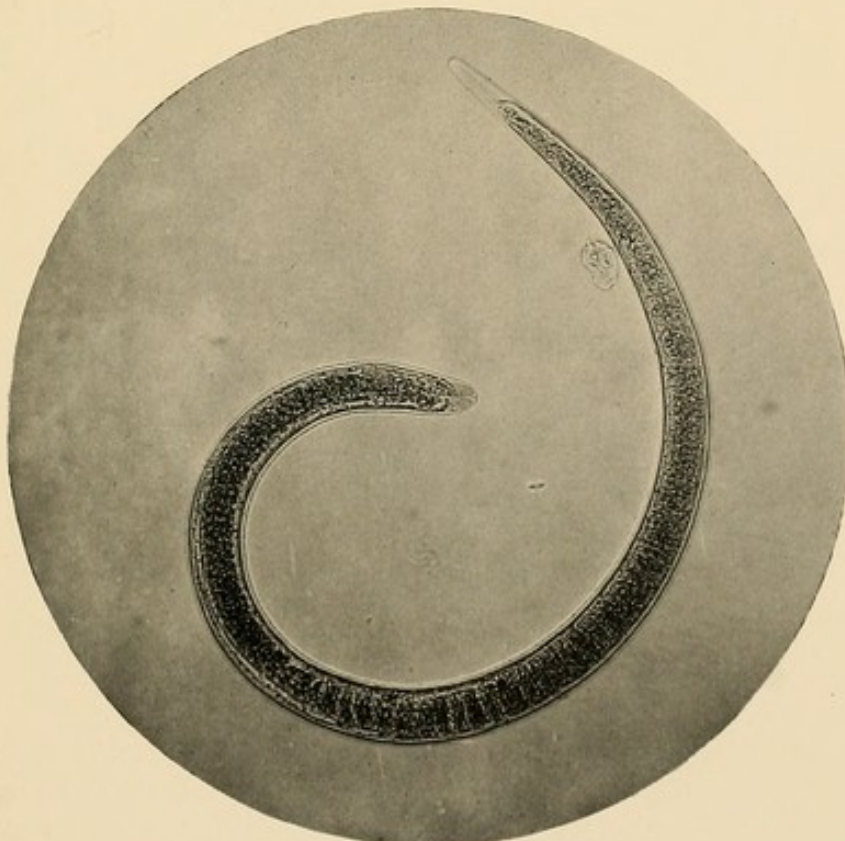
PETROFF, N., *Balnitsch, Gaz. Botkina*, St. Petersburg, 1897, VII, 745-751.

BERTEUSEN, *Vratch*, St. Petersburg, 1893, XIV, 145-181.



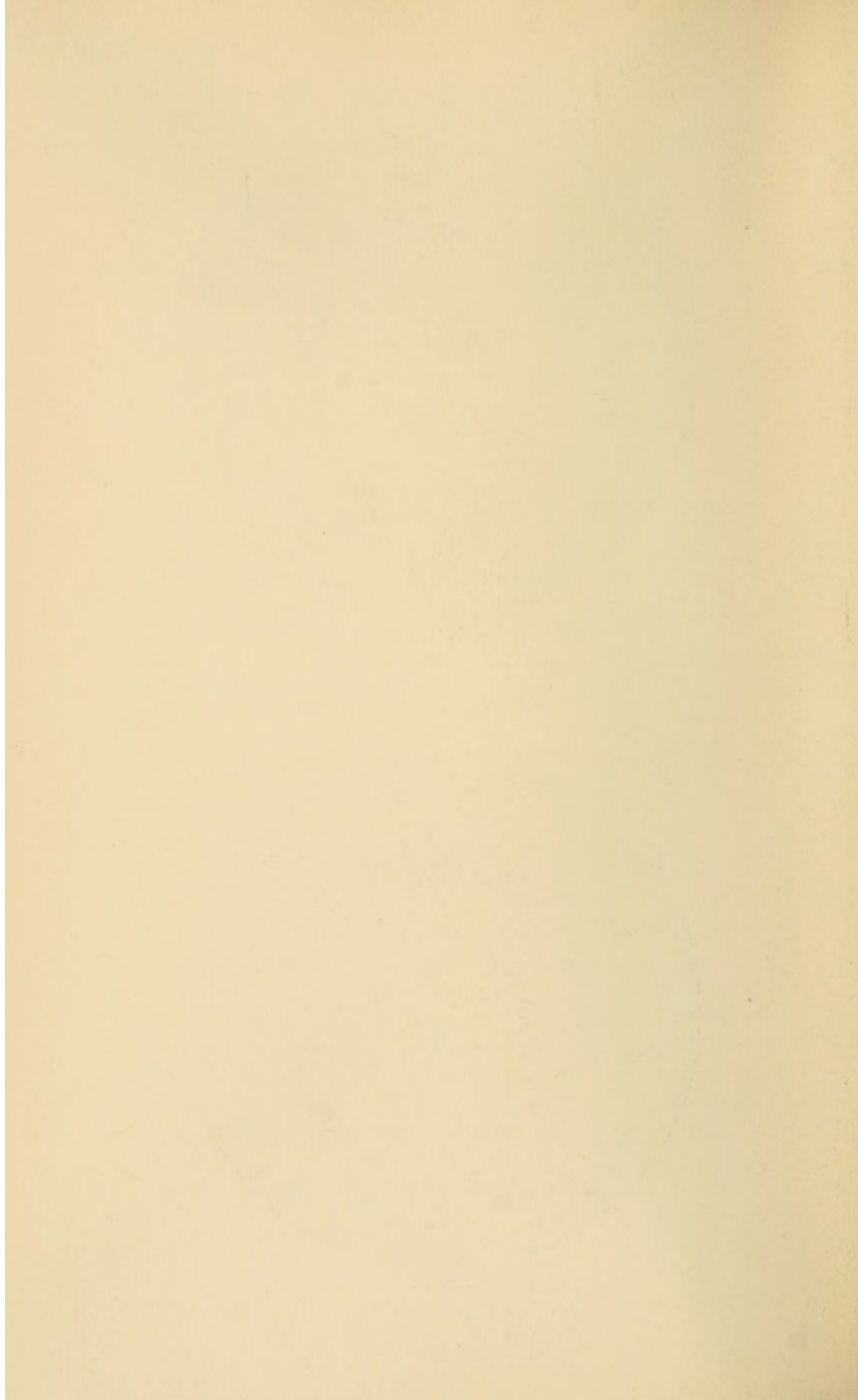
X 180.

TRICHINA SPIRALIS,
(Encysted in Human Voluntary Muscle).



X 180.

TRICHINA SPIRALIS, (Free).



POLYPI (1689-1903).—Polypoid growths may develop upon any part of the endocardium or at any point upon the external surface of the heart. They are benign when composed of fibrous tissue, and slow in their development. When of rapid growth, they are associated with sarcoma and myxoma. They are sometimes called œdematous fibroid, and may have a broad base, or be pedunculated.

They may become detached in part or as a whole, and when upon the endocardium in such case occlude one or more of the cardiac orifices or enter the general circulation, or both, and act like an embolism.

Polyps within the cardiac chambers were recognized as early as 1689 by Pretten and by Rossen (1693), Behrena (1724) and Klotzsah (1727), the last-named investigator having found them in a subject who had succumbed to pneumonia.

The most interesting of the earlier observations, however, were made by Huxham (1732) of polypi, taken out of the hearts of several sailors arrived at Plymouth from the West Indies. Their development was probably due to blood changes, resulting from the habits of the sailors, and their prolonged stay in a tropical climate. Nothing has since developed to indicate anything of an epidemic nature in their formation. Templeman (1756) reported a polyp in the heart of a subject who had scirrhus tumor of the uterus.

Sherrill (1820) gives a detailed report of a polyp found in the heart of a child eight years old. Le Groux (1827) made an exhaustive research into the causation and character of cardiac polypi. He was followed by Barrera (1829) who failed, however, to add anything new to the knowledge already obtained. Harty (1830) ventures to speak of polypi of the heart as an idiopathic affection and as a cause of death. Zabriskie (1835) reports a case of polyp in the heart of a woman with death during labor.

Henderson (1843) mentions a diseased heart with a globular polypus in the right auricle. Aran (1844) one in the ven-

tricle extending into the pulmonary artery and obstructing it. Harpur (1845) reports a similar one. Fletcher gives a most interesting case of this character in which an organized polyp of the heart grew from the left auricle and hung from the left ventricle, giving rise to a peculiar bruit, distinctly audible some yards from the patient. This was verified by the autopsy.

McCormick (1864) wrote an able essay on the effect of blisters in the formation of polypi, and McGillivray (1866) described fibrous polypi in the right heart, accompanied with tricuspid regurgitation, in a case of double pneumonia. Douglas (1868) and Gaskoin (1869) each report a polyp in the left auricle. Hill (1875) reports a case of cardiac polypus in connection with malaria and Ribail (1883) one in a case of pulmonary tuberculosis, associated with parenchymatous nephritis. In the case of Aikins (1888), death was sudden from a cardiac polypus. Voelker (1892) reported a case of intra-auricular cardiac polypi.

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CHAPTER XVI

MALIGNANT TUMORS

TUMORS of the heart may be primary or secondary, malignant or benign, and slow or rapid in their development, involving all or any part of the cardiac tissue. There are several varieties of each.

SARCOMATA of the heart are very infrequent. They may be primary or secondary. They are composed of embryonic connective tissue with cells varying in character and number, and are very vascular, sometimes pulsating. They seem to be intimately associated with blood-vessels, and are more frequent in men after the age of forty. They are supposed to be of rapid growth in the heart, causing distress and death from pressure alone. They may be cystic and rupture into the chambers of the heart or into the pericardial sac and cause death in either event. Fibromatous, diffused, melanotic, spindle, and round-celled varieties seem to attack the heart with equal frequency.

Historical (1880-1903).—Gross (1880) records one of the first round-celled sarcomata of the heart, and Jacobi (1881), a fibrosarcoma. Broadbent (1881) records a case of sarcoma of the pericardium and Liberius (1883) one of the same character which also involved the bronchial glands. Loomis (1892) reported a diffused infiltrating sarcoma of the heart. Manero (1882) is the only one to record a case of melanoma of the heart. Hektoen (1893) records three specimens of metastatic tumors of the heart; 1st, a carcinomatous nodule, implanted in the myocardium; 2d, a sarcoma of the right ven-

tricle; 3d, a primary round-celled sarcoma of the epicardium. Thacher (1895) mentions a case of sarcoma of the heart. Leroux and Meslay (1896) also record a primary sarcoma, and Lambert's (1898) case was a primary sarcoma of the heart. Raw (1898) recorded a spindle-cell fibrosarcoma, three inches in diameter, and adherent to the wall of the right auricle.

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CARCINOMATA (1847-1903).—Scirrhus and encephaloid cancers of the heart are rare and are found more frequently upon the right side. They may be primary or secondary, usually secondary malignant, and they have been found in intra-uterine life and may occur at any age, but are more frequent in middle life. The nodules are usually situated upon the surface of the heart and may not implicate cardiac fibres. •

Carcinoma is more inclined to produce pericarditis than sarcoma which is more frequent. About fifty per cent. are secondary to disease in other organs or tissues. It is supposed to be more common than tuberculosis of the heart.

Andral and Bayle were the earliest writers on cancer of the heart. They reported several such cases. Walsche collected twenty-five cases of cancer of the heart, but, like Andral and Bayle, did not attempt to classify them. The distinctive characteristics of malignant growths were not known until after Virchow had made his classification. Until that time, and with a few cases thereafter reported, doubt will prevail as to the true character of the neoplasm. However, they were known to be of both primary and secondary origin. One must of necessity refrain from attempting to classify those of primary origin in the heart, even many of those of secondary origin. The last, however, came before the time of Virchow, who gave them their identity.

Ormerod (1847) recorded a case of encephaloid disease of the endocardium and Hewitt (1847) during the same year reported two remarkable cases of encephaloid disease of the heart. In the case of Fletcher (1850) there were copious deposits of cancerous matter in the heart and left pleural cavity. Wilks (1854-1857) found these masses in the base of the heart. Sibley (1857) recorded a case of endocarditis in the right side of the heart, caused by small cancerous tumors beneath the endocardium, with additional adhesive phlebitis. Fuller (1859) reported a case of encephaloid disease of the heart and right lung, and Wilks found secondary cancer in the heart and intestines. Maxon (1867) observed encephaloid cancer of the heart and scirrhus cancer of the thyroid gland. DeCosta (1880) reported a case of cancer of the heart resulting in cerebral embolism.

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CHAPTER XVII

ANIMAL PARASITES—PARASITIC FUNGI—BACILLI

Echinococcus.—About three and one-half per cent. of all cases in man are found in the heart (Cobbald and Davaine). It is generally multiple and may be within the myocardium, or beneath the pericardium or endocardium in the form of a tumor. Sometimes the sac is pedunculated and is allowed to swing within one or more cavities of the heart, and even in the greater vessels. It may rupture and pass into the general circulatory system, acting as emboli. Rupture may also take place into the pericardial sac.

Echinococcus is the smallest tape-worm known. It needs to be magnified in order that its structure may be made out. Except to one trained in making examinations it is very hard to distinguish the *Cysticercus* ordinarily found in man, from many individuals of the dog tape-worm. Measly beef and pork are caused by cattle and hogs being infected with cysticerci which have become encysted. The cysts in pork can be easily seen with the naked eye. Corned beef very frequently is measly. This condition can be easily detected by allowing a piece to dry, when the calcareous shells of the cysts may be seen as small white spots.

The heart may become infected by carrying dirty hands to the mouth, or from the cysts of meat being broken in the mouth and the cysticerci penetrating the œsophagus and thus entering the heart.

Historical (1718-1903).—Price (1821) records a sudden death in which an hydatid cyst was found in the substance of

the heart. Evans (1832) records a similar case, and Williams (1834) found one in the heart of a child. Vines (1845) found the cysts in great numbers, floating freely in the cavities of the heart. Budd (1858), Coote (1854), Wilks (1859), Rosi (1866), and Barclay (1866) found them in the lungs, and Budd discovered them in the branches of the pulmonary artery. Kelly and Maon each reported cases in which there was obliteration of the coronary arteries from pressure of the cyst. Peacock (1873), Goodheart (1876), and Guglielani each report cases. Goodheart cured his by aspiration. This was in 1876, so it can be classed among the earlier operations upon the heart.

Arnould (1881), Renaul (1882), Knight (1886), and Martin Durr (1889), report cases of sudden death as result of rupture of the cyst. Demantke (1895), Knaggs (1896), Andreini (1897), Guillemand (1897), and Jameson (1897) each report cases of this parasite in the heart, one of which ruptured in the right auricle.

The presence of entozoa in the heart is little credited at the present time. Osborne (1847) reported a case in which he found worms in the heart of a dog with symptoms of hydrophobia. Simpson (1851) also reports having found parasites in the heart of a dog.

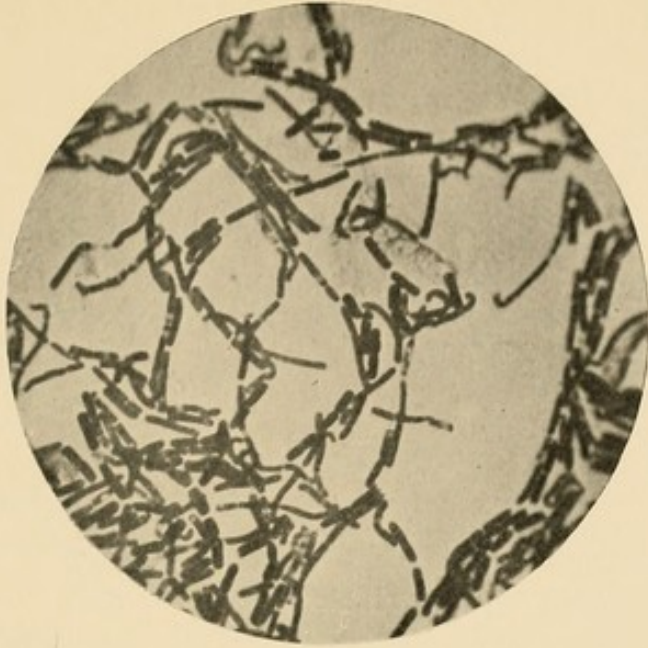
Somerville made the same observations and Morgani, Dupuytren, and Trotter each report such cases.

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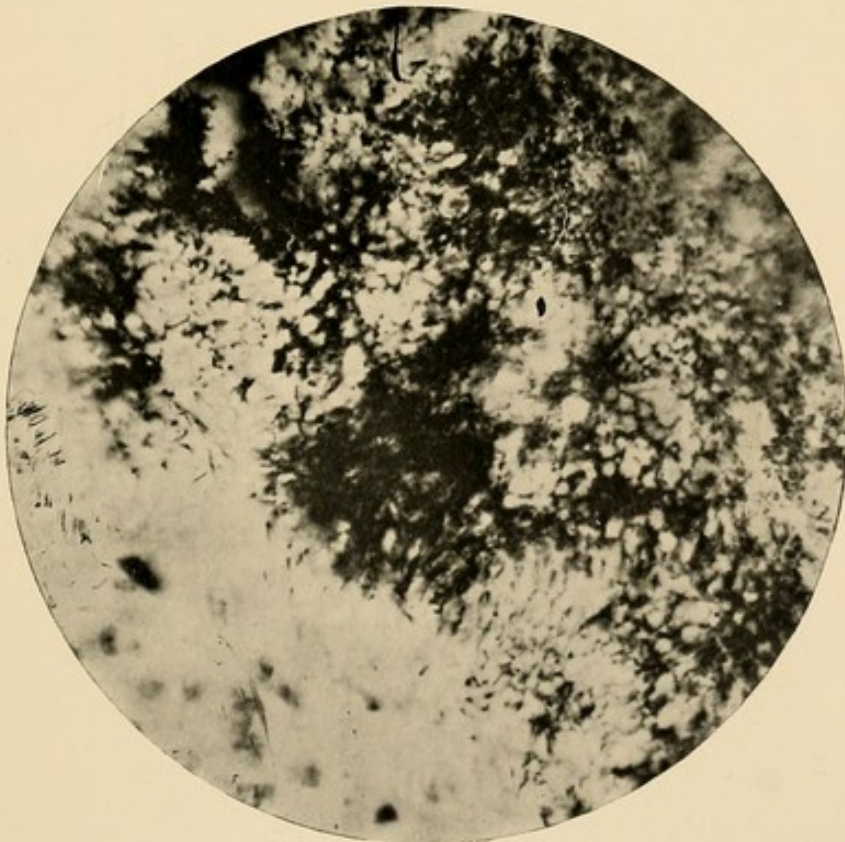
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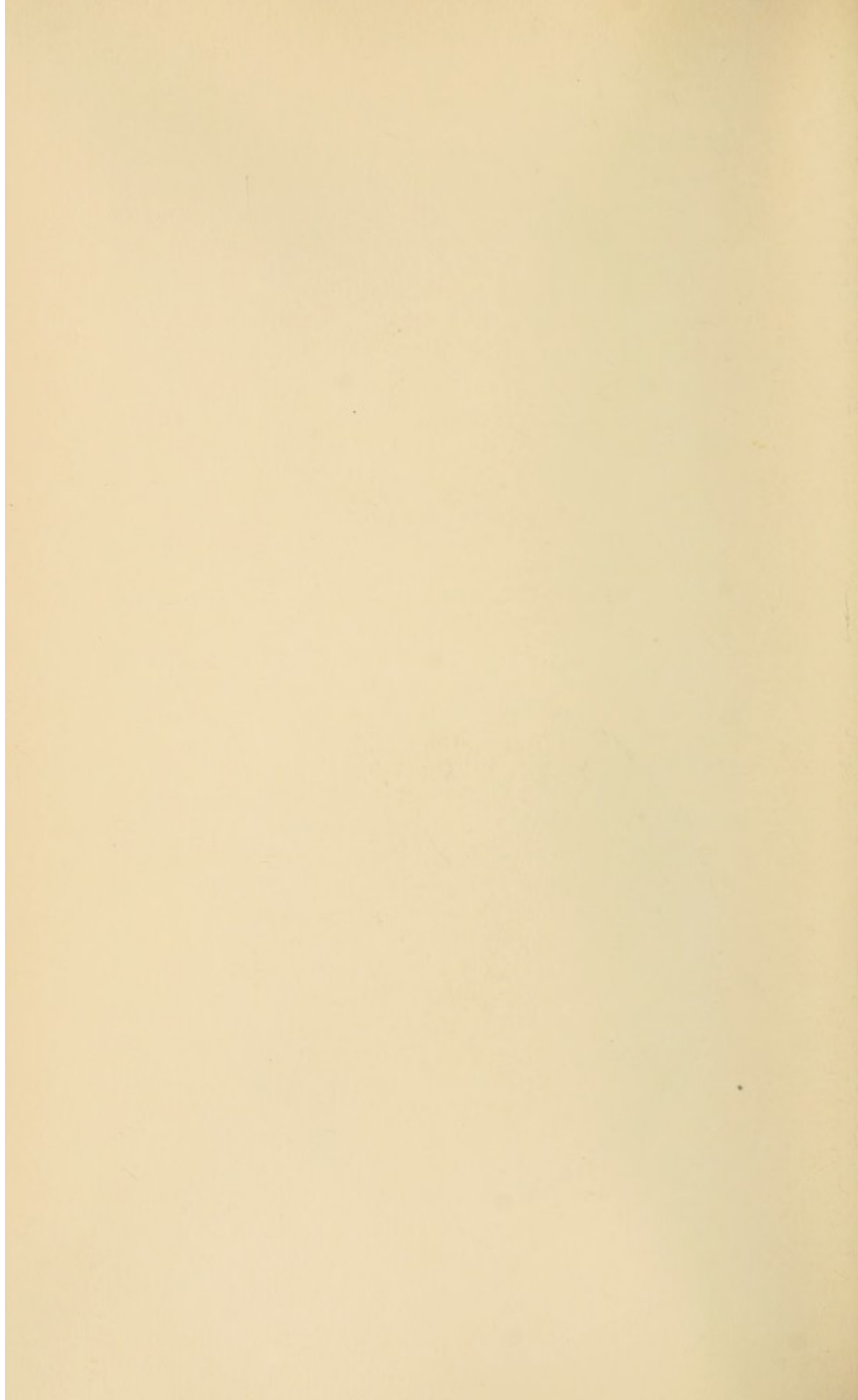
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X 1000.
OIDIUM.



X 720.
ACTINOMYCES.



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Cysticercus (1852-1903) is of two forms, *Saginata* and *Solium*. It is more frequent in India and England, but is found in all civilized countries. It is found in the muscles, liver and lungs of the ox. The urinary bladder is its most frequent location in man. It has also been found in the lung, liver, kidney, eye, brain, and heart of man.

Tænia Saginata is a yellowish, soft, flattened worm varying in length from one-fortieth of an inch to twenty feet. The great variation in length is due to the fact that the worm grows in length by fission, or in segments, and these remain attached to each other, and continue to grow at the head end until they are found in a large mass, which, when straightened out is often very long. The head is about one twelfth of an inch in diameter, without beak or hooklets and has a small proboscis. There is a muscular sucker in each of the four corners of the head, and from each sucker runs a water vascular canal. The round opening in the centre of the head is surrounded by the canals into which the canals from the suckers open. From the circular canal two longitudinal branches continue, one down each side of the various segments. (Examine the fully matured proglottides, as they are arranged in a row. Small papillæ with central openings may be observed alternating irregularly on each side of the ribands, a little below the centre of the segment. Running down each side of the flattened segments, which are square, or longer than they are broad, is the branch of the water vascular canal, while at the front part of each segment runs a transverse connecting branch.)

By plunging the living worm into a solution of carmine, a most beautiful injection of the water vascular system may be obtained. The uterus is very much branched, the diverticulæ dividing dichotomously. The testes consist of a convoluted

tube placed in the anterior part of the segment, from which leads a duct ending in a cirrhus, or penis, which may, in some cases, be seen protruding through the genital pore. Close to this is the opening of the vagina, and near the posterior part of the segment are a couple of vitelline glands. Each strobilus consists of three or four thousand segments, those sexually matured commencing at or about the four hundred and fiftieth from the head. The cystic form is seen in beef as small yellowish spots, which are especially numerous in the thin curved muscles of a round of beef.

Tænia Solium.—*Tænia cucurbitina* or *vulgaris* is the form which is seen most commonly in Germany. The cyst form—*Cysticercus-cellulosæ*—occurs in pork, where it gives rise to the so-called measly condition. A similar cystic form is met with more rarely in man, in the subcutaneous areolar tissue, between muscles, and in the eye and brain. As in the *tænia mediocanellata*, the strobilus is composed of head, neck and proglottides. The worm is several feet in length and consists of about twelve hundred segments. There are four suckers around the head, arranged below a well-marked proboscis or rostellum. The proboscis is armed with two rows of hooks, the anterior of which is the larger; but all of them are considerably larger than the hooklets of the *tænia echinococcus*. The water vascular system near the head is double, and is similar to that met with in *Tænia Mediocanellata*, and may be injected in the same manner. The segments are square or oblong. The uterus, or more properly speaking, the ovary, has a number of lateral branches (seven or ten), which again divide, but not nearly to the same extent as in *Tænia Mediocanellata*. The genital pores of the cirrus, which alternate regularly, should also be examined.

The use of uncooked meat, soiling of the hands by working or handling dirt in which the fæces of human beings, domesticated animals and fowls may have been deposited, are fruitful sources of infection. Persons who have harbored the

mature form of the tape-worm, have been known to infect themselves by the hands coming in contact with the anus in sleep, or at other times, or by searching in the deposits for segments, etc. Cysticerci have been known to invade all parts and organs of the body.

Cysticercosis of the heart is comparatively rare but by no means unknown, as is shown by report of cases. It is quite probable that some cases diagnosticated and reported as hydatid cysts of the heart, have been cases of cardiac cysticercosis. Lendet (1852), Laure (1869), Gibbs (1872), Frank (1879), Joso (1883), Vitto (1884), Meljnikoff (1891), Firhet (1895), Giordano (1898), Railliet (1898), and Moret and Stoneson all give reports of having found the cysticercus in the heart of man.

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Trichina Spiralis.—The presence of this parasite in the cardiac tissues is rare, especially in the human heart. It is a nematode, commonly found in the pig, encysted in the muscles

of the neck, shoulders, back and diaphragm. The female is larger and more numerous than the male and when found in the heart is of secondary origin, having escaped through the alimentary canal, into which the parasite has been taken with infected pork.

Paragonimus Westermani.—The distoma Westermani is a trematode found in Asia, but now being carried to all sections of the world, attacking the stronger of mankind. It is found in the heart, lungs, brain, liver, and other organs of man, and animals in general, being carried into the stomach with food and water, and into the lung with air. It penetrates the tissues and finds its way into those of the cardiac system. Nodules are formed, generally near the base of the heart, and as a rule contain a male and a female parasite. Distoma Westermani is often confounded with tuberculosis, especially if the lungs are involved.

PARASITIC FUNGI.—Mycoses of the heart constitute the fungoid neoplasms, showing an abnormal growth of lymphatic glands, caused by pathologic microbes (bacterial or parasitic) in the organism. They may occupy a part or all of the endocardial or pericardial surface of the heart, or may be interstitial; however, this is exceedingly rare as compared with the other two varieties, which themselves are rare. The true character of the earlier cases reported has not been well established. This is also true of many of the more recent reports. Many of them were, no doubt, parasitic, possibly cysticercus, or trichina hydatids being more frequent and generally known.

Julia (1846) recorded cases in which he found vegetations upon the valves and inner walls of the heart. Bertin (1857) found a case in which there were adhesions of the heart to the pericardium as the result of vegetations. Blanchez (1875) reports a case of a primitive form of vegetation upon the endocardium. Desjardins-Beaumetz (1877) noted a case in which the vegetations were upon the endocardium about the orifice of

the pulmonary artery. Williams (1884) reported vegetations upon the mitral valve, with multiple embolisms and consecutive aneurysmal dilatation of arteries. Meigs (1897) mentions fungous excretions on the valve of the aorta.

Actinomyces was discovered by Langenbeck. It is a vegetable parasite, occasionally found in the heart. It may be primary or secondary. The infection of the heart is usually from the left lung, as it is more frequently affected than the right. The nodules are threadlike, pearly or yellow, and from one-half to two millimetres in diameter. They are star-shaped and composed of club-shaped ends. The branching, segmented mycelium is diagnostic. It is not so serious if only the external surface of the heart is involved. The nodules undergo fatty degeneration and cause abscesses, which may rupture into the cardiac cavities, or into the pericardial sac.

Carnivorous animals seem to be immunized to this disease. Infection is by eating and drinking food, and by inhalation of air. Macroscopically it can only be diagnosed by the presence of yellow seed-like bodies which may be seen by the eye, and a greasy feel to the sense of touch.

Aspergillus is a vegetable parasite, was discovered by Virchow in 1856. There are three varieties: (a) *Aspergillus fumigatus*. (b) *Aspergillus niger*. (c) *Aspergillus flavus*. Either one may be found in any part of the cardiac tissue of man or beast.

The most dangerous of the three is *Aspergillus fumigatus*. It is green in color. The conidia are generally colorless, round and smooth, and without a membrane. It grows best in an atmosphere of thirty-seven to forty degrees, centigrade.

Aspergillus flavus is greenish yellow in color. The sclerotia are very small and black. It grows best at about twenty-eight degrees centigrade.

Aspergillus niger is very malignant, and brownish black in color. The fruit bearers are globular, sterigmata long and branching; conidia round and black, or nearly so; sclerotia

brownish, and about the size of a rape seed. Best temperature for its growth is about thirty-five degrees centigrade.

Oidium albicans is a vegetable parasite which has but seldom been found in the heart. It forms delicate horizontal filaments, which are apparently homogeneous in structure, and from which short articulated pedicles take their rise. The uppermost cells of these pedicles become expanded into oval bodies, which fall off, germinate, and become filaments. It is generally found growing in tangled masses, like minute bunches of mistletoe, mixed with the débris of scattered spores, cells of the leptothrix, and epithelial scales, but if separate filaments are followed out, such forms as these, which are represented, may easily be obtained (Clark).

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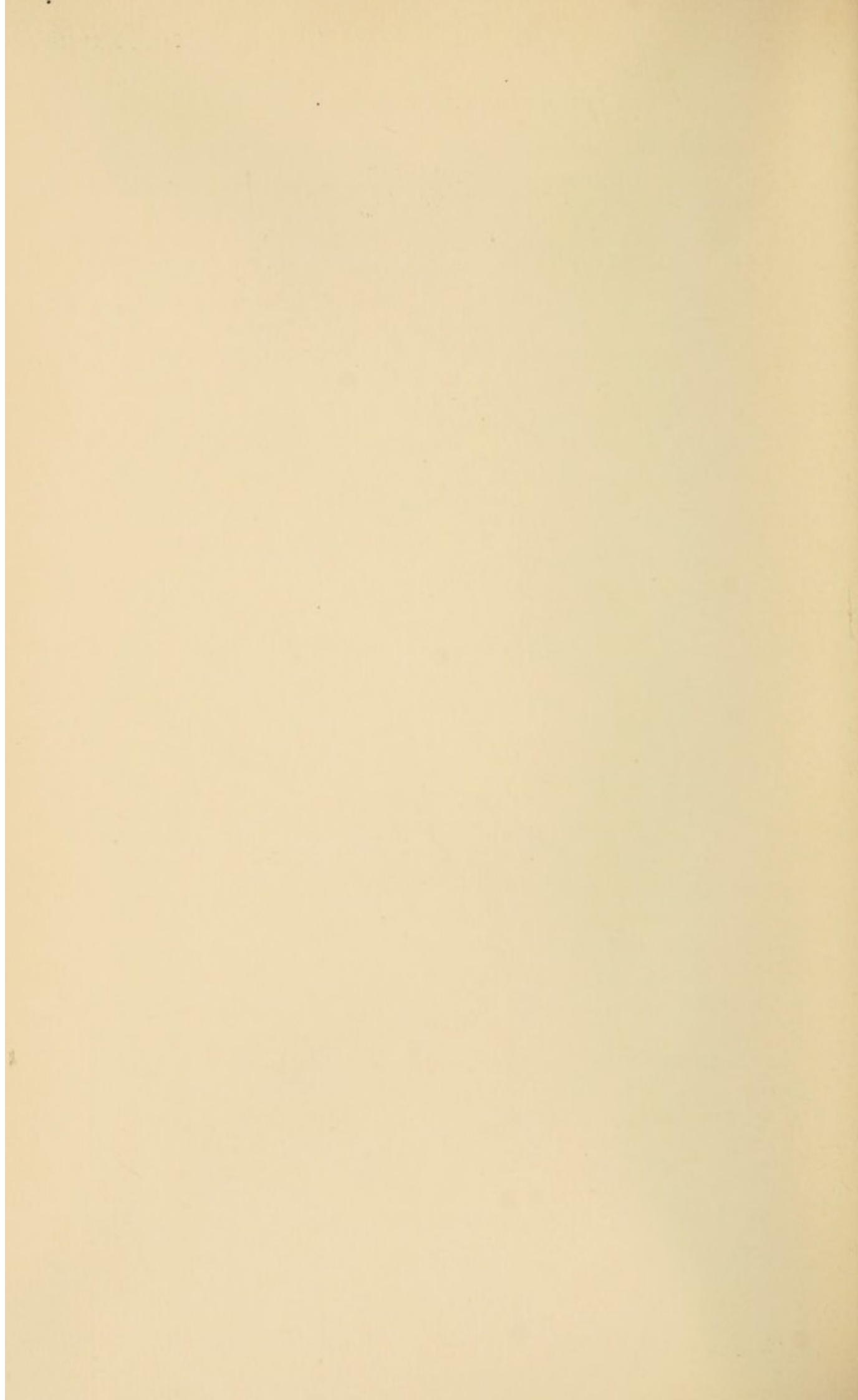
X 1000.

BACILLUS ŒDEMATIS MALIGNI.



X 1000.

BACILLUS TYPHOIDES.



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Anthrax.—Anthrax is a bacillus which has become generally distributed over the world, but it seldom affects man.

It has been found in the human heart but a few times. It was discovered by Davaine and Rayer in 1850. Koch discovered the spores. It infects by being taken into the body with food, water, or air, or it may do so by coming in contact with the body in many ways. It may be primary or secondary in the heart. The period of incubation is from a few hours to four days.

Bacillus Œdematis Maligni.—*Bacillus œdematis maligni* is a progressive gangrenous œdema and emphysema resembling the bacillus anthracis. The colonies have a granular appearance, forming long chains, which are often twisted. It may be primary or secondary, but is usually secondary. It is one of the few bacilli found in the heart. It attacks all forms of animal life, and all kinds of living tissue.

This bacillus is found on all serous surfaces, internal organs being but slightly affected. It is often associated with the bacillus of tetanus, and originates in the fecal matter of fowls, garden earth, and filth in general.

Tuberculosis (1826-1903).—Tuberculosis may be primary or secondary; more frequently secondary. In the form of

nodules, miliary abscesses, or ulcers, varying in size; it may invade the endocardium, pericardial surface, or the muscular structures, in part or as a whole. It may occur in childhood but is more frequent between the fifteenth and thirtieth year, and is, as a rule, slow in its development. It is sometimes associated with syphilis.

HISTORICAL.—Macmichael states that he found tuberculous deposits in the cardiac cavities, pericardium, and lungs. Post records a case of pericarditis with tuberculous nodules in the cardiac substance. Hache mentions tuberculous affections of the heart. Gilman speaks of a case of extensive tuberculization in the walls of the heart. Banks mentions a scrofulous tumor in the posterior wall of the left ventricle of the heart. Gros records one of tuberculous cardiac granulations, with complete adherence of the pericardium to the heart.

De Costa (1860) records a case of tuberculous disease of the walls of the heart; Sherad (1860) mentions a similar case. Leyden (1869) wrote upon three forms of cardiac tuberculosis: (a) heart, (b) muscle, (c) endocardium clots in cavities.

Demme (1887) records a case of primary tuberculosis of the heart; Oliver (1887) gives a case of tuberculosis of the heart and pericardium. Sumbera (1889) mentions a case of cardiac tuberculosis, following acute general miliary tuberculosis. Labbi (1896) reports two cases of tuberculous myocarditis, one in a boy six years of age, and the other in a girl of four years. Sabraze (1899) reports a case of tuberculous disease at the base of the sigmoid valve and pulmonary artery. Hektoen (1901) reports tuberculous perimyocarditis with a tuberculous aortic aneurysm in a dog. Jones says that tuberculosis and syphilis are both exciting and predisposing causes of muscular and valvular lesions of the heart. Smith records two cases of tuberculosis of the heart.

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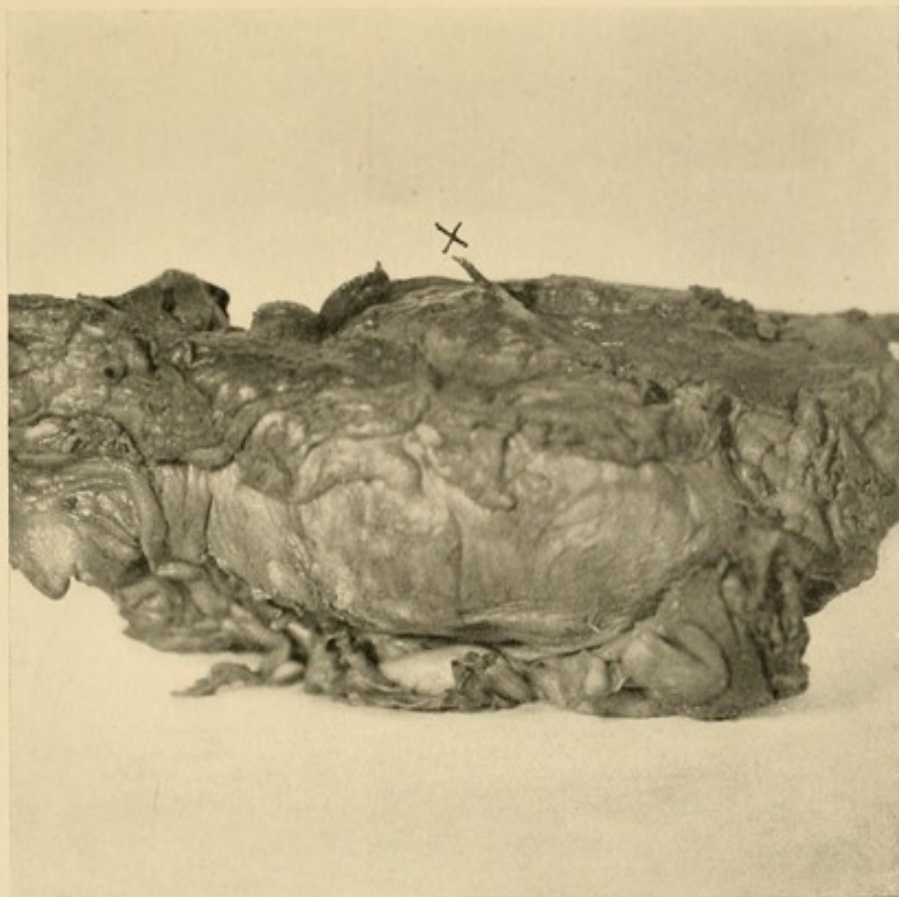
Bacillus Aerogenes Capsulatus (Gas Bacillus).—This bacillus has been found in the heart muscles of rabbits by Olhmacher, who says that it was not found in the smears of the heart's blood. It was first described by Welsh, who says that it practically dominates the whole field of pneumatopathology. It is extremely virulent but dies at about the end of fourteen days.

Bacillus Typhosus.—Typhoid bacilli have recently been found in the heart of man, by Vincent (*Merek Medicine*, Feb. 17, 1892). They have been found in nearly all organs and tissues of the human body. So far as known they are secondary, and the effect of their presence in the heart is but little understood.

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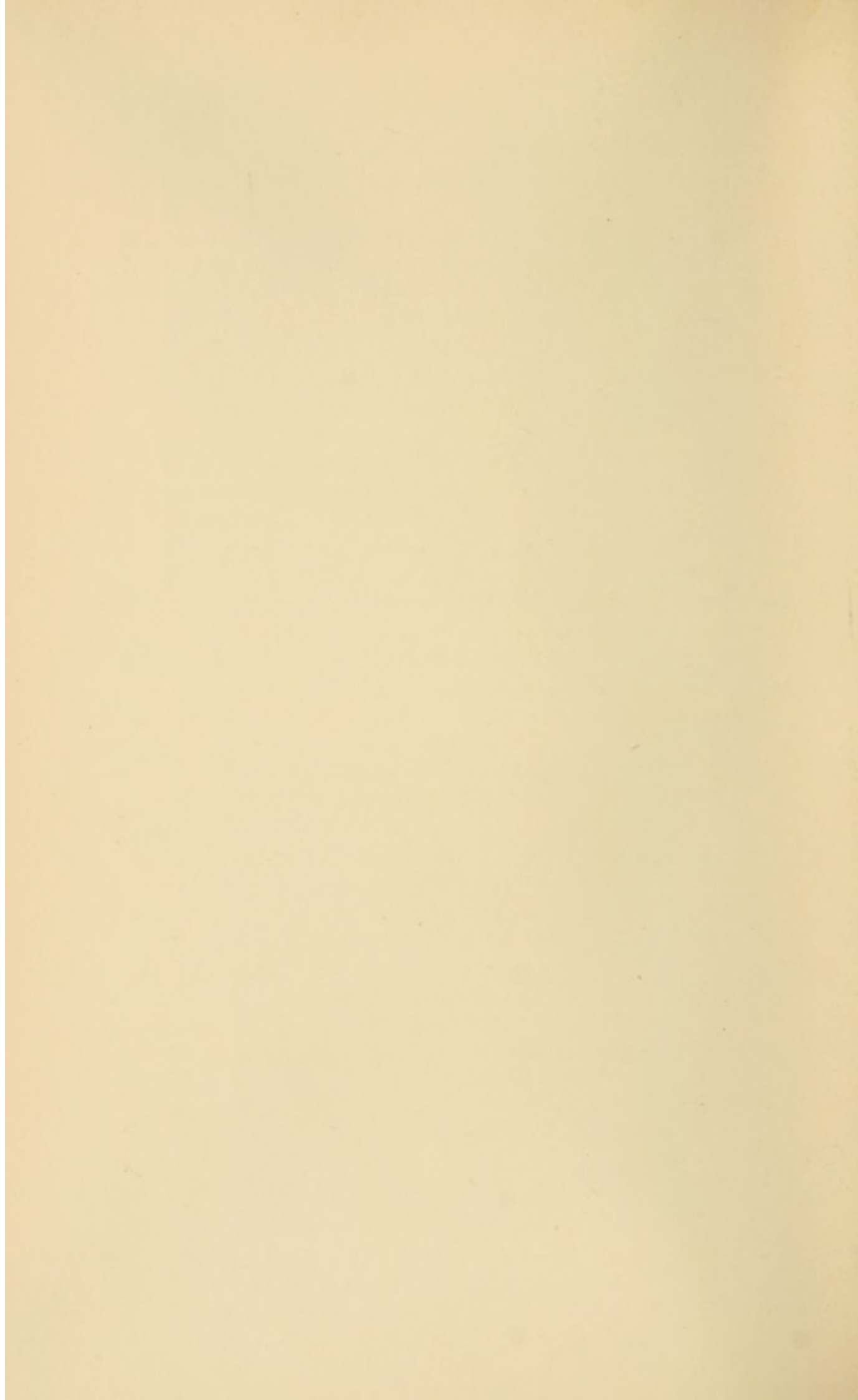
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THE CROSS REPRESENTS THE END OF A KANGAROO TENDON WHICH WAS USED TO LIGATE THE LEFT CORONARY ARTERY AND VEIN.
(Experiment on the Heart, No. 3, page 263.)



THE CROSS REPRESENTS THE END OF A SILK LIGATURE ABOUT THE ANTERIOR CORONARY VESSELS.
(Experiment on the Heart, No. 6, page 264.)



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CHAPTER XVIII

EXPERIMENTAL RESEARCH ON THE HEART OF THE DOG

THE experimental work contained in this chapter was done at the laboratories of the University of Cincinnati during July and August, 1901. There were forty-five dogs used in this series of experiments, to determine the effects of different kinds of injuries to the heart, pericardium and diaphragm, and the results of various surgical operations thereon. Many valuable deductions were made, but it will require further work by surgeons and experimenters to determine many of the possibilities in surgery for injuries and diseases of the heart. This work is, therefore, but a small contribution to this most interesting subject. The author desires to take this opportunity to thank his assistant, Dr. H. V. Spargur, and student Charles T. Souther, for their valuable assistance in conducting these experiments.

Original Experimental Surgery (1901-2)

Nothing indicates more clearly the lack of confidence in surgical intervention in lesions of the heart than that the latter have been treated as anomalies. The best history of the surgery of the heart, accessible to the general reader, is to be found in a work that treats of anomalies and abnormalities. They of themselves show that the heart is more susceptible to injury, disease, and surgical operation, than is generally supposed.

Simple puncture with a needle was at one time thought to result in instant death; indeed such an idea generally prevails at this time. Infection in animals is more likely than in man, because of the great difficulty in making the former sterile and keeping them so, after they have been operated upon.

If experimental physiology and surgery have taught anything, it is to reason by analogy from animal to man. Animal experimentation has led the way to more successful surgical work, and it will continue to do so. It not only shows what can be done, but it teaches, by manipulation alone, if nothing more, how it should be done.

There are many diseases and many lesions which do not manifest themselves, or cause symptoms which are readily discernible. In other words, the particular lesion is wholly unsuspected until it has advanced far enough to produce functional disturbances, which are often serious. Then search is made for the cause. Then again, it is possible to diagnose certain diseases only by the symptoms caused by the functional disturbance, produced by the lesion, and not by the lesion itself. The functional disturbances, resulting from a given lesion, are not always the same. Pathological physiology receives only scant attention, or none at all, in our medical schools, yet it is of the utmost importance. Only a few works on this subject are accessible, and these are unsatisfactory in some respects. Many questions of the utmost importance are unsettled. These remarks apply with peculiar force to the heart. The intimate connection of the function of respiration with the heart, and the disturbance produced in the functions of the other, when either heart or lung is diseased, is the reason for taking up both the normal and pathological physiology of the heart.

Aspiration of the pericardium should not be attempted, owing to the dangerous consequences, such as injury to the coronary, internal mammary, and intercostal vessels, and puncture of the walls of the heart itself; and also, the possibili-

ties of infection from the escape of fluid, through the puncture, into the pleural cavity and mediastinal space. The probabilities are, that many cases in which fluid has been purported to have been aspirated from the pericardium, that it was contained within the pleural cavity, mediastinal space, pulmonary cyst, or abscess, or a pleural cyst.

The heart is very susceptible to alkaline solution, which accelerates it. The absence of stomata in the diaphragm within the pericardium, tends to exclude fluids from the peritoneal cavity. The pleural fluids will, however, pass through the pericardium. In the lower animals (fish), the pericardium and diaphragm are wanting. As they ascend in scale, the pericardium becomes more fully developed to form the pericardial sac; the same is also true of the diaphragm.

There is no way of determining whether or not the heart will absorb to any degree any fluid that may be contained within the pericardium. Nor have such observations been made upon the ability of the pericardium itself to do so. It has, however, been determined that the heart will not withstand a high degree of pressure, from fluid or otherwise, within the pericardial space. It will stand a greater pressure, if the pressure be gradually increased, as in the case of pericardial effusion, resulting from pericarditis. It will, in a normal state, absorb more or less of its exudate; and it will probably have a greater capacity to absorb in a pathological state.

Pressure, from any source, may be sufficient to force a part, or all, of the blood out of the cavities of the heart. This may be gradual or sudden, fatality resulting only when functional circulation cannot be maintained. The consequences are less severe, and serious trouble is delayed, if the pressure is increased slowly, as by the growth of new tissue. Rapid pressure is usually due to change in shape of the chest, from trauma, or from concealed hæmorrhage, within the pericardial, pleural or mediastinal spaces.

Operative Technics

Sterilization of the local area of the dog is almost impossible. The area should be shaved after the dog has had a thorough bath, which is difficult to give to tramp dogs, as they are not accustomed to it. A sterile sheet, in which there is a hole large enough to operate through, should cover the dog. Alcohol or turpentine is applied to the shaven surface, which is then ready for incision. Ether should be employed in all cases for operation, and carried to complete relaxation, and then chloroform given to produce death.

The incision should be made longitudinally, beginning at the third or fourth rib on the left side, and about one-third to one-half inch from the internal mammary artery, and diverging slightly from the sternum down to the desired point, even to the apex of the heart. It may be extended to the attachment of the diaphragm, and down to the costal cartilages. The external soft tissues, being divided, are then reflected outward, great care being taken not to have the point of the knife slip into the chest cavity, as the heart, lungs, or arteries may be injured.

Divide the third, fourth, fifth, sixth, and seventh ribs if necessary. Great care must be observed, in opening the chest, that bone spiculæ are not left to lacerate the heart during its pulsations; otherwise serious, if not fatal laceration of its wall might ensue. Such an accident must be guarded against during the entire operative procedure. Great care must be taken to avoid such an injury to the pericardium also. It is, therefore, safer, completely to sever the bony structures with a sharp cutting instrument, than to fracture them by force or otherwise. The same precautions should be observed in dealing with the cartilaginous structures. If necessary, the cartilages may be cut near the left border of the sternum and retracted outwards to the right or left.

If the mediastinal space be opened, the respiratory motion

of the thin membrane, that walls off the right lung, may greatly interfere with rapid work. It will especially be so, if over distention of the right lung should rupture it. The right lung would then retract upon itself. It is, therefore, safer and less difficult if that space be not opened. The opening can, however, be closed with the hand of an assistant during the entire operation.

The bleeding in the skin and muscle is seldom annoying. The intercostal arteries usually cease to bleed after they have been exposed to the air, and sponge pressure; if not, they can be easily controlled by forceps. The internal mammary once wounded, the hæmorrhage is great, and troublesome to check, except in one way, namely, by pulling the skin to the right, leaving only the costal cartilage and muscles to constitute the chest wall, then with the finger, or a larger pair of acupressure or artery forceps, including all the tissues between the cartilages, just above the wound, in the forceps, which is put on parallel to the long axis of the costal cartilage, or in the transverse diameter of the chest. It may be necessary to do this above and below the wound, as the internal mammary artery may bleed a little from below, the anastomosis being very free with the deep epigastric. After the hæmorrhage has been checked, it is best to apply a ligature *en masse*, as it saves time, which is an item with the heart exposed.

The first opening should give good view and room to work; if not, incise two inches to the left in the intercostal space, and cut the ribs transversely with a pair of sharp bone forceps, beginning at the outer border of the incision, in the intercostal space. If necessary, other ribs are divided, that a flap sufficiently large may be turned back to give ample room.

There is no occasion for using gauze, or any kind of packing in heart injuries, especially in pericardial injuries, as bleeding from the pericardium is insignificant except in cases of injury at the point of attachment of the extreme base of the heart; even then experiments show that hæmorrhage from in-

juries to it is but slight. To secure beneficial results from gauze packing in heart injuries, it is necessary to employ firm pressure. To do this would interfere with the heart's action. Therefore, it would be more injurious than beneficial because such pressure would force the heart back upon the posterior wall of the thorax.

If a patient survives the immediate thrust of a stiletto-like instrument, however small, the probabilities are that the hæmorrhage will be less when the weapon is withdrawn at the end of several hours, than on its immediate withdrawal.

The styptic effect of the metal as the result of its coming in contact with blood, together with the formation of clots and the closing of the opening resulting from the puncture, by allowing the weapon to remain, will be amply sufficient in a few cases to prevent a fatal hæmorrhage on its withdrawal.

The blood that most resembles in constitution the blood contained in the cavities of the heart, is that found in the coronary arteries, which, like that in the heart, coagulates with wonderful rapidity.

The blood, after having made the round in the body, comes back to the heart practically exhausted of oxygen. It not only contains CO_2 but other chemical compounds, formed by the débris collected uniting with the constituents of the blood. At the same time it contains more fibrin, and doubtless, also, more of the other elements which add to the coagulability of the blood, for in its course it has taken up the material prepared by the digestion process to repair the wear and tear of the body.

In all cases where important blood-vessels were punctured, the observers have been impressed by the rapidity of coagulation. It is very probable that nature has so arranged, that in case of trauma, where there is hæmorrhage of the more important organs, coagulation shall be more rapid than elsewhere, thus preventing death. It seems probable that the rapidity of coagulation is proportionate to the importance of the organ to the animal economy.

Contraction of a lung, when the thorax is opened, will cause congestion of the heart. The contraction of the lungs, whenever the chest is opened, exerts considerable pressure upon the various pulmonary blood-vessels and thus forces a volume of blood, equal to nearly the entire volume of blood normally contained in the lung, into the already engorged heart, thus bringing about a congested condition of this organ.

Care should be taken in operations upon the heart, lest undue manipulation cause death from paralysis of the vagi.

Having checked all hæmorrhage from the chest-wall incision, and the wound being dry, lift up the pericardium with a tenaculum. Great care must be taken not to puncture the cardiac tissue, or coronary artery. The tenaculum should be inserted over the ventricles, as there is danger of wounding the thinner auricular wall.

The incision should be made in its longitudinal diameter. This incision in the pericardium may be extended to any degree necessary to facilitate rapid work, and should be done by tearing. Each bleeding vessel must be closed as soon as opened. When the pericardium is incised, it retracts, and owing to its thinness, is almost lost sight of. It however can be replaced, and sutured in position with a moderate degree of ease. The pericardium normally is closely filled by the heart, and when the heart is beating, and not even restrained by the chest wall, its range of movement is very great. This must be seen to be appreciated.

The pericardial cavity is now cleared of all clots, by one sweep of the finger if possible. Gauze may be carefully wrapped around the finger, but it is best not to use it.

The heart is gently grasped in the palm of the left hand, great care being taken not to use any more pressure than is absolutely necessary to enable the needle to be plunged through the wall of the incision.

The heart can be handled to a remarkable degree without any appreciable change in beat, except the dilatation caused by

the loss of the supporting sac—the pericardium. This handling of the heart is safe, provided not too greatly prolonged. The loss of support of the chest wall and, more important, of the closely fitting pericardium cause a great extra strain on the myocardium.

Careful inspection of the naked heart shows its great distention, and when it seems, or really is, paralyzed by overdistention, holding together for a moment the wound in the chest wall will cause the heart to regain its normal action. The operation may now be continued. If necessary, this may be repeated several times during the operation. The operation being finished, the heart is returned to the pericardial cavity, the pericardium now being brought into position with small tenacula and a running suture of catgut placed in it.

As the artery tension is not great when the chest wall is closed, a suture can be used that need not last so long. The pericardium tends to go back in place after the replacement of the heart. There was a plastic pericarditis in all the autopsies, and the pericardium was adherent for a distance around the incision in the pericardium of from one-half to one inch.

In most cases the pericardium was not sutured, and the result was very good as to replacement. So good, that in any case in which there is danger in prolonging the operation, one is justified in allowing the pericardium to remain open, for the closing of the wound tends to keep the heart in place, and keep the pericardium closed.

This same work does not control so well the hæmorrhage in wounds of the left ventricle, as the wall is very strong and resilient; however, this method is the best and most convenient, and it is always easy to govern the degree of pressure, which should be only great enough to prevent blood from coming out during systole. In diastole, the pressure should be slightly relaxed.

As to putting the needle through, during systole or diastole, I think that will be forgotten when it comes to the work, as

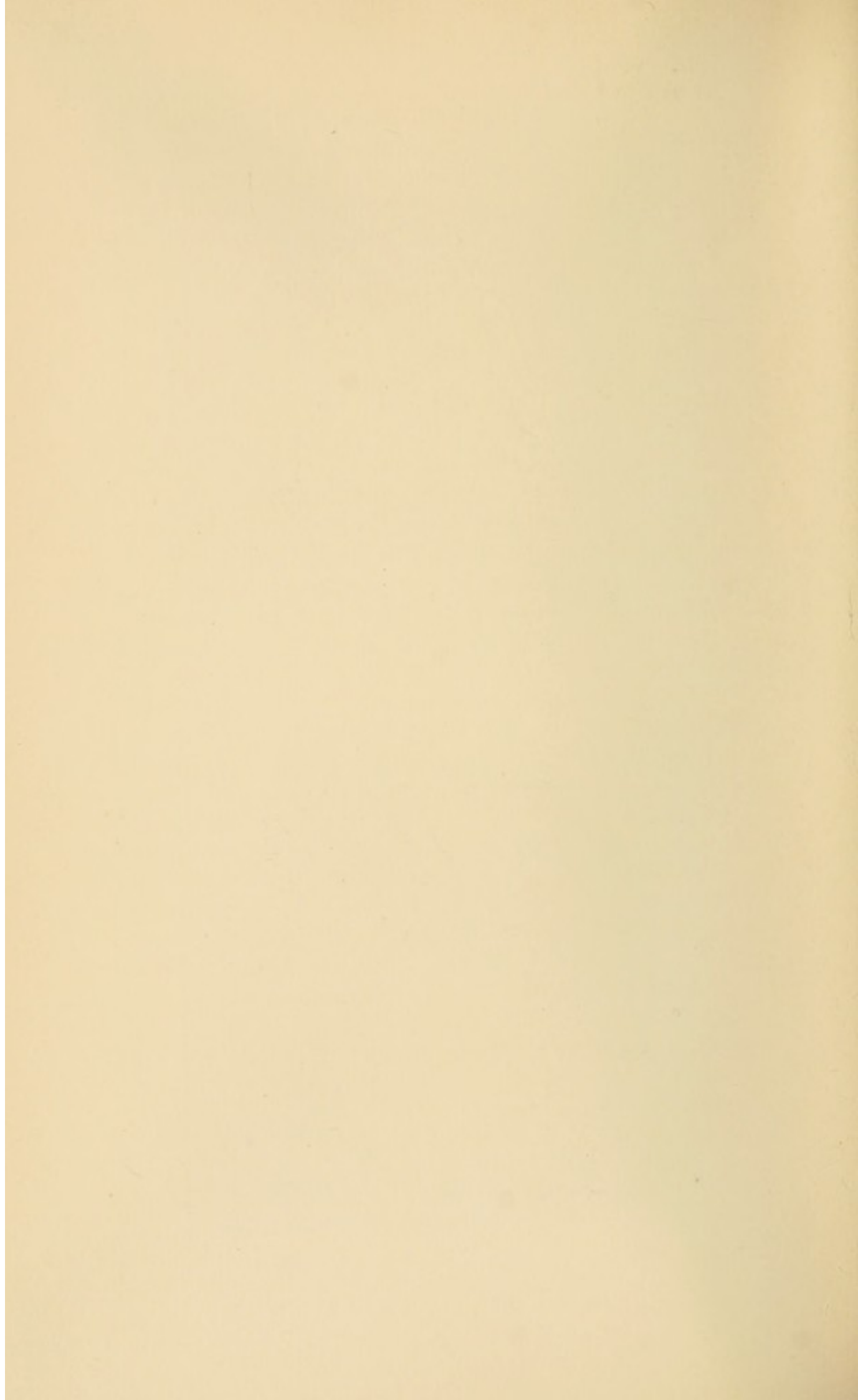


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Experiment on the Heart, No. 10, page 266.

、 SHOWING SILK SUTURES IN PLACE.



with a heart bounding and changing position at least one-half to one inch, seventy to one hundred times a minute, we are glad to get a needle within one-quarter inch of the work aimed at.

When the auricle is opened, naturally the blood comes out with considerable force, but this can be entirely controlled by putting the ball of the finger over the opening, yet the force does not have to be great enough to obliterate the auricle, or press the walls in contact. The pressure can be accurately gauged in this way, and it controls the hæmorrhage almost perfectly.

Suturing the heart is very essential, and should a needle not be ready, the finger can be kept in place while a well-curved needle is passed from one side to the other, under the finger. The needle should be long and semicircular, but not heavy. Theoretically, to insert the needle in diastole is right, but it is one part of theory that we lose sight of, in the critical moment, and should the heart cease to beat for a few seconds to a minute, or even two minutes, as it does, our duty is to keep the finger on the heart wound, and close the wound in the chest by grabbing its edges, keeping finger in position. Then, if the heart resumes its beat, further effort can be made to close; if not, the work is done as best it can be.

The question whether to continue work even though the heart stops, is an open one. On one side, we have the very great advantage of a quiet tissue to work on, which will be positively frightening when it comes so suddenly, and on the other, the less chance or probable less chance of resuscitation, if we keep the chest open. We should choose the lesser evil, if we can sometimes decide which really is better.

In suturing the heart's tissues, the organ should be held as securely as is consistent with minimum pressure, and the suturing done as rapidly as possible, the knots being made by an assistant.

Glover's continuous suture is preferable to all others, because

fewer and less complicated knots are required. This is especially desirable when silk is used, the object being to get rid of knots by absorption, as quickly as possible.

The simple continuous suture without knotting, except in the first and last punctures, would be ideal, but for the great danger of the suture breaking, and thus allowing reopening of the wound. This is the great danger in using absorbable or non-absorbable material, as it must, of necessity, be very light. Both silk and kangaroo tendon have been used with great satisfaction in suturing penetrating and non-penetrating wounds of the heart, also for ligating the coronary arteries at various points.

However, the preponderance of evidence is in favor of the interrupted suture, and that it should be twisted silk, even though kangaroo tendon is more absorbable. Wounds of the heart repair themselves, as rapidly as, if not more so than those of other tissues, and the pericardial adhesions are proportionate to the extent of injury, whether clean or infected.

Interrupted sutures therefore should be used, and the needle and silk should be as small as will render service. They should be about one-eighth of an inch apart, and taken deeply in the tissue. If the cavity of the heart has been opened, the needle should be made to pass through the entire thickness of the heart's wall. If the endocardium has not been punctured, the needle should be made to traverse the floor of the incision. The strength of the suture material should be determined at time of operation.

Knotting of the sutures should be firm, and their respective ends about one-quarter of an inch in length. If shorter, the constant action of the heart may possibly untie them.

Kangaroo tendon has been used in suturing muscular tissue of the heart, and in ligating the coronary arteries, with considerable satisfaction, more especially in the latter. Its life will depend upon the size and quality—the greatest objection being to its size. A larger needle is required and the punctures from

it must necessarily be larger than when silk is employed. Cat-gut offers the same objections.

It is pretty well agreed upon by experimenters that the sutures should be applied during systolic relaxation, that the cut edges may be perfectly coaptated. However, Rhen tied them during diastole with equal success.

It is not necessary to suture or apply any kind of treatment to some wounds of the heart, as they will close and recover spontaneously. It is impossible to say, or determine, the size of wounds necessary to be sutured or to be let alone, except when there is continuous bleeding, which can only be determined by opening the chest. It must necessarily require much time, and careful observation of many heart wounds, to determine the necessary procedure in each individual case.

The probabilities are that punctures, however small, into the left ventricle or auricle, become enlarged with its systole, and that death results sooner or later from hæmorrhage alone. Not so, however, with the right ventricle and auricle, the mortality being less with similar wounds. Therefore, one is justified in believing that sutures are less likely to tear out in the thick walls overlying the cavities of the left heart. This statement appears inconsistent. In the more highly developed and older animals of mature ages, the heart will be more likely to be sutured successfully.

The superficial vessels (coronary arteries and veins) lie side by side, and the amount of hæmorrhage, in case of trauma, depends upon its distance from the origin of those vessels. It will depend also upon the character of the wound.

Knife and needle wounds, or those of sharp-edged weapons, bleed the most, and superficial, lacerative, the least.

The closure of the chest of animals is difficult, for the reason that the animal cannot be kept quiet. Of course there are severed ribs, and at times these have to be closed in two places.

Silk-worm gut and silk (heavy) were used in most cases, silk for the bony wall, and intercostal muscles, one suture

on each side, or rather one between each rib, the ribs being as nearly approximated as possible. Then the muscle, and the skin, all in one layer, were sutured with silk-worm gut. As before stated, the two tiers of sutures did not come directly above each other, from the fact that after the first incision was made, the outer flap was dissected up for a distance of an inch, and then the wall opened. This puts the two rows one inch apart, and protects them from contamination by infection, and also makes a sort of valve, as in the operations for colotomy and gastrotomy.

In putting in the external sutures, they should be close, and extend down into the intercostal muscle under the line of skin incision, to add to the security of the wound. Not often was there any trouble in getting the wound closed well enough to prevent the passage of air into the pleural cavity.

Drainage should be provided for in the same way as for wounds in other parts of the body, and governed by the same principles.

The dressings should be aseptic, and securely held in place with adhesive plaster, and bandages encircling the body, and about the shoulders.

The post-operative treatment requires that simple, nutritious food should be prescribed, with more or less stimulation, as the case may require. Alcohol may be given by the stomach, in the absence of nausea. If there be nausea, it should be given by the rectum. Artificial heat should be applied, if the temperature becomes subnormal, or if it be otherwise indicated. Oxygen is indicated, and is probably the most satisfactory way of stimulating, when stimulation is demanded.

Remarks on the Various Experiments

In carrying on the series of experiments the object was to induce as many complications as possible. That this might be accomplished, aseptic principles were disregarded, and the

pleural cavity many times entered. In a few instances, clots were allowed to remain in the pleural or cardial sac, and sometimes both, that their disposition might be observed. In Case No. 1, two tablespoonfuls of blood were allowed to escape from the coronary artery into the pericardial sac, and there allowed to remain. The clot was afterwards found intact.

Removal of the pericardium by incision was done in two cases. In one death did not ensue; dissolution occurred in the other (No. 8) as the result of infection which might have been avoided. In the case of recovery, the heart was adherent to the surrounding tissues. In two cases, the pericardium was divided from apex to base, with scissors, and allowed to retract upon itself, leaving the heart practically in the same condition as if the pericardium had been removed by excision. Death resulted in one of the cases.

In Case No. 5, the pericardium was divided longitudinally, and sutured to the chest wall with silk. The animal was killed sixteen days afterward. Even though this dog on the third or fourth day removed the sutures in the chest wall with his teeth, the wound was not infected. He was allowed to lick the wound until the sixteenth day, when he was killed. Autopsy revealed about one ounce of serous fluid in the pleural cavity. There were adhesions of the pleura, pericardium, lungs, and heart to one another, and to the chest wall.

It has been found that the ligation of either of the coronary arteries at any point of their distribution will not produce death.

In Cases Nos. 1 and 9, silk was used for ligature. In Case No. 3, kangaroo tendon was employed, the ligature being applied at the origin of the artery. The dog's life was taken in the latter case, on the fourteenth day, and complete repair following the ligation was found to have taken place.

Several similar experiments were made with the anterior coronary arteries, with practically the same results.

Accidental puncture of one or more branches of the coronary

arteries occurred in three cases, more or less complicating the operation.

In Case No. 2 the posterior coronary artery was ligated about midway between apex and base; the second branch, being accidentally punctured with the needle, was also ligated at the bifurcation of the main branches.

Penetrating and non-penetrating wounds of the heart were made with a bistoury after the chest had been opened, and were allowed to remain open from one to ten minutes, before closing them with suture.

In Case No. 6 two incisions were made in the apex, over the left ventricle, each being one-half inch long. The dog died at the end of seventy-two hours. The incisions were estimated to penetrate about one-fourth the thickness of the ventricular wall. They were shown at autopsy to have practically repaired themselves. The dog was found to have general tuberculosis, which was suspected at the time of operation, and which was, no doubt, the cause of his death, there being no other perceptible cause.

In Case No. 9, while suturing a penetrating wound, three-eighths of an inch long, made in the left ventricle, the left branch of the anterior coronary artery, which had been accidentally punctured, was included in the last and upper suture. The animal died at the end of seventy-two hours. Autopsy revealed about a pint of bloody fluid in the pleural cavity, also adhesions between the pericardium and chest wall, and between the pericardium and heart. The wound in the heart was completely and permanently closed.

In Case No. 10 a fine needle, armed with silk, was made to pass so as to make four sutures closely approximated over the left ventricle, the object being not to perforate the endocardium.

Case No. 11 demonstrates the suturing of a non-penetrating wound one inch long, involving about half the thickness of the ventricular wall, and in which silk was used for suture. Complete suspension of respiration lasted two minutes, but operation

was not discontinued during this time. Normal respiration was re-established spontaneously. Death occurred seventy-two hours afterward as the result of infection due to the animal having torn out all the sutures in the chest wall. The incision in the heart had firmly united, the heart itself being nearly firm.

In a small non-penetrating wound in Case No. 14 in the wall of the left ventricle a continuous suture of silk was applied. Respiration ceased, as the pericardium was being opened, but soon re-established itself and again ceased upon completion of the last stitch. It was not again re-established. The heart continued to beat two minutes after the last respiration. If death had resulted from the puncture of one or more cardiac ganglia, the heart would not have continued to beat for two minutes after the last respiration.

In Case No. 17 death occurred while incision was being made in the left ventricular wall. This may have been due to injury to one or more of the automatic ganglia. This is hardly probable; at least it has not been proven, because death has occurred under similar circumstances without any injury to the heart.

An incision requiring two silk sutures was made in the wall of the left ventricle in Case No. 18. These sutures were made too tight, and therefore cut through the muscular tissues of the heart, resulting in death.

Needle punctures of the heart were made in several cases, in various portions of the organ. In one, eighteen such punctures were made in the various portions (of the heart) from apex to base, the object being to injure the cardiac ganglia. In no instance did death ensue, nor were the movements of the heart influenced to any noticeable degree.

Stimulation of the heart to action after it had ceased to beat, was accomplished several times by rhythmically compressing the apex of the heart with the fingers, also by pricking the apex of the heart with a needle.

The most interesting of all the experiments was in Case No.

16, in which a non-penetrating incision was made in the left external ventricular wall, necessitating the introduction of four silk sutures to close it.

Record of Experiments

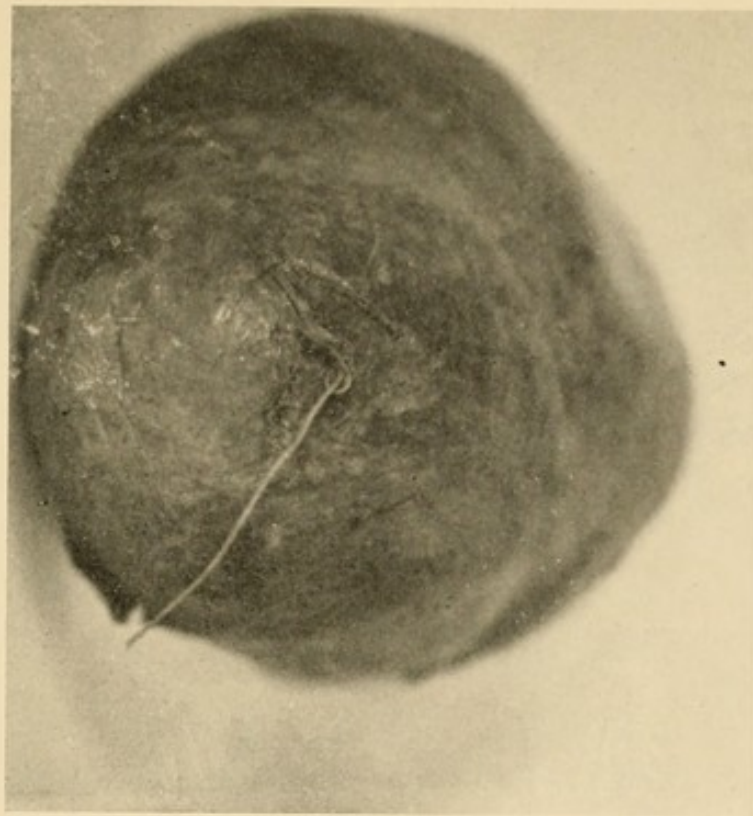
No. 1. August 6, 1901, 9.45 A. M.—Incision made in the chest wall, beginning in sixth intercostal space; five ribs resected, pericardium divided, and the left coronary artery ligated, after being punctured. Two tablespoonfuls of blood allowed to escape from the artery, and let into the pericardial space, and permitted to remain there. Silk used for a ligature. Chest walls closed with sutures of heavy silk, and integuments sutured with silk-worm gut. At 1 P. M., dog was in good condition, drank water, and walked about.

Autopsy. Dog died some time during the night of August 6. He was injected on the following day with formalin. Post mortem made August 9 at 2.30 P. M. General peritonitis, peritonæum greatly congested, abdominal cavity filled with a bloody serous effusion; left upper lobes of left lung congested; pericardium adherent to both chest wall and heart.

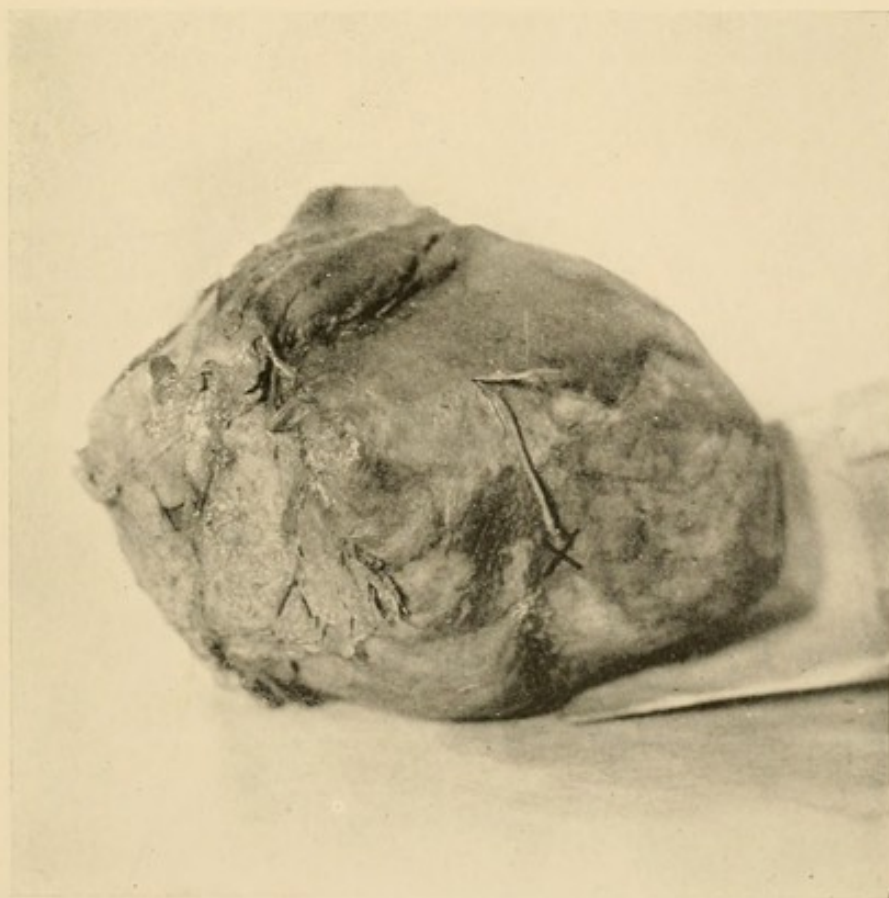
No. 2. August 6, 1901, 10.20 A. M.—Time of operation 6 minutes. Mixed fox-terrier, weight 25 pounds, age two years. Apex beat normal; pulse 110.

Incision made two inches to the left of the median line, extending from second to eighth rib. Pericardium divided from apex to base. In passing a small needle about the posterior coronary artery midway from apex to base, the second branch was accidentally punctured. Bleeding was profuse, requiring ligation. The ligature was applied at the bifurcation of the main branches. About four ounces of blood escaped before the ligature could be secured. Clots were taken out of the pericardial cavity three different times. Respiration ceased at the end of eight minutes. Heart, however, continued beating sixteen minutes. Resorted to tracheotomy, ten minutes after cessation of respiration; and various artificial methods were of no avail. Before this, the operator had to stop occasionally and hold chest opening closed with his finger, as respiration was not good at any time.

Autopsy was made immediately. No special cause of death dis-

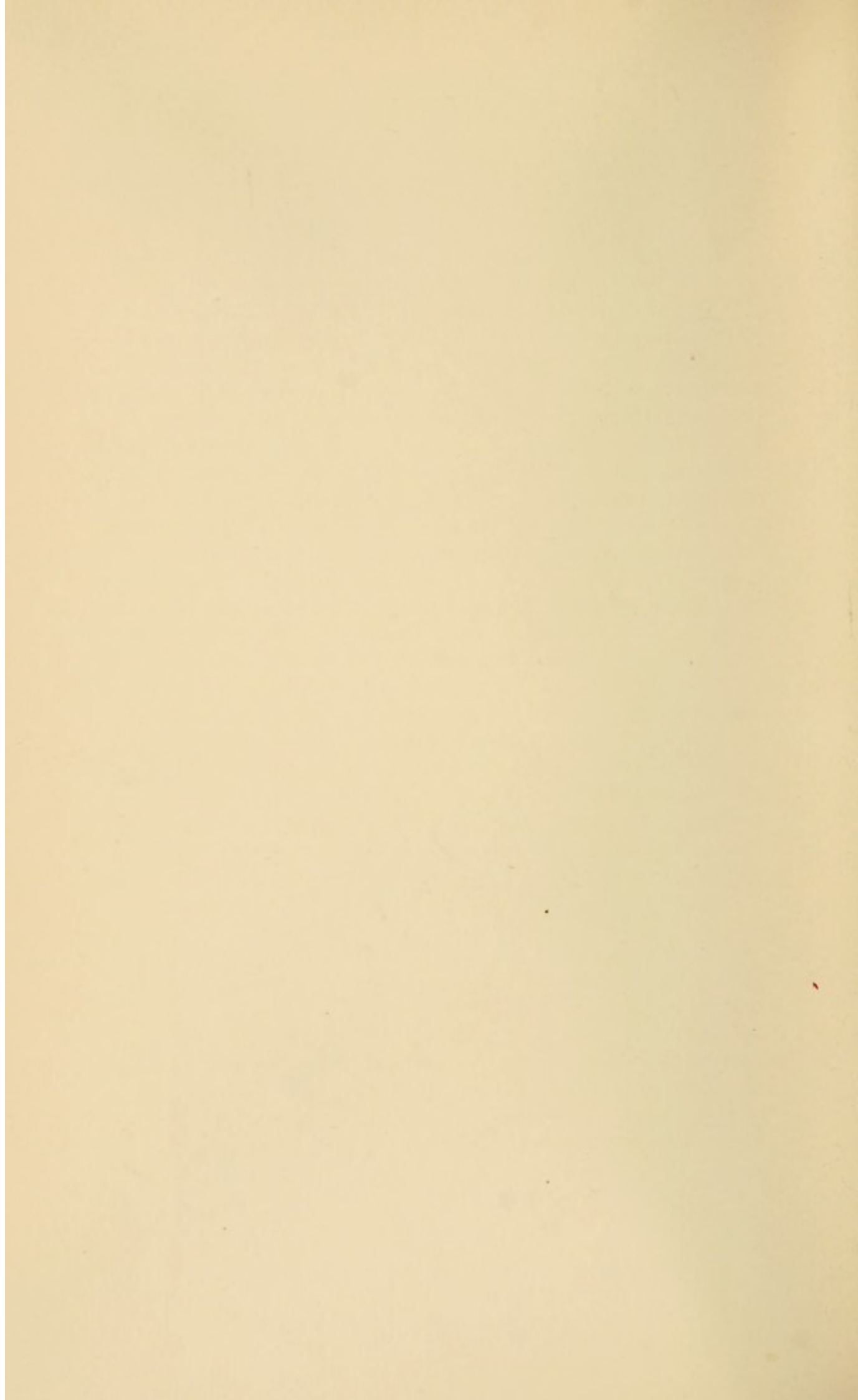


Experiment on the Heart, No. 11, page 266.



Experiment on the Heart, No. 12, page 267.

SHOWING SILK SUTURES IN PLACE.



coverable. It was probably due to paralysis of vagi, the result of manipulation of the thoracic organs during operation.

No. 3. August 6, 1901, 2.45 P. M.—Time of operation eight minutes. Mixed spaniel, weight 25 pounds, age one and one-half years, well nourished.

Incision made two inches to left of median line, from second to eighth rib, cutting through the cartilages. A transverse incision also made at the lower end of seventh rib. Left coronary artery ligated at base with kangaroo tendon. About one and one-half ounces of blood escaped from the internal mammary and intercostal arteries. This blood flowed into the pleural cavity, because the pericardium had been divided. The pericardium was not sutured. Blood permitted to remain in pleural cavity, where it soon clotted. (Plate XXIX.)

Autopsy, August 20, 1901, 9 A. M.—Heart, lungs, and sternum removed intact. Heart adherent to the line of incision in the chest wall. Lobes of left lung adherent to both heart and chest wall.

No. 4. August 6, 1901, 4 P. M.—Mixed bull, weight 20 pounds, age one and one-half years, general condition at time of operation, good.

Chest wall incised two inches to the left of median line, from second to seventh rib. Pericardium divided from apex to base. A puncture one-eighth inch wide made with a bistoury in the wall of the heart, over lower end of the left ventricle. Immediately on withdrawal of the knife, blood spurted out with great force. The force was so great that the blood was thrown a distance of twenty feet. This prevented further operative procedure. Heart ceased beating at the end of four minutes.

Autopsy was made at once. Examination of the heart showed that the forcible expulsion of blood enlarged puncture in the wall by the bistoury, also slight lacerations to the right of the puncture, made by the forceps in an attempt to control the hæmorrhage. All organs were found to be normal.

No. 5. August 15, 1901, 1.30 P. M.—A young street dog, half pointer (liver colored), healthy, but emaciated, weight 25 pounds, age nine months, took anæsthetic very hard.

Incised fourth, fifth, and sixth ribs. Pericardium divided and sutured to chest wall with silk, and silk-worm gut used to close chest wall.

Autopsy, August 31, 1901, 9 A. M. External sutures had either broken or were gnawed, on the third or fourth day following operation,

At the autopsy, external wound, though open, was clean and without infection, although in the case of all the other dogs, where the external sutures gave way, death occurred in a few days from infection. The incision dividing the ribs, etc., had healed so perfectly that it was with the utmost difficulty that the line of union could be discovered. About one ounce of serous fluid in pleural cavity; but all thoracic organs were in a good condition. There had probably been a great amount of the fluid absorbed. The fluid found would have been absorbed in a few days. Adhesion of the pleura, pericardium, lungs, and heart to one another and to the chest wall.

No. 6. August 17, 1901, 10 A. M.—A brown spaniel bitch, about one year old, weight 20 pounds. She was tuberculous.

Four ribs incised. A slit one and one-half inches long made in pericardium. The wall of the heart slightly scarred at the base over left ventricle. Pericardium was not sutured. Chest wall closed with sutures of heavy silk. Integuments sutured, partly with silk-worm gut, and partly with silk, because the operator ran short of silk-worm gut.

Autopsy. Dog died August 20, 1901, at 10 A. M. Post mortem was made at once. Dog was found to have been in an advanced state of pulmonary tuberculosis. Death due to infection. Pus about pericardium. (Plate XXIX.)

No. 7. August 20, 1901, 8.30 A. M.—Water spaniel, about two years old, weighing about 25 pounds.

Operator, in making the incision through the chest wall, began too near the median line, and thus accidentally severed the internal mammary artery. Further operative procedure had to be suspended, in order to secure this artery. A silk ligature was applied transversely in the intercostal space, next above the one where the cut in the artery was made. (This accident served as a caution to those present. In all operations involving the incision of the chest wall, it is safer to cut too near the spine, than too near the sternum. In other words, make the incision as far from the sternum as possible.)

Respiration ceased at this point. The suspension lasted over two minutes. Tongue was cyanotic, heart beat in time and energy reduced 50 per cent. No attempt was made at artificial respiration. The only thing done was to hold the chest opening shut with the fingers. Respiration finally became normal, and operation continued. The pericardium was incised one and one-fourth inches over and below the origin of left

coronary artery. One branch of this artery was accidentally punctured with a tenaculum, in lifting up the pericardium, causing profuse hæmorrhage. Condition of dog precluded further operative measures. A clot was allowed to form in order to stop the bleeding. Two or three drams of blood, which entered the pleural cavity, were allowed to remain. Chest wall sutured with silk, and integuments closed with sutures of silk-worm gut.

Autopsy. Dog died suddenly at 12.15 P. M., August 21. He had been walking around during the morning, but was not in very good condition. He had been lying down, got up, staggered five or six feet, and fell dead. Post mortem held immediately. One-half pint of fluid in left pleural cavity. No clots in the pericardial space. Pleural cavity was filled with clots of blood, as was also the heart. A fibrous clot closed the incision in the pericardium, thus hermetically sealing it. Ligature about left coronary artery intact and covered by fibrous exudate. Left lung greatly congested, but not pneumonitic. Lobes of left lung adherent to the pericardium. Slight adhesive exudations connected heart and lungs with the anterior thoracic wall. Clot, forming the adhesion to the pericardium, was accidentally removed at the autopsy. The right margin of the incision in the pericardium was inverted. Evidences of infective pleurisy. The blood permitted to remain in the pericardial and pleural cavity had been partly absorbed. The effusions present were no doubt pleuritic. Death, perhaps, due to infection.

No. 8. August 20, 1901, 10 A. M.—Terrier (Scotch), weight 20 pounds, age one year.

Incised chest wall, two inches to the left of the median line. Removed pericardium by a circular incision. Respiration ceased at this point, remained suspended ninety seconds. There was no bleeding from the pericardium.

Autopsy. Dog died some time during the night of August 22 (death probably occurred about 12 o'clock, August 21-22). Post mortem 11 A. M., August 22. About eight ounces of fluid in left pleural cavity, evidently from the pericardium. The fluid was covered by more or less blood, but was not purulent. A tough fibrous exudate covered the exposed surface of the heart (that portion devoid of pericardium). Adhesions connected the left lung to the chest wall, and the heart to the remnant of pericardium. Left lung partially collapsed, and superior lobe congested.

No. 9. August 20, 1901, 10 A. M.—White dog, weight 25 pounds, age two years.

A longitudinal incision was made in the pericardium, which was then sutured through the chest wall. A very fine needle, armed with silk, was used in making three punctures through the walls of the heart, into the left ventricle. On the withdrawal of the needle after the last, an upper puncture, the coronary artery was accidentally punctured. The sutures were made taut. The left branch of the anterior coronary artery was included in the last and upper suture. Sutures were made with both silk and silk-worm gut.

Autopsy. Dog died 6.30 A. M., August 22. Post mortem at 10 A. M., August 23. Death due to general infection. A pint of bloody fluid in pleural cavity. Adhesions between the pericardium and chest wall, and between the pericardium and heart. Adhesions, formed of fibrous bands, connected the lungs also with both chest wall and pericardium. The adhesions of pericardium were exceedingly intimate. Stitch abscesses in both rows of sutures, *i.e.*, those closing chest wall and those closing the integuments. Greenish pus filled each stitch hole. Heart, lungs, pleura, and pericardium covered with mucopurulent exudate. Even the diaphragm was covered with a similar exudation. (Plate XXX.)

No. 10. August 20, 1901, 2 P. M.—Shepherd dog, weight 25 pounds, age two years.

Pericardium incised; heart punctured with a fine needle, armed with fine silk. Four sutures were then placed in the external surface of the heart, over the left ventricle. Chest wall closed with silk, integuments with silk-worm gut. (Plate XXX.)

Autopsy. Dog died 6.30 A. M., August 24. Post mortem 2 P. M. same day. Death from infection. Fluid in pleural cavity. Effusion of blood into the contiguous cutaneous structures. Adhesions connected pericardium to the pleura and both to the chest wall.

No. 11. August 20, 1901, 2.30 P. M.—Shepherd dog, female, weight 50 to 60 pounds, age two to three years.

Pericardium incised about one inch. The heart itself was incised over the left ventricle. Cut about one and one-half inches long through the wall (non-penetrating). Closed incision in the heart's wall with sutures (interrupted) of silk. Chest wall sutured with silk, and the integuments with silk-worm gut. Respiration ceased, but operation

was not suspended. Suspension of respiration lasted fully two minutes, then normal respiration was restored spontaneously.

Autopsy. Death occurred 8 A. M., August 23. Post mortem 2 P. M., same day. Sutures in chest wall had been torn loose. Infiltration of blood into the contiguous cutaneous structures, two ounces, at the very least, in a clotted condition.

External sutures had rotted away. Incision through the integuments filled with a foul, ill-smelling, greenish-colored pus. Pleural cavity held about a quart of dark red fluid. Part of pericardium had sloughed away; the remainder was closely adherent to the heart and covered with a mucopurulent exudate. Adhesions connected heart, pericardium, pleura, and lungs to one another, and to the chest walls. Incision in the wall of the heart closely and firmly approximated, and union nearly accomplished. Infection of contents of the thoracic cavity, general. The material forming the adhesion, on visual inspection appeared to be formed of fibrous tissue, held together by half-formed connective tissue. The parietal pleura, where immediately attached to the chest wall, was very much thickened by a mucopurulent deposit on its surfaces, but more especially by an infiltration that presented the appearance of clotted blood. All the thoracic vessels, except the bronchial, were extraordinarily hard and firm when removed from the chest cavity. They felt as if they had been hardened in alcohol three or four days. (Plate XXXI.)

No. 12. August 20, 1901, 3 P. M.—A black cur dog, about six months old, weight, 15 pounds.

Dog was tuberculous. Chest wall opened and pericardium divided. At this stage of the operation the coronary artery was accidentally punctured. Operation suspended to secure the bleeding vessel. Both the coronary artery and the coronary vein were included in the ligature applied. The dog's condition being so critical, nothing more was done. Chest wall closed with silk sutures and the integuments with silk-worm gut.

Autopsy. Dog died August 24, 1901, 6.30 A. M. Post mortem 2 P. M., same date. General infection. A bloody, serous fluid in the pleural and pericardial spaces. The adjacent cutaneous structures infiltrated with an exudate resembling clotted blood. Adhesions connected pericardium to the heart and pleura, and the latter to the chest wall. These adhesions consisted of white, tough, fibrous bands. The incision was filled with foul, greenish pus. (Plate XXXI.)

No. 13. August 20, 1901, 3.15 P. M.—A young fox-terrier, age one year, weight 12 pounds.

Chest cavity opened and left lung excised. Chest closed with silk sutures; integuments closed with silk-worm gut. Lung stump sutured with gut.

Autopsy, August 29, 1901, 2.30 P. M. Dog killed with chloroform, recovery had been rapid and uneventful, and dog had been up and around, manifesting a lively interest in the work in the laboratory. Evidently he had been a pet, for he was very affectionate, and solicited caresses from the operator at each visit to the laboratory. When chest cavity was opened all the organs were found to be in good condition. Evidences of recent congestion of the lungs, adhesions to chest wall. A little fluid in the pleural cavity, but there were no signs of infection; a few days, probably, would have seen the disappearance of the last vestige of fluid by absorption. There had been also some infiltration of the cutaneous structures, but at time of autopsy it had been about all absorbed.

No. 14. August 21, 1901, 10 A. M.—A cur dog, about half pug, weight 18 pounds, age two years.

Chest cavity opened, and pericardium divided. An incision, about one-tenth inch in depth, made in the wall of the left ventricle. This incision was closed with a continuous suture of silk. Respiration ceased as the pericardium was being divided, but it began again just as the last stitch was being placed; the dog died. Death was probably due to chest cavity being kept open too long, or to one of the special ganglia in the walls of the heart being pierced by the needle in making the puncture for the last stitch. The operator punctured the heart's wall deeper than he intended. Heart continued beating fully two minutes after respiration had ceased.

No. 15. August 21, 1901, 10 A. M.—Cur puppy, three months old, weight 8 pounds.

Anæsthetized and throat cut. The puppy was not old enough for this series of experiments, and in order to compare a puppy's heart and lungs with the adult organs, was thus sacrificed. The thorax saved for examination and comparison. Observations were made of his appendix. This was very large, much larger than those of adult dogs weighing fifty or sixty pounds. There was nothing abnormal in this. It but illustrated the law that among the higher orders of the carnivorous

quadrupeds and also of the still higher classes, the appendix at an early stage of existence is much larger relatively than in the adult. Among some animals this condition is found in the fœtus, in others, a short time after birth. It is not only relatively, but even absolutely much larger in early life, in some classes, than in adult life. This law holds good for men, too.

No. 16. August 21, 1901, 2 P. M.—A very fat, black mongrel, age four years. Weight, 50 pounds.

Chest cavity opened and pericardium divided. An incision one-half inch long was made in the external wall of the left ventricle. Incision in heart's wall closed with four sutures of silk. At this stage of the operation respiration ceased. Muzzle was taken off (cone for applying the anæsthetic had been withdrawn about the time the operator began to suture). The operator held the opening in the chest cavity closed with both hands. An assistant kneaded the abdomen, in an effort to restore respiration. At the end of the first minute the operator introduced one hand into the thoracic cavity, still holding chest opening closed with the other hand, and stimulated the heart by pinching the apex. After a time the dog took a deep, labored inspiration. Then respiration was suspended again, again a few deep labored inspirations, then suspension for a considerable interval. This procedure continued for several minutes. There would be several deep labored inspirations at comparatively short intervals of time, then inspirations would be single, with a longer interval of time after each respiration, then a series of labored respirations at shorter intervals of time after each inspiration. This alternation of single, deep-labored inspiration at considerable intervals, followed by a series of several inspirations not quite so labored, and at shorter intervals after each inspiration, continued until the dog regained normal respiration. The operator, in stimulating the dog's heart, observed, and called the attention of his assistants to it also, that the heart began beating at the end of each inspiration. There were three beats of the heart after each inspiration. The movements of the heart ceased with the suspension of respiration. After each labored inspiration the heart would beat three times, but would be absolutely motionless in the interval between inspirations. The heart's movements were completely suspended three and one-quarter minutes. Respiration was suspended this length of time, and the heart did not beat until after the first inspiration. It took about three

minutes after the first deep-labored inspiration for the dog to regain normal inspiration. In no case when suspension of respiration occurred in this series of experiments were drugs given subcutaneously or otherwise to promote the heart's action. Neither was resort made to transfusion, nor any other artificial means employed to stimulate the heart.

Autopsy. Dog died 12 M., August 24, 1901, and post mortem made the same date at 2 P. M. Infection general. A quart of bloody fluid in the pleural cavity. Sutures in both the chest wall and cutaneous structures had rotted away. Pericardium, heart, pleura, and lung were adherent one to the other, and to the chest wall. (Plate XXXII.)

No. 17. August 21, 1901, 2.25 P. M.—A brown spaniel bitch, two years old, weighing 30 pounds.

Chest cavity opened and pericardium divided. The external wall of the left ventricle was incised. After a vain effort to restore the dog, respiration, which had ceased just after incision, was made. The thoracic and abdominal organs were examined to discover if any lesion of any organ would account for death. No lesions of any character were discovered in any organ. Death is supposed to have been due to injury to one or more of the automatic ganglia from the penetration by the knife in making incision.

No. 18. August 21, 1901, 2.40 P. M.—A black mongrel bitch, age two years, weight, 35 pounds.

Chest opened and pericardium divided and incision made in the wall of the left ventricle. This incision was closed by two sutures of silk. An assistant, in making the first puncture with the needle to suture the chest wall, made too deep a thrust, and injured the coronary artery. Artificial respiration was of no avail. The intention was to complete the operation if respiration could be restored.

Autopsy made at 2.50 P. M. proved that the accident was a benefit rather than a loss, as it permitted several valuable observations to be made. The heart continued to beat four minutes after removal from the thoracic cavity. It was discovered that the suture closing incision in the heart's wall had been drawn too tight; because of this, and because of the high tension of the heart muscles, the latter had been torn. The needle which was the cause of the accident was a very large one, with cutting edges. The holes made with the needle in the heart were fully one-eighth of an inch long. The strain upon the heart muscle was so great that the punctures were doubled in size. The autopsy also

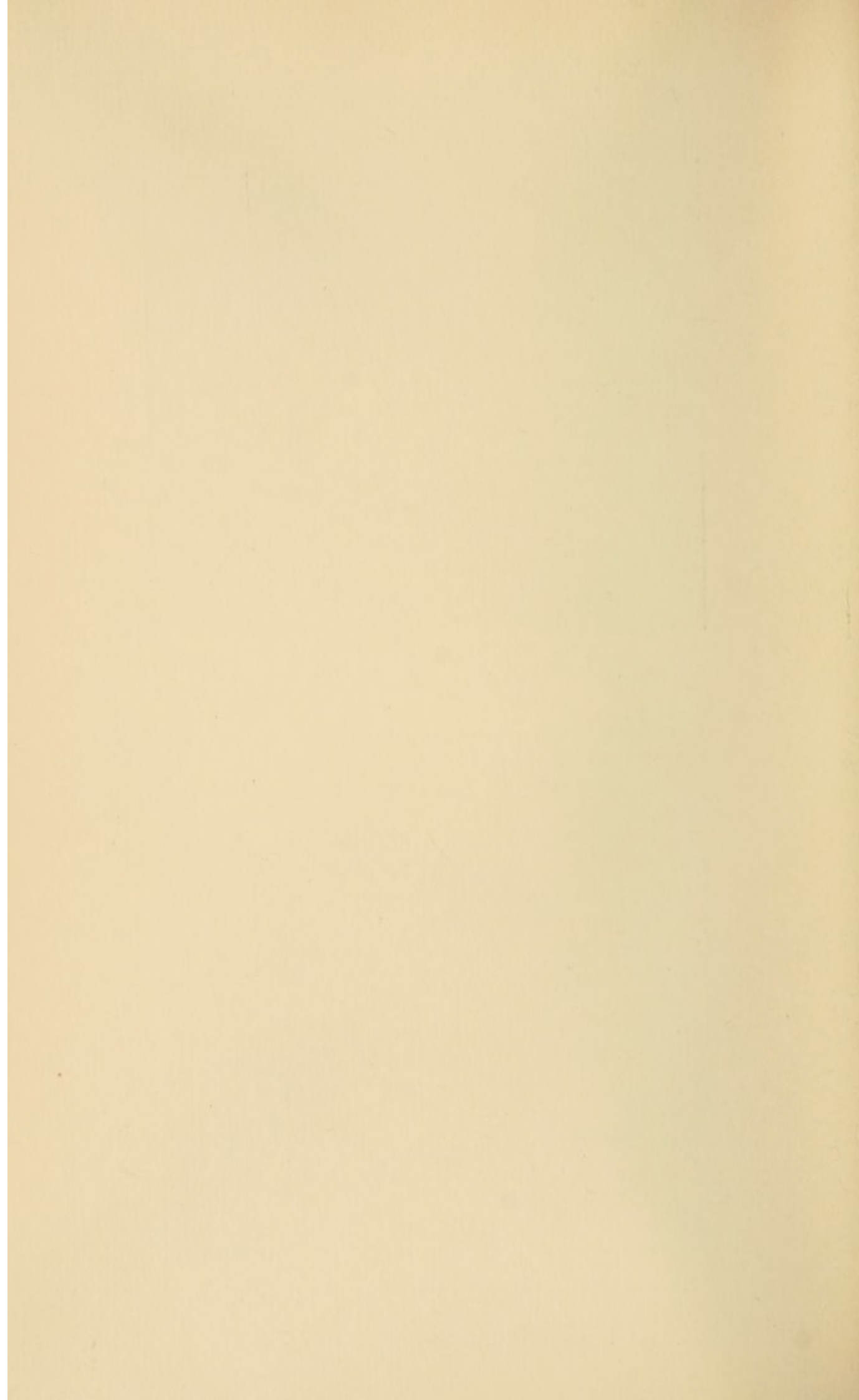


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Experiment on the Heart, No. 18, page 270.

SHOWING SILK SUTURES IN PLACE.



showed that the coronary vein had been punctured, as well as the coronary artery. (Plate XXXII.)

No. 19. August 21, 1901, 3.15 P. M.—Fox-terrier, age two years, weight 15 pounds.

Chest cavity opened and pericardium divided. At this stage of the operation the operator accidentally thrust the tenaculum with which he was attempting to pull the pericardium up from the heart, in order to divide it, into the coronary artery. This is always a difficult procedure, because the pericardium is so intimately united to the heart. A silk ligature was immediately applied to control the hæmorrhage. This operation was performed so hurriedly that the needle used in applying the ligature was passed through the pericardium, which was thus enclosed in the ligature. Respiration had ceased before the ligature could be applied, but it was almost immediately restored on the artery being ligated. Blood spurted out with great force when the walls of the artery were penetrated, but it did not fill the pericardial space. It lost its fluidity with amazing rapidity, so that it remained quiescent, forcing the pericardium out like a balloon. The pericardium began to fill and stretch as long as the hæmorrhage lasted. Doubtless the elastic tension of the pericardium aided also in preventing the blood from flowing into the pericardial space. All this combined to cause a clot to form very quickly. It also permitted the attachment of the fibrous elements of the blood, thus showing how fibrous, exudative adhesions are formed.

Autopsy. Dog died August 25, 1901. Post mortem held 8.30 A. M., August 26th. Infection general. Abdomen distended with gas. No fluid in the thoracic cavity. Pericardium and pleura adherent to each other, and both adherent to the heart and chest wall. A bloody infiltration into the mediastinal space, and also into the cutaneous structure, adjacent to the thymus gland. The adhesions consisted of fibrous bands. Both pericardium and the surface of the heart were covered with a granular exudate.

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TO THE PRESENT TIME
BY
JOSEPH NEALE
OF THE BOSTON BAR
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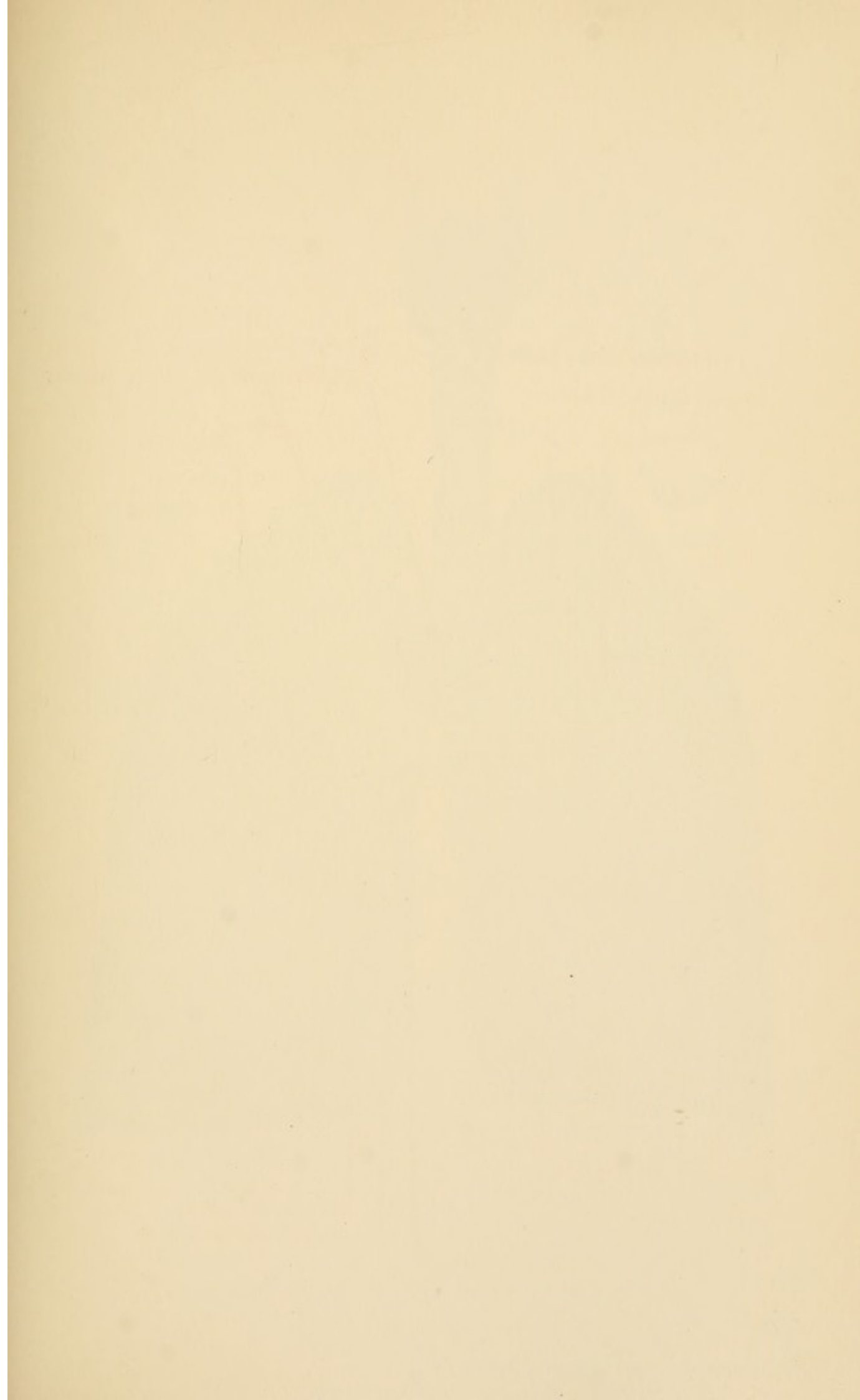
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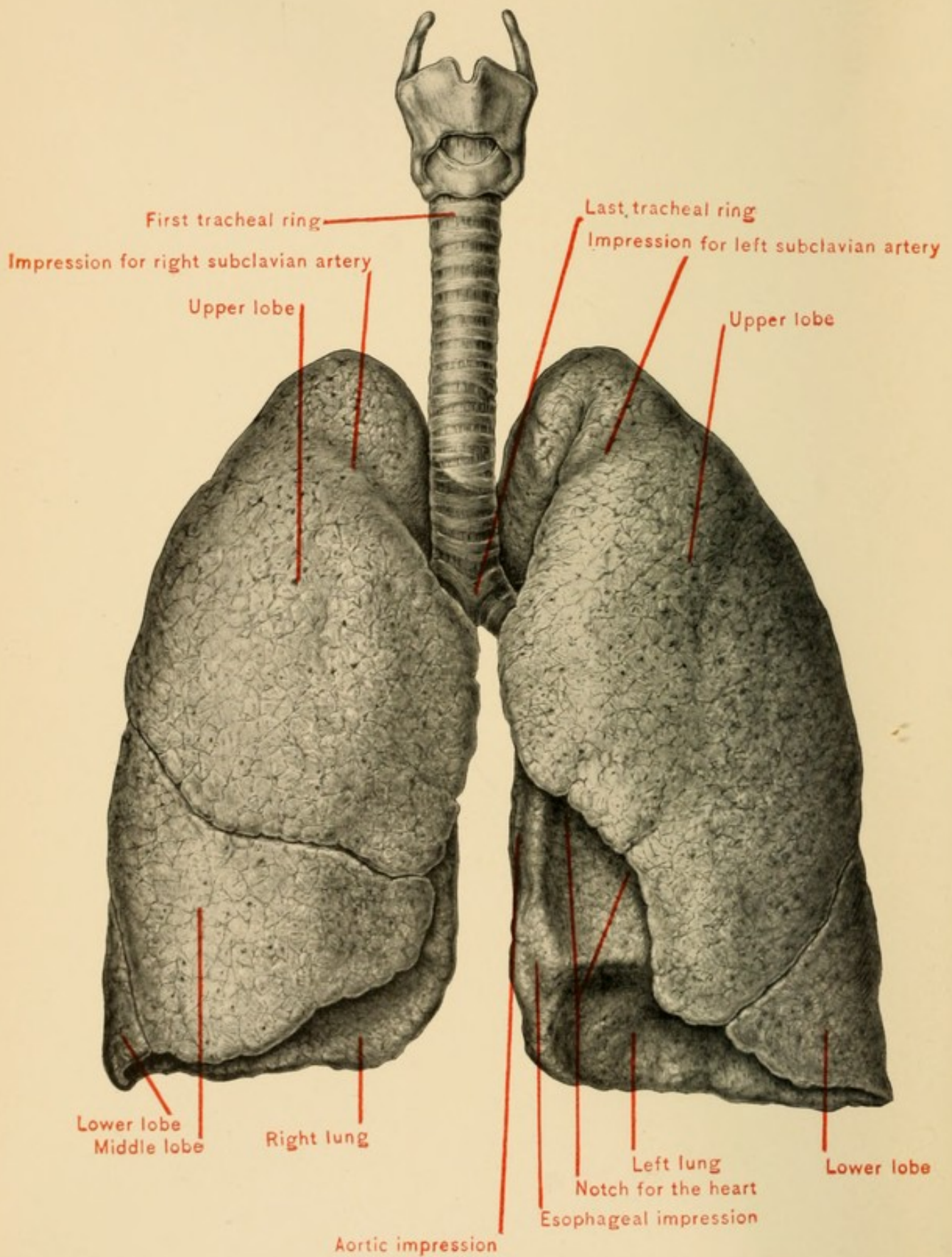
PART II

THE SURGERY OF THE LUNGS

PLATE II

THE SURGEON OF THE LUNGS





ANTERIOR VIEW OF THE LUNGS.

PART II

THE SURGERY OF THE LUNGS

INTRODUCTION

No part or organ of the body is to-day held sacred from the surgeon's knife.

As there are many pulmonary diseases which cannot be cured by the employment of the agents furnished by our modern *materia medica*, attention has been directed to the employment of surgical means to cure these conditions.

But there are many practical difficulties to be settled before the surgical technique for pulmonary operations can be established on a firm basis.

In order to devise an efficient and a successful technique many experiments have been undertaken by different workers.

Wintrich, as early as 1854, made a series of experiments on animals. Pagenstecher nearly half a century later made another extensive series of similar experiments. The latter demonstrated that animals would survive both resection and excision of the lung.

Other investigators have been successful in similar work. Still many little details remain to be settled. Many investigators do not say anything about their methods, and it is just these little details of technique that are needed.

Some writers claim that experiments on animals, no matter how successful, do not prove that man can safely undergo the same operations.

At the congress of French surgeons in Paris, 1895, Reclus condemned many operations for pulmonary diseases. He says, in regard to tuberculous diseases and primary cancer of the lung, that resection of the lung for these conditions is "condemned past appeal."

In criticizing an operator for cutting off the protruded part of a herniated lung, M. Reclus claimed that the term resection should not be applied to such procedures, because none of the healthy lung had been cut. No better word could be used: resection comes from two Latin words, the inseparable particle, *re*, and *sectio*, given by Andrews as meaning, a cutting of parts of the diseased body.

Accepting the above authority, the word seems sufficient to characterize the operation of cutting off a gangrenous part of a lung.

Reclus is one of those who believe that the results obtained by experimentation on animals cannot be applied to man. He says: "There is no reason in resecting the human lung, or in arguing from rabbits to men."

M. Reclus is referred to because he represents a certain class of writers who decry all bold advances in the application of the results of experimental science.

His criticism of published reports has some truth in it. It is quite true that sometimes only successful cases are mentioned, and nothing said of the unsuccessful, but a surgeon is supposed to be familiar with the literature of his profession. Long before 1895 many cases were published of operations on the lungs, especially for those conditions in which Reclus condemns surgical interference.

A relatively large number of resections for hernia of the lung have been tabulated. One table shows that 87½ per cent. are cured when operated upon; another that 85 1-7 per cent. are cured.

In gangrene 60 per cent. recover after operation. About 71 per cent. recover when operated upon for bronchiectasis;

in tuberculous diseases 60 per cent. recover; in case of septic lesions 64.8 per cent. recover when pneumonotomy is employed, and in case of aseptic lesions 75.8 per cent. recover. In a late list of 306 cases of pneumonotomy 218 recovered and 88 died.

These figures ought to be conclusive evidence that surgical interference in these cases is justifiable. Many of the diseases enumerated above cannot be cured by other means, and any method of treatment that will cure sixty per cent. of what otherwise would be fatal should be employed. It is no excuse for a surgeon to let his patient die because surgery does not cure all cases, or because some prominent writer proscribes pulmonary surgery. If arguments from analogy have any force, the strongest possible argument for surgical operations for tuberculous diseases of the lungs can be drawn from the success of similar work in case of tuberculous abscesses in the abdomen. Patients seemingly almost moribund are relieved, and recover from the operation in a surprisingly short time.

Reclus's statement, "I know of no instance of operation for this disease in the lungs," speaking of actinomycosis, may have referred only to France. If not, it shows a want of knowledge of the history of pulmonary diseases.

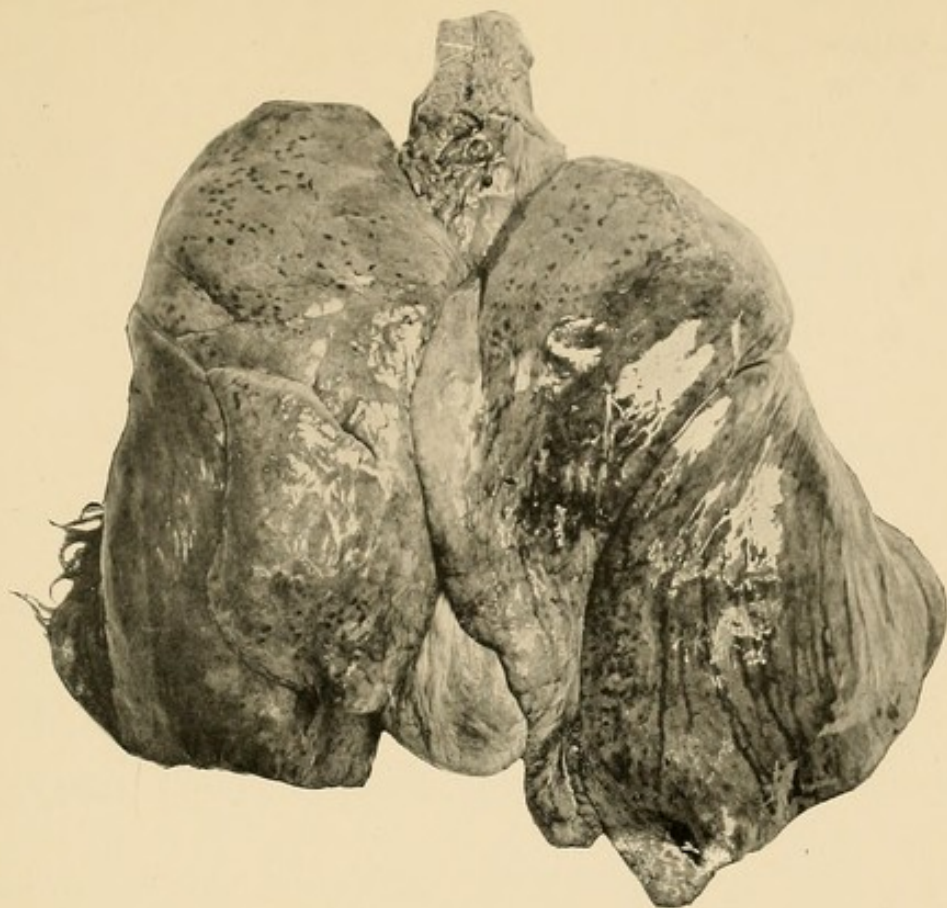
The decade preceding 1895 had numerous reports of cases of actinomycosis in man. The German surgeons and scientists wrote extensively on this subject, and there are a large number of cases of this disease invading the human lung. English and American writers also published cases.

In considering the feasibility of pulmonary surgery the fact should be borne in mind that there are no diseases of any part of the body, or any organ, which are always attended by immediate fatality, and there are but few injuries of any one of the tissues or organs of the body which are necessarily fatal, if not immediately so.

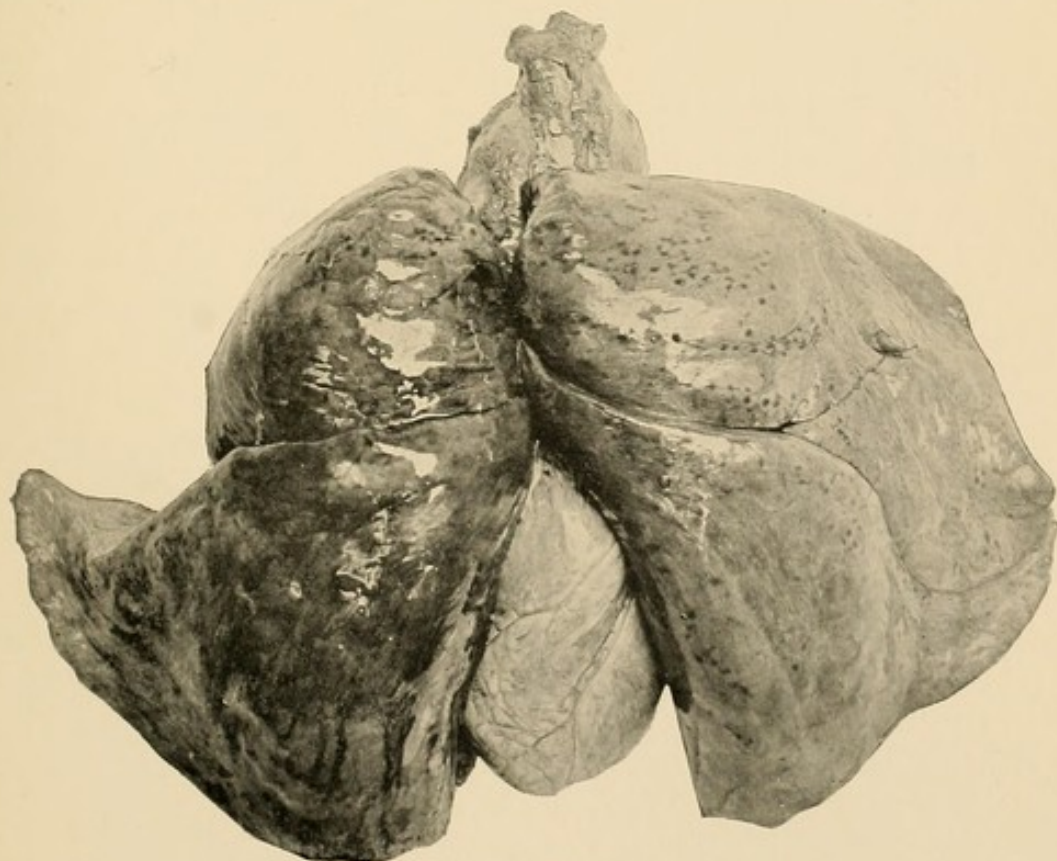
Hope is not to be abandoned under any circumstances,

the old proverb to the effect that, "where there is life, there is hope," holding good, especially in diseases of the lungs.

The diseases which are held to be incurable are not always so, because many instances have been recorded where they have yielded to some kind of treatment, or have been cured spontaneously. These facts are to be kept in mind when an apparently incurable case is encountered.

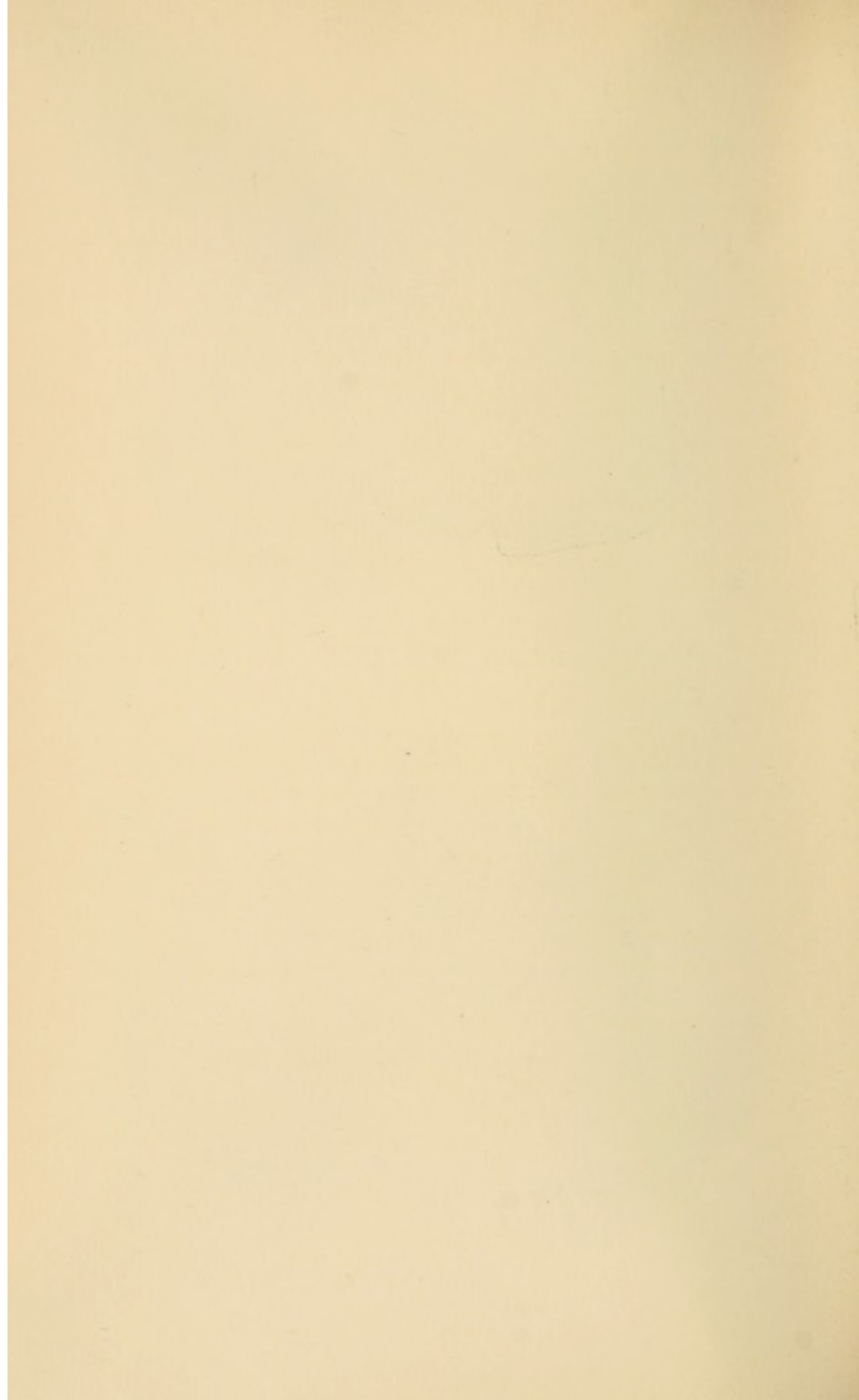


Anterior View showing Apex of Heart and Tissues.



Posterior View.

NORMAL HUMAN LUNG



TERMINOLOGY

Pneumatelectasis	imperfect expansion of the lungs
Pneumochysis	pulmonary œdema
Pneumohæmia, or Pneumo- næmia	congestion of the lungs
Pneumokoniosis; pneumoco- niosis	lung disease caused by inhalation of dust; anthracosis, when caused by coal-dust, coal-miner's lung; siderosis, when caused by metallic dust; chalicosis, when caused by mineral dust
Pneumonalgia.....	pain in the lungs
Pneumonapoplexia	a sudden hæmorrhage into the lung tissue
Pneumonectasia, or Pneumo- nectasis	emphysema of the lungs
Pneumonemphraxis	obstruction of the lungs or bronchi
Pneumonemphysema.....	emphysema of the lung
Pneumonica.....	a slight inflammation of the lung
Pneumonoblennozæmia	pulmonary blennorrhœa
Pneumonodynia	pain referred to the lung
Pneumonopathia	any disease of the lung
Pneumonœdema	pulmonary œdema
Pneumonorrhœa	hæmorrhage from the lungs
Pneumonosyrinx	a fistula of the lung
Pneumonyperpathia	any very grave disease of the lung
Pneumoparesis	progressive congestion of the lungs, due to faulty innervation
Pneumophthisis	a destructive process in the lung
Pneumophyma	a tubercle of the lung

- Pneumophymia.....tuberculosis of the lungs
- Pneumonitispneumonia
- Pneumonocholesiabilious pneumonia, or pneumonia
accompanied with icterus
- Pneumonophlebitis.....inflammation of the pulmonary
veins
- Pneumonoscirrhusinduration of the lungs associated
with bronchiectasis
- Pneumatosisair in abnormal places, or in exces-
sive quantities
- Pneumocoele, Pneumatocele,
Pleurocelehernia of the lung
(Pleurocele is sometimes used to denote a serous effusion into
the pleural cavity.)
- Pneumoclasiarupture of the lung
- Pneumocacegangrene of the lung
- Pneumatodyspnœaemphysematous dyspnœa
- PneumolithA stony concretion in the lung—
sometimes used to denote a
calcified tubercle
- Pneumomalaciaabnormal softness of the lung
- Pneumosis, or Pneumonosis ..any affection of the lung
- Pneumonosepsis.....septic inflammation of the lung
- Pneumorrhagia.....expectoration of blood from the
lungs
- Pneumordesire for air, or to breathe
- Pneumonocarcinoma.....carcinoma of the lung
- Pneumoactinomycosisactinomycosis of the lung
- Pneumocentesis.....paracentesis of the lung
- Pneumonectomy or Pneumec-
tomyexcision of a portion of lung
- Pneumonotomy or Pneumoto-
my.....surgical incision of the lung
- Pulmonariousaffected with pulmonary disease
- Pulmoniferous.....provided with lungs

- Pleurapophysis.....a true rib
Pleurapostemaa collection of pus in the cavity of
the pleura
Pleurarthron.....the articulation of a rib
Pleurarthrocace.....disease of the costo-vertebral joints;
also caries of the ribs
Pleuritis or Pleurisyinflammation of the pleura
Pleuroclysis or Pleuroklysis ...injection of fluids into the pleural
cavity
Pleurocollesis.....adhesion of the pleural layers
Pleurogenic or Pleurogenous .originating in the pleura
Pleurona rib
Pleuropathia or Pleuropathy ..any disease of the pleura
Pleuropyesispurulent pleurisy
Pleurorrhagiahæmorrhage from the pleura
Pleurorrhœa.....effusion of fluid into the pleura
Pleurostosiscalcification of the pleura
Pleurotomyincision of the pleura
Bronchotomy.....a surgical cutting operation upon
the bronchus, larynx, or trachea
Bronchoplastythe surgical closure of a tracheal
fissure or fistula
Bronchophymaany growth, as a tubercle, in a
bronchial tube.

CHAPTER I

ANATOMY OF THE LUNG

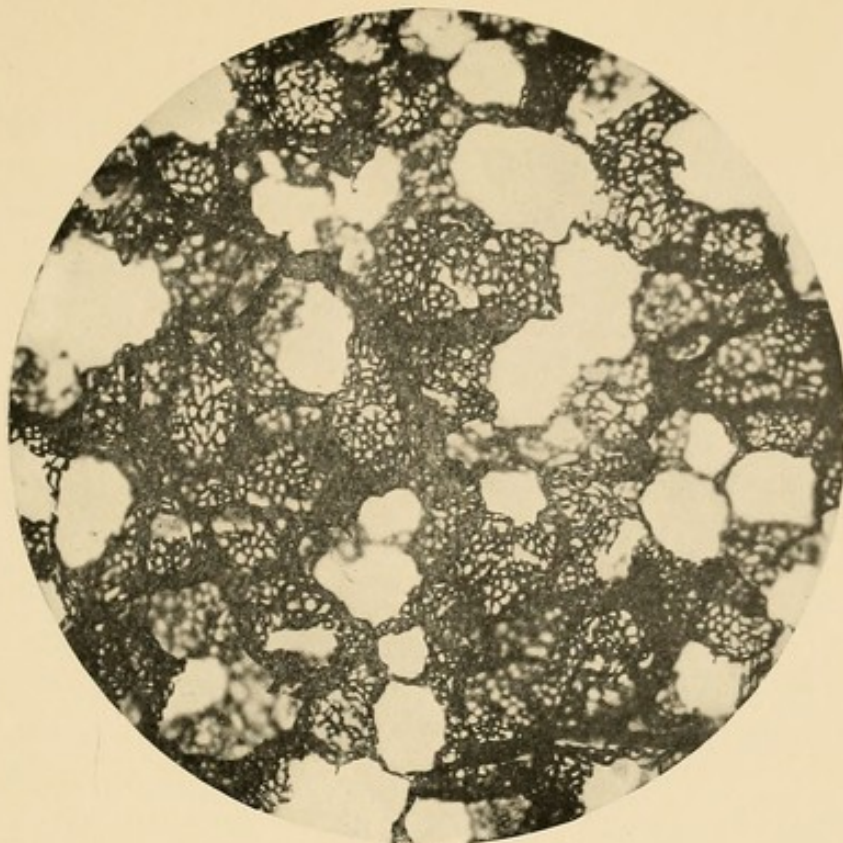
THE lungs are thin membranous sacs, attached to the trachea. There are two sacs, known as the right and left lungs, made up of the ramifications of the bronchi, blood-vessels, nerves, and lymphatics, held together by areolar tissue.

The external framework of the lungs consists of the pleura and the trabeculæ sent down between the lobes and lobules. The right lung is shorter and broader than the left, and has three lobes, divided by two fissures; the left has but two lobes and one fissure.

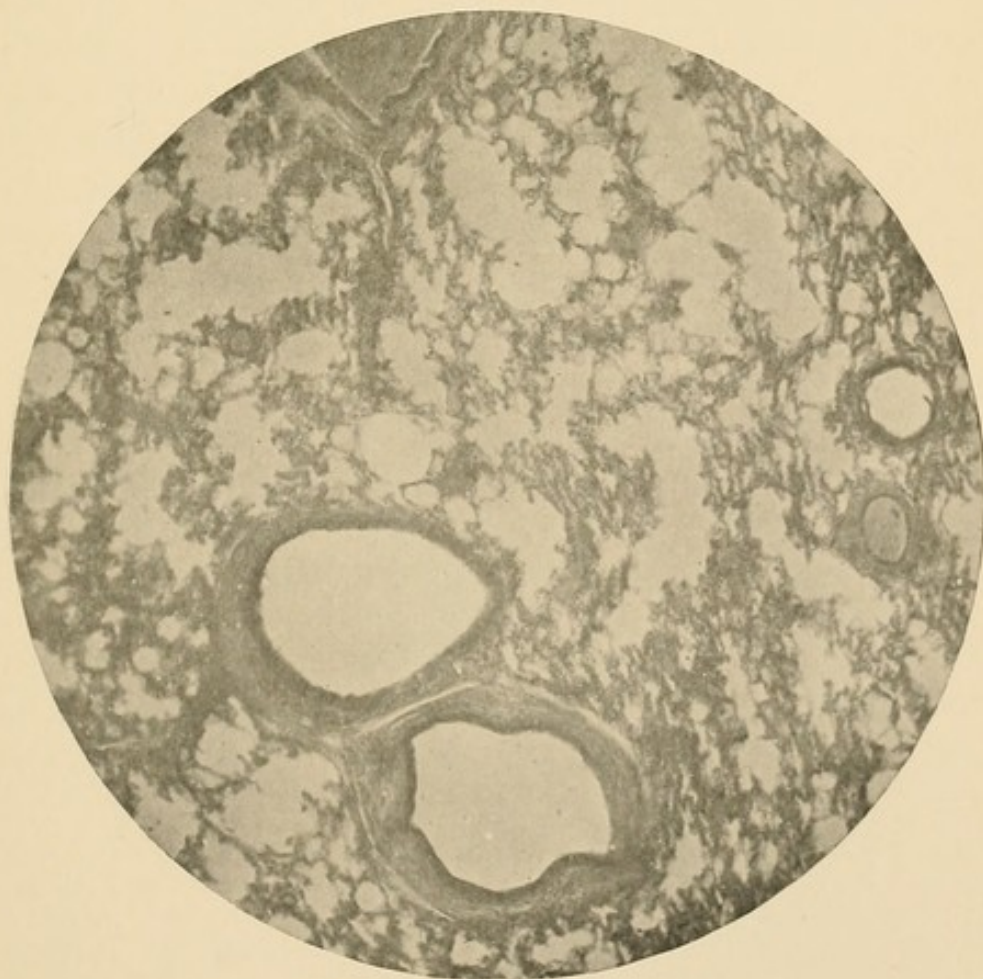
The pleura is formed of two layers, the external, a fibrous membrane, covered by large, flat, transparent, endothelial cells, and the subserous, or second layer, formed of loose areolar tissue, containing many elastic fibres, and in the lower animals non-striated muscular fibres.

The pleura has a lymph system which communicates with that of the sub-pleural alveoli on one side, and by stomata with the pleural cavity on the other.

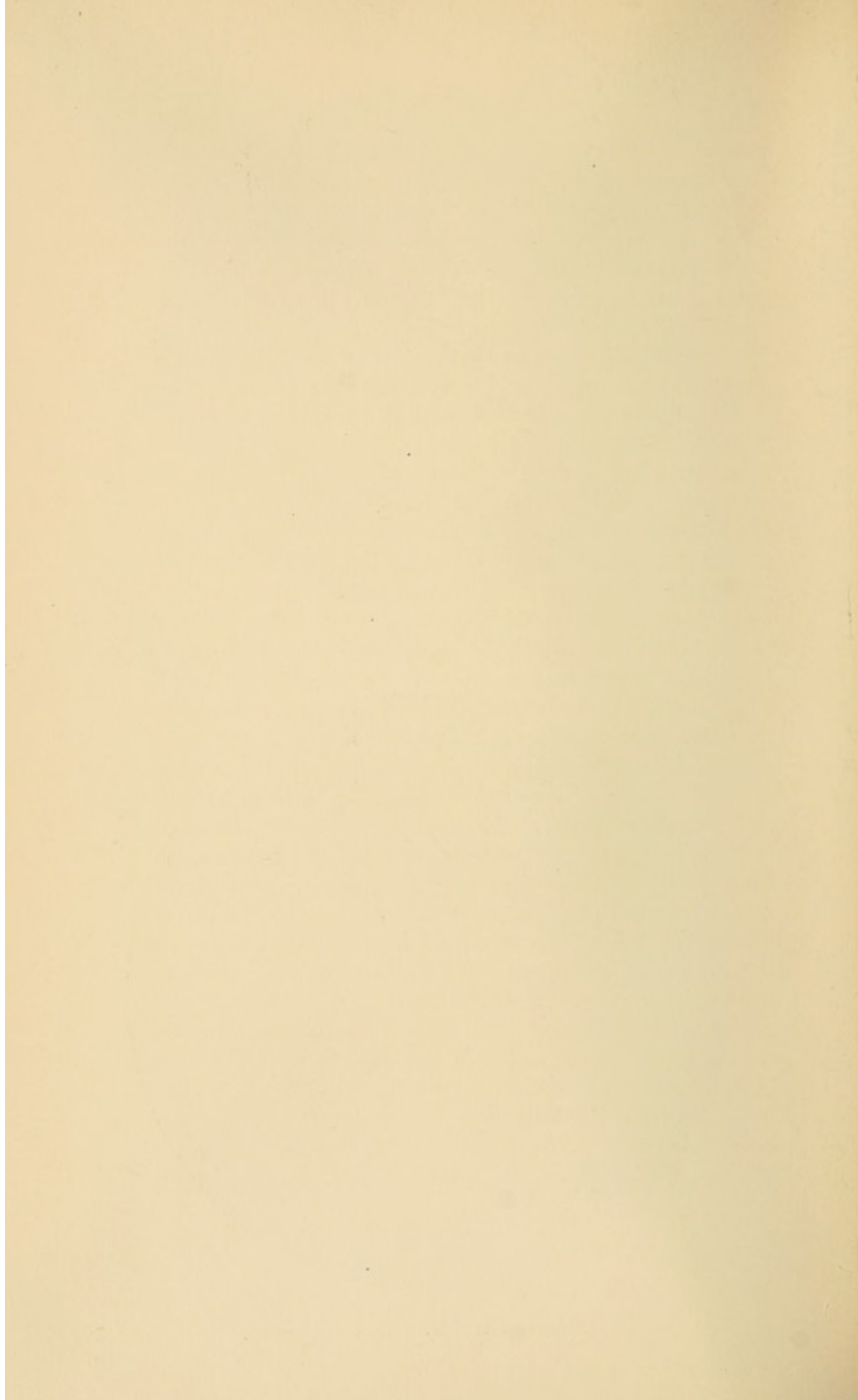
The bronchi (properly *bronchia*—*Βρόγχος*, the old Greek word from which the modern term is derived) have their origin at the tracheal bifurcation opposite the third dorsal vertebra, and terminate in the pulmonary lobules, which are miniature lungs themselves. The primary tracheal branches are called the right and left bronchus. The right bronchus is shorter, larger, and more horizontal than the left, and enters the lung opposite the fifth intercostal vertebra, while the left bronchus enters the lung opposite the sixth dorsal vertebra, or



X 160.
SECTION OF INJECTED HUMAN LUNG, (Showing Air
Cells).



X 160.
SECTION NORMAL HUMAN LUNG.



two inches below the right. (Charles Carey, "Anatomy of the Bronchus.") In sheep the left bronchus grows from the trachea direct.

The *sæptum bronchiale*, which separates the right and left bronchi, is placed to the left of the longitudinal axis of the trachea; this is, perhaps, why foreign bodies lodge more frequently in the right bronchus.

"Monkeys have an accessory lobe called the azygos lobe. This is supplied by an accessory bronchus which arises from the right bronchial trunk near the point where the first branch is given off." (W. S. Miller.)

Hyrtl says that post mortems on babies dying after a few respirations show that the right lung respire before the left; he claims that this is due to the difference in size and location of the point of origin of the right bronchus.

The right bronchus sometimes divides into three branches; small branches are also sent at times from the main trunk. When the bronchi, in their ramifications, dwindle to about $\frac{1}{120}$ of an inch, they enter the apices of the pulmonary lobules; branching again at acute angles, they dilate slightly, forming the *infundibula vesica*.

The bronchi are hollow cylindrical tubes, and throughout the greater part of their extent exhibit the characteristics of the trachea. They are formed of four layers, an external fibrous, a muscular, an internal elastic, and a mucous layer. The external layer consists of a dense network of connective tissue, in which are rings of hyaline cartilage. These are disposed in broken rings in the primary bronchi, held together by fibrous bands; the rings are completed by bundles of unstriped muscular fibres attached by microscopic tendons to the ends of the rings, which by their contraction increase the curvature of the cartilages and thus diminish the calibre of the tube. The right bronchus contains a less number of these cartilages than the left; as the distance increases from the trachea the cartilages gradually lose their ring-like shape,

becoming smaller and less frequent, until they finally disappear, but the fibrous layer still continues to form the external coat.

Within the fibrous coat just described is the muscular coat. It consists of separate bundles of unstriped muscular fibres disposed transversely to the tube. It is better developed in the intervals between the cartilages than just beneath them. The muscular coat becomes better and better developed as the cartilages disappear. This muscular coat continues to the final branching of the bronchioles to form the alveolar passages. Here it develops into a sort of sphincter at the point of entrance to the alveolar passages. The function of this layer is to narrow the calibre of the tube. The contraction of the bronchioles is, perhaps, for the purpose of expelling collections of mucus that the ordinary ciliary and expiratory efforts cannot dislodge.

Under the muscular layer and the mucous membrane are found bundles of elastic tissue. It is this layer which produces the wavy, corrugated appearance on transverse section. Extending through this layer and also through the muscular layer in the bronchial tubes containing cartilages are the muciparous ducts. The mucous crypts are found in the external fibrous layer, principally in the intervals between the cartilages. The mucous layer loses its character in the ultimate tubules and comes to resemble the lining membrane of the alveoli.

The bronchial arteries have their origin in the thoracic aorta. These arteries, after having received branches from the first intercostal and internal mammary arteries, closely accompany the subdivisions of the bronchi. They supply the walls of the bronchi, the pulmonary vessels, the lymphatic glands, and the connective tissue of the lungs. They terminate with the respiratory plexus. The corresponding veins empty into the *vena azygos* and the *vena pulmonalis*. The venous radicles from the ultimate bronchioles empty into the

vena pulmonalis and the arterial branches into the *vena azygos*. Hence in all operations involving the bronchus, the latter should be ligated transversely, whether it be transverse to the lung or not.

The lymphatics rise from the alveolar sæptum. They communicate directly with the alveolar cavity by stomata in the alveolar walls. The lymphatics form a plexus in the submucous tissue accompanying the branches of the bronchi, as well as the pulmonary veins and arteries, emptying finally into the bronchial glands at the roots of the lungs. They often present a gray or black speckled appearance from the absorption of pigment or foreign bodies.

The pulmonary plexuses are formed from branches of the *vagus* and *sympatheticus*. The filaments of these plexuses follow the ramifications of the bronchi, and finally become lost on them in the parenchyma of the lungs.

The sensibility of the bronchi is thought to be slight, especially in the smaller branches, because consumptives make little complaint. But the destruction wrought in tuberculosis is so thorough that the nerves are included in the fell process.

It now remains to describe the alveoli. These are irregular dilatations into which the alveolar passages terminate. They even remain partly dilated after death, until the thoracic cavity is opened and they are subjected to the pressure of the atmosphere. Their walls are the continuation of the infundibula and consist of very thin connective tissue, within which greater or smaller bundles of elastic fibres are scattered. They also contain the black masses known as lung pigment. This pigment is not melanin, but foreign particles from the atmosphere which make their entrance into the alveoli during respiration. In wild animals in their native state this pigment is never found; it is only present after they have been brought to the dusty and smoky habitation of man.

The lung receives its blood supply from two systems, the bronchial and the pulmonary. The former has been already described.

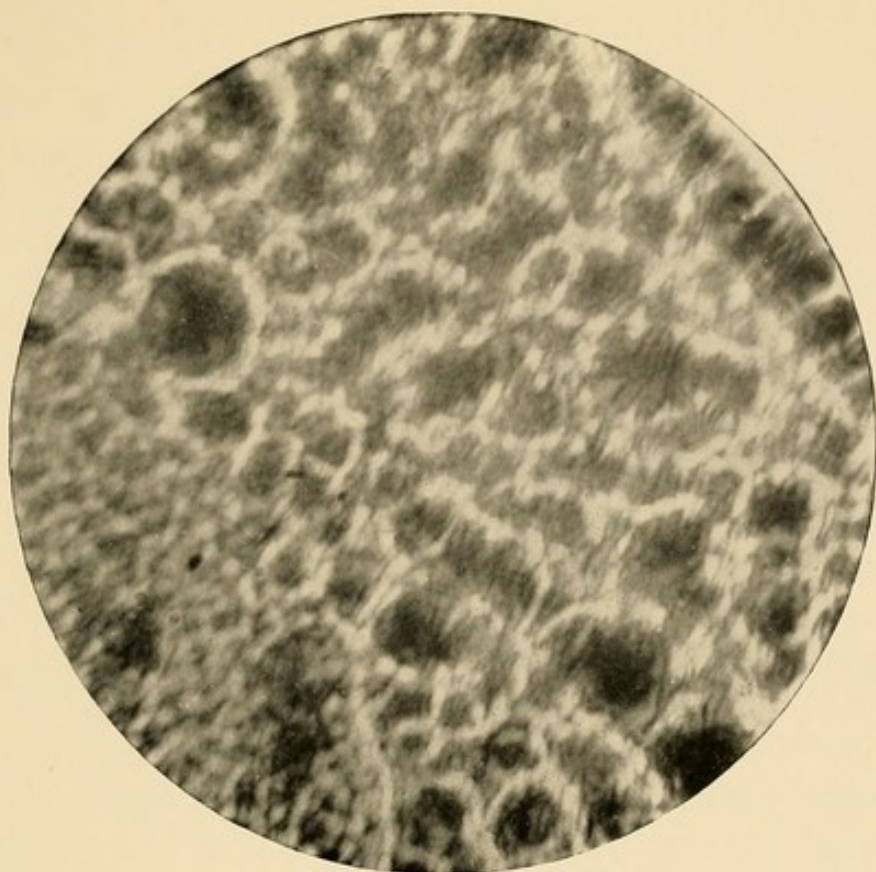
The larger pulmonary arteries and veins are situated in the intralobular connective tissue. They subdivide into minute vessels, each encircling an alveolus, and then split up into a very fine capillary network, only separated from the air by the exceedingly thin alveolar membrane. Only a single mesh of capillaries exist in an inter-alveolar sæptum.

Malpighi (1661) was the first to discover in the lungs and mesentery of frogs the capillary circulation and lung-cells. In Reptilia, only one surface of the capillaries is exposed to the air, while in man the arrangement is such that all sides of the capillaries are so exposed.

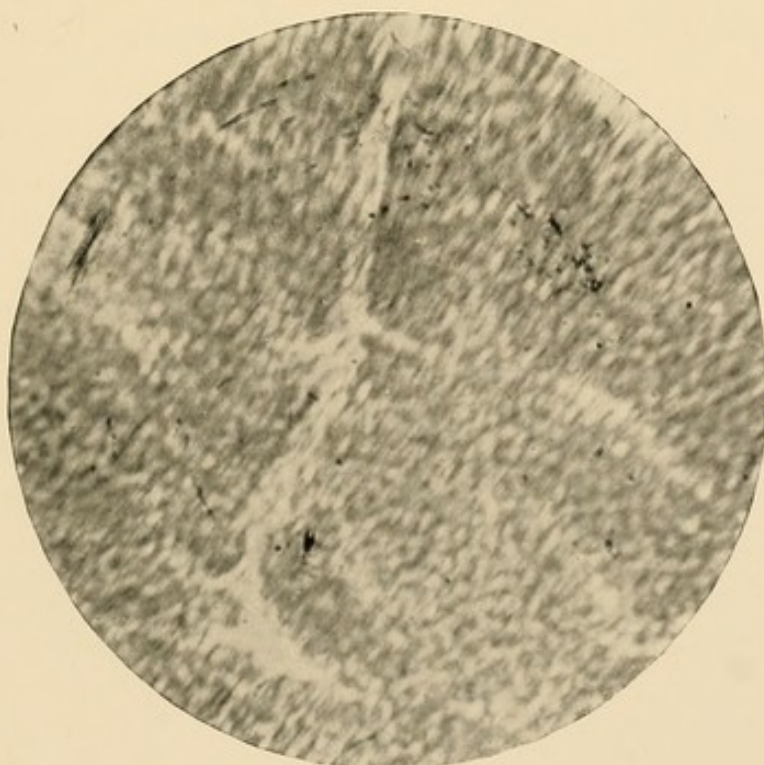
The pulmonary veins have their origin in the inter-alveolar sæptum, uniting gradually to form larger and larger branches. They accompany the bifurcations of the bronchi to the hilus of the lungs. There is one peculiarity, that the vascular area of the pulmonary veins is narrower than that of the corresponding arterial, being an exception to the rule.

The lung is richly supplied with lymphatics, there being three systems, all of which intercommunicate freely. The first system, peribronchial, has already been described. The other two begin in the lymphatic canicular system, connecting the various alveoli. The subpleural take their origin from those in the subpleural alveoli, and with branches from the pleural system, terminate partly in the bronchial glands at the hilus, and partly unite with the perivascular lymphatics in the interlobular connective sæptum. The perivascular system has the same origin as the subpleural, and following the *arteria pulmonalis*, terminate in the bronchial glands. All three systems have valves situated in slight saccular dilatations.

The nerves of the lungs have their origin in the pulmonary plexuses, which are formed of branches of the pneumogastric

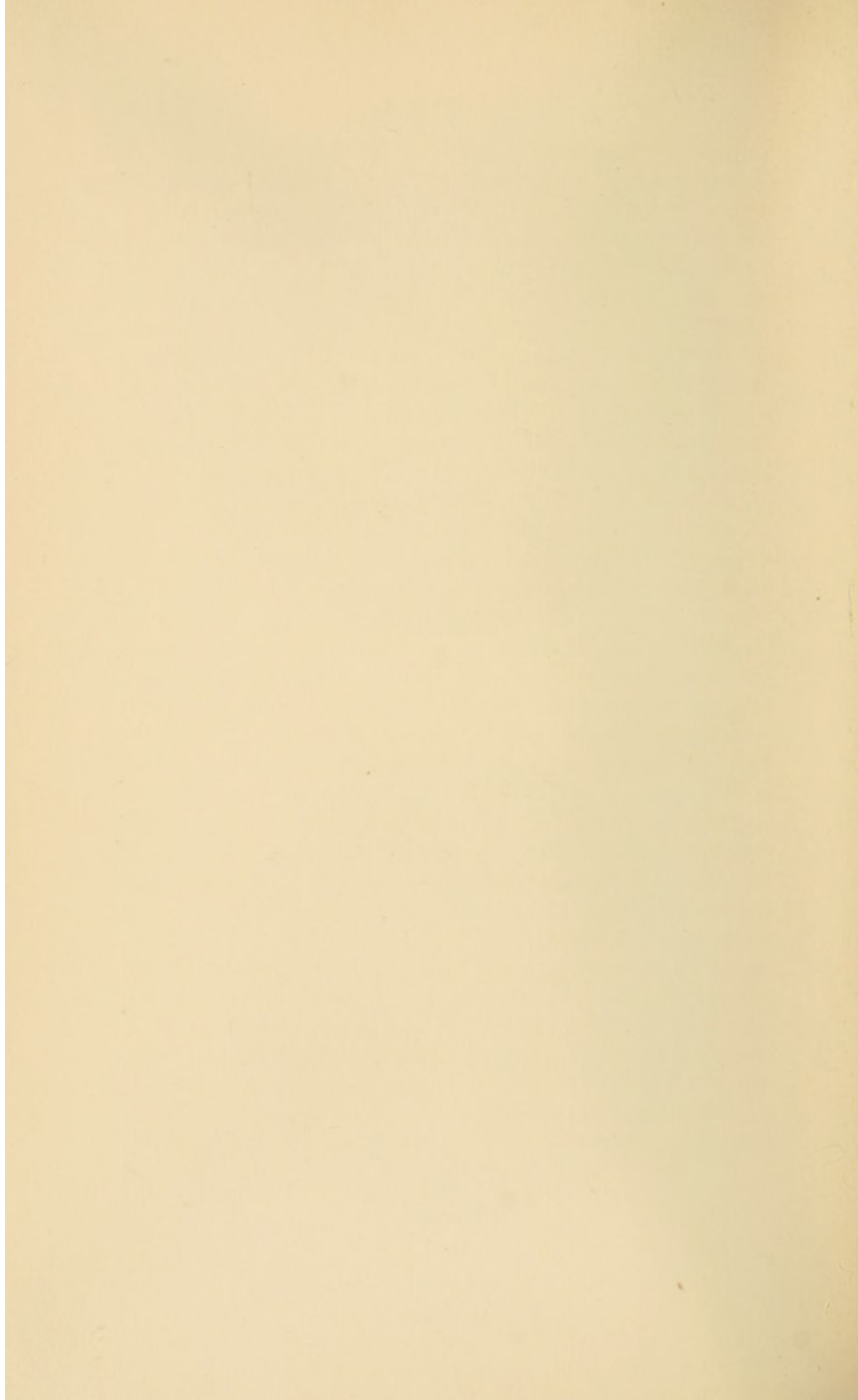


X 60.



X 40.

SECTIONS OF NORMAL LUNG OF A WATER DOG,
(*Necturus Lateralis*).



and sympathetic. They enter the lung with and follow the divisions of the bronchi. Both medullated and non-medullated nerve fibres containing numerous small ganglia exist in bundles. They are distributed to the blood-vessels and walls of the branches.

Pathologic changes in the lungs tend to produce cicatrices. When any of the bronchioles are cut off by disease or cicatrices, that portion of the lung beyond the cicatrix, which is directly connected with the severed bronchus, becomes useless. This is true even if the lung tissue be itself in a healthy condition. Therefore, there is a loss of capacity after every accident or disease that causes loss of lung tissue.

In 1894 Meckel published his report on the apparatus of respiration, and in 1895 appeared Boruttan's report of the examination of the lung nerves. This, apparently, is one of the neglected fields of human knowledge and scientific investigation.

Notes.—The lung of the “mud-puppy” or “water-dog” (*Necturus lateralis*), consists of two elongated, cylindrical bodies. Both the outer and inner surfaces are smooth. There is both an arterial and venous system. These are so arranged that each vein is at right angles to the corresponding artery.

The lung in snakes (they have only one) is an elongated, cylindrical body. It is smooth two-thirds of its length. The posterior third is divided into numerous air-cells which communicate with a central cavity. There seems to be no communication between the air-cells.

In birds the lungs are attached closely to the ribs. The bronchus after penetrating into the lungs, breaks up into numerous tubular passages. These passages are not true bronchia, since the alveoli, or true lung structure, arise directly from them. The principal bronchi communicate by large rounded openings with large air-bags situated in the abdomen and in the hollow bones. These air-bags should

be considered as part of the lungs, as they are directly connected with the bronchi. The air-sacs do not communicate with one another.

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CHAPTER II

ABNORMALITIES

THAT congenital abnormalities of the lungs should be properly considered from a surgical point of view, it is necessary that all such defects of the thoracic viscera should be reviewed. As a rule, a congenital defect of one destroys the landmarks of all of the thoracic viscera. The diaphragm may have its attachments higher or lower than commonly described, while the mediastinal space may be entirely obliterated, congenitally, or by subsequent irritation. The pericardium, while never having been found absent, may be very much thickened, adherent, and malpositioned.

The pulmonary vessels, both arterial and venous, are perhaps more frequently malformed than is generally supposed, while the bronchus in one or both lungs has been found absent. The absence of one need not result in death. The bronchi are also prone to malposition, indeed, they are subject to as great a variety of anomalies as the blood-vessels themselves.

The bony chest may vary from the normal formation, and thereby displace one or all of the thoracic viscera.

Any one or all of these abnormalities may be congenital, or acquired by injury, or the formation of new tissue, such as the benign or malignant growths, cysts, fluid, or foreign bodies of any character within or without the chest cavity. Malposition of the thoracic viscera is especially to be found in caries of the dorsal vertebræ. It is, therefore, important that these conditions should be thoroughly considered be-

fore attempting any operative measures upon the lung, for the adoption of such measures is far more important in abnormalities than in normalities.

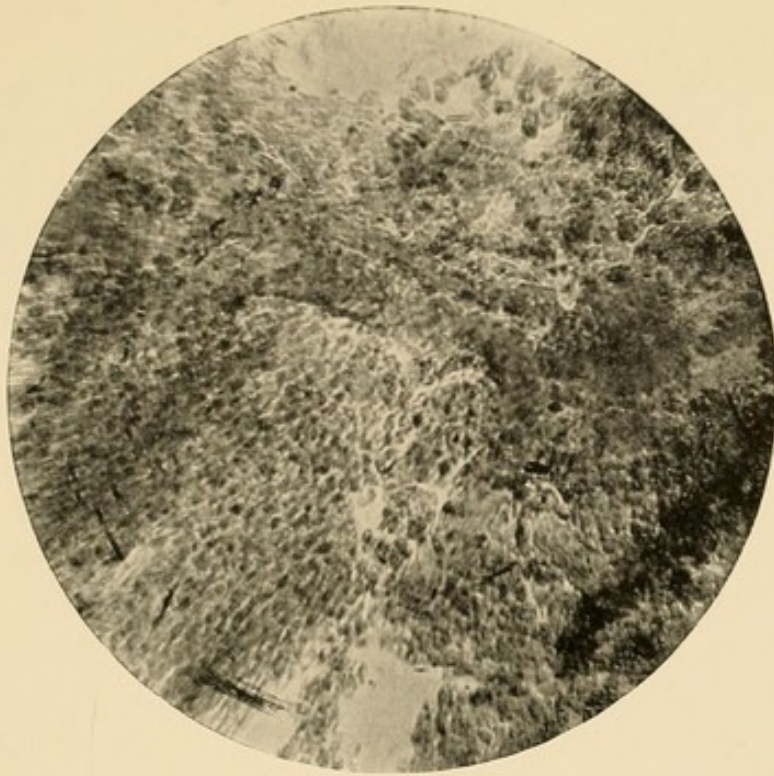
Historical (1783-1903).—Tichomiroff reported a case of congenital absence of the left lung, which was found in a woman twenty-four years old, who died of pneumonia. He also mentions four cases of absence of left lung in men. There can be no reason assigned why the left lung should be oftener absent than the right. Necropsy in the case of the woman revealed no difference in the vagi of the two sides. A left superior vena cava was present, while the left thymus was larger than the right.

(The left lung in snakes is rudimentary. See notes at end of chapter on anatomy.)

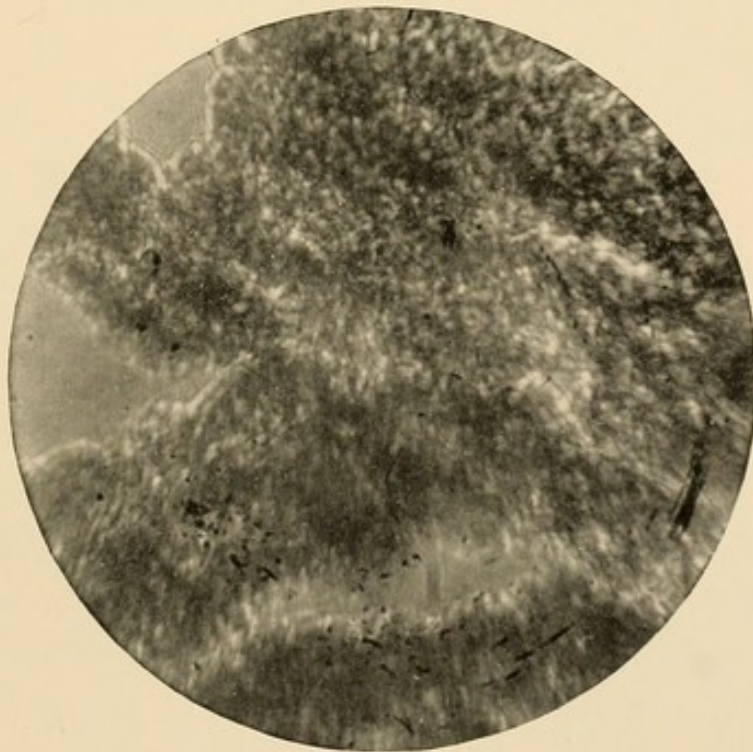
One or both lungs may be absent in man or animals, or they may be partially developed, or converted into numerous sacs containing air and serum, and connected with one or more bronchi. (Delafield and Prudden, "Path., Anat. and Hist.," 1892, p. 354.)

Kirsch (1889) reported an interesting case of irregular formation of the lung, while Wollman (1891) mentioned a similar condition. Schmidt (1893) described a pathological lung, while Hoffman (1783) reported a case of diaphragmatic junction with the lungs. Boca (1852) reported the complete separation of the two lobes of the lung. Thomson (1886) collected cases of thoracic defects, and states that there may be rupture of lung, not hereditary, but probably due to the pressure of the arm against the chest.

Pavy gives a very remarkable case of sternal fissure in a young German twenty-five years old. There was a longitudinal groove outlined with a hard ridge, which articulated with the costal cartilages instead of a sternum. Alderson gave a report of a case of diaphragmatic hernia with symptoms of pneumothorax, which ended fatally. Gibson and Malet reported a case of præsternal fissure uncovering the



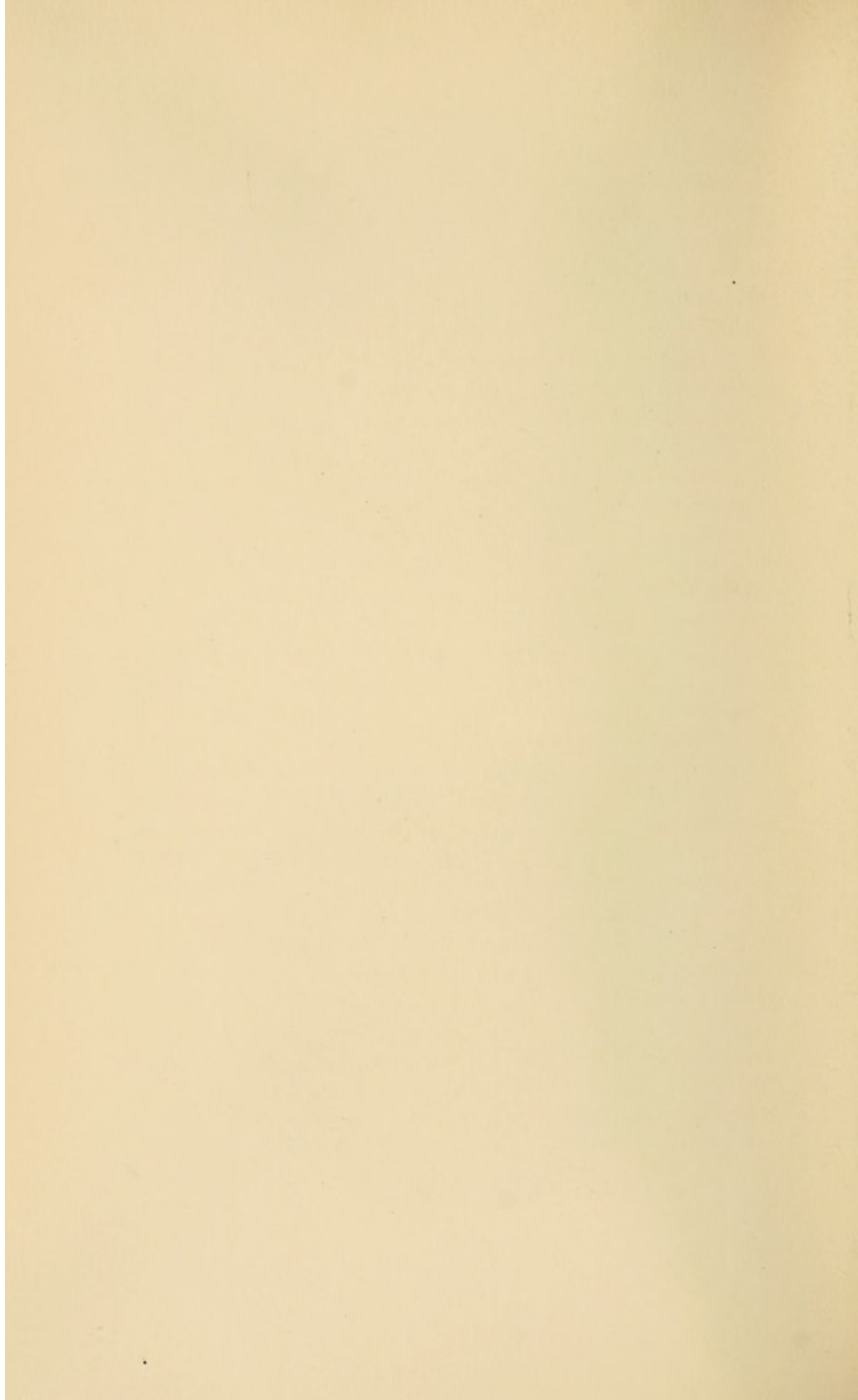
X 40.



X 40.

SECTIONS OF NORMAL LUNG OF A BLACK SNAKE.

(Anatomy of the Lung.)



base of the heart. Chene (1870) gives an account of a supernumerary lobe to the right lung.

Dicky (1870) published an account of malformation of the lung. Tyson (1872) reported a case of congenital deficient left lung. Collins, in 1874, published a case of accessory pulmonary lobe of the *vena azygos*, and Hodges published a case in which there was exstrophy of the heart through the fissure.

Testut and Marcendes gave a description of a lung with six lobes. Humphrey (1884) reported a case of an accessory lobe to the left lung. Thermin (1884) reported cases of the congenital absence of the left lung. Madden reported the case of a Swede, forty years old, with congenital absence of middle of the sternum, leaving a fissure $5\frac{3}{8}$ inches long. Edwards (1885) reported an anomalous lung (human) having four lobes on the right side, and much valuable material was given in Maylard's (1885) article on the abnormalities of the human lung.

Lukin (1885) reported two cases of entire absence of the lung. Lamb (1886) published an account of anomalous lobation of the human lung. Kirsch (1889) published a report of congenital *pulmonalostien-stenose*. Wollmans and Schmidt also give interesting reports. Rheinhold (1893) and Bowles (1893), report the finding of four lobes on the right side. Motti (1893) published a case of rare anomaly of the lung. Tichomiroff, Durck, and Eckley (1895) mention accessory, anomalous or abnormal cases of lobation. Bouchard reported a case of absence of the right half of the diaphragm in a newborn child, while Berchon reported a double perforation of the diaphragm with hernia of the epiploon.

Lawrence (1896) reported a case of abnormal lobe. Dumerin, of Lyons, showed an infant of eight days which had arrested development of the second, third, fourth, and fifth ribs. Carper found a foetus of thirty-seven weeks in which there were no lungs, only a voluminous thymus gland.

Wister (1897) gave an account of a person in whom one

side of the thorax was at rest, while the other performed the movements of breathing in the usual manner. Diemberbroeck is reported to have dissected a human subject in whom the diaphragm and mediastinum were apparently missing. Schafer (1898), Matthews (1898), and Springer (1898), each mention the same anomalous lobation of the human lung.

Herxheimer, *Central f. d. med. Wiss.*, Leipsic, July 1, 1901, mentions an autopsy of a three-weeks'-old infant in which bifurcation of the trachea was noted, and a third lung was discovered communicating with it by a separate bronchus. All three lungs had fatal catarrhal pneumonia.

Three cases of rudimentary lungs have been recorded, but this was the first in which they had actual functional connection with the trachea.

These reports of anomalies illustrate the fact that deviation from the normal in structure is not necessarily inimical to life, and also prove that deviation from the type is as frequent in the genus *Homo* as in genera of the lower orders. In fact, the higher the order and genus, the greater the frequency of anomalies, and the greater the deviation structurally from the type.

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CHAPTER III

EXPERIMENTAL RESEARCH (1795-1903)—INFLUENCE OF TRAUMA ON THE LUNGS AND HEART

MORE than a century ago attention was turned to the experimental study of the lungs. Davidson's observations on the anatomy and pathology of the pulmonary system in 1795 mark the first recorded step in this direction. Some little time elapsed before Harlan, in 1819, showed by experiments on living animals, that the circulation of the blood through the lungs is immediately and entirely suppressed during expiration. Carson gave science the result of his researches on the elasticity of the lung in 1820. In 1832 appeared Gaste's historical *résumé* of the principal discoveries upon the structure and functions of the lungs. This is very valuable, especially to those interested in the history of medicine, and it is none the less so because of the practical observations embodied in it.

The next step forward was by Schützenburger, who, in 1832, published his studies on the physiological effects of certain dynamic lesions of the lungs. Rossignol, in 1848, gave the result of his researches on the respiratory organs of man and the principal mammals, thus completing the work of T. Addison on the anatomy of the lungs, and that of W. Addison on the ultimate distribution of the air passages, and the formation of the air-cells in the lungs.

Certain problems were solved in 1847 by Sappy in his great work on the respiratory organs of birds. Cauman, in 1848, showed that the capillaries of the lungs do not anasto-

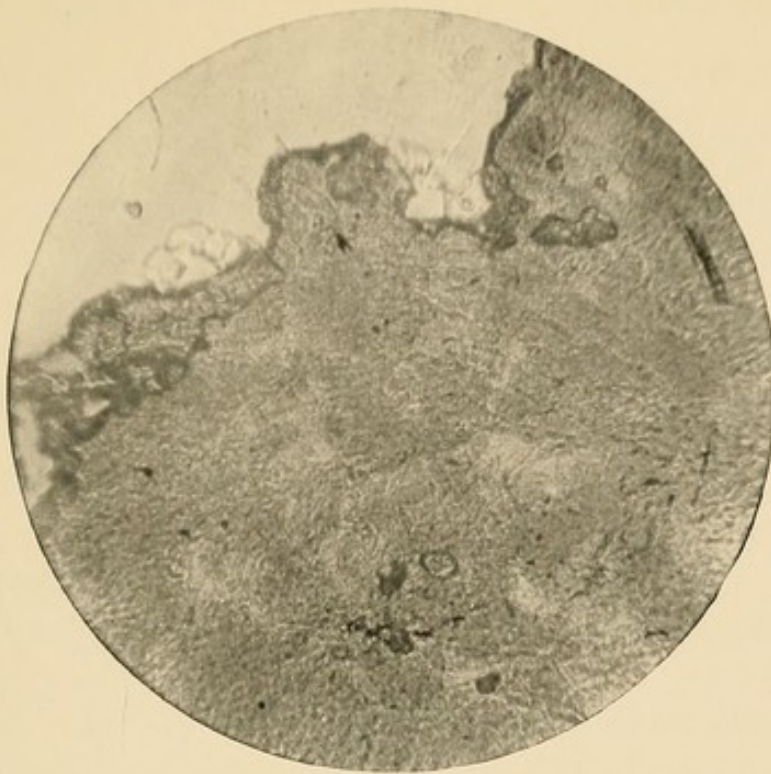
mose. Le Fort, in 1858, devoted himself to the study of the anatomy of the human lung. Waters investigated the ultimate structure and distribution of the blood-vessels of the human lung.

Bert, in 1869, brings us back to pure science by his work on the elasticity and contractility of the lungs, and the connection of these properties with the pneumogastric nerves. Brown's article on the alveoli of the lung containing squamous epithelium is a most concise one, and offers many suggestions concerning the repair of the lung tissue. D'Arsonval's researches (1887), theoretical and experimental, upon the part played by the elasticity of the lungs in the phenomenon of circulation should be consulted.

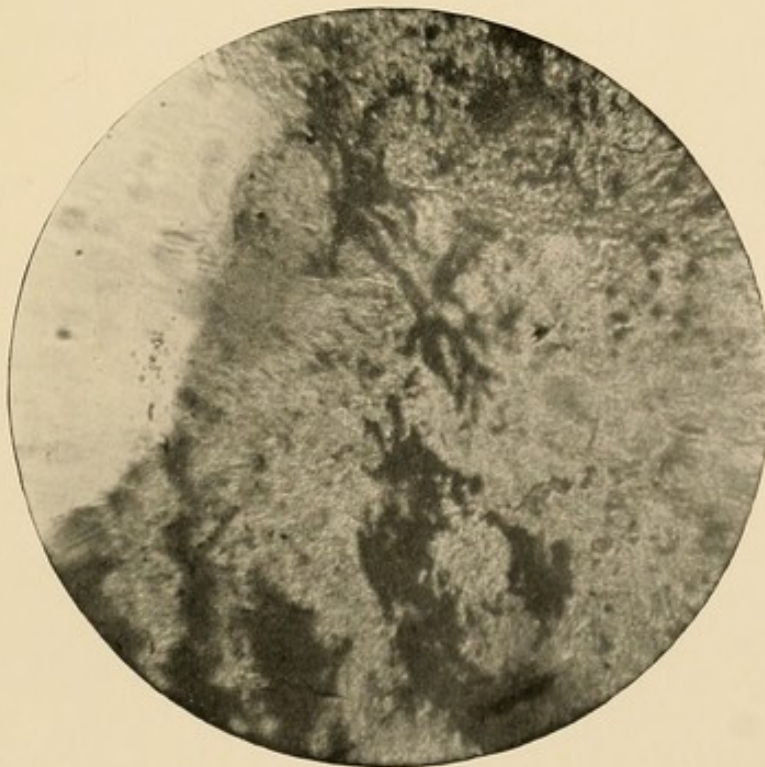
Grehant (1879) brings us to the employment of physics in physiological investigation, by his study of endosmosis of gases in the detached lung. Casse, previously, had given the results of his experiments on the absorption and elimination of gas by the internal organs of animals. Heger (1880) followed with his researches on the circulation of blood in the lungs. Roy and Brown (1885) showed that the bronchi contract under certain conditions.

Gage (1885) showed the value and necessity of histological investigations, by his paper embodying the result of his study of the structure of the respiratory membrane in the pharynx of the soft-shelled turtles. The important work of Lamb (1886) showed that anomalous lobation of the lung is not infrequent, while the normal position of the lungs is a little more than an inch above the first rib. Cruveilhier was the first to show by the dissection of a foetus that one or both apices may extend along the cervical spine.

Here it may be remarked, that the fact that the pericardium has never been found absent, should be remembered in eliminating its absence in herniated lung of the left side; it should also not be forgotten that the lower costal cartilages on the left side in women are rare. The cervical ribs are also



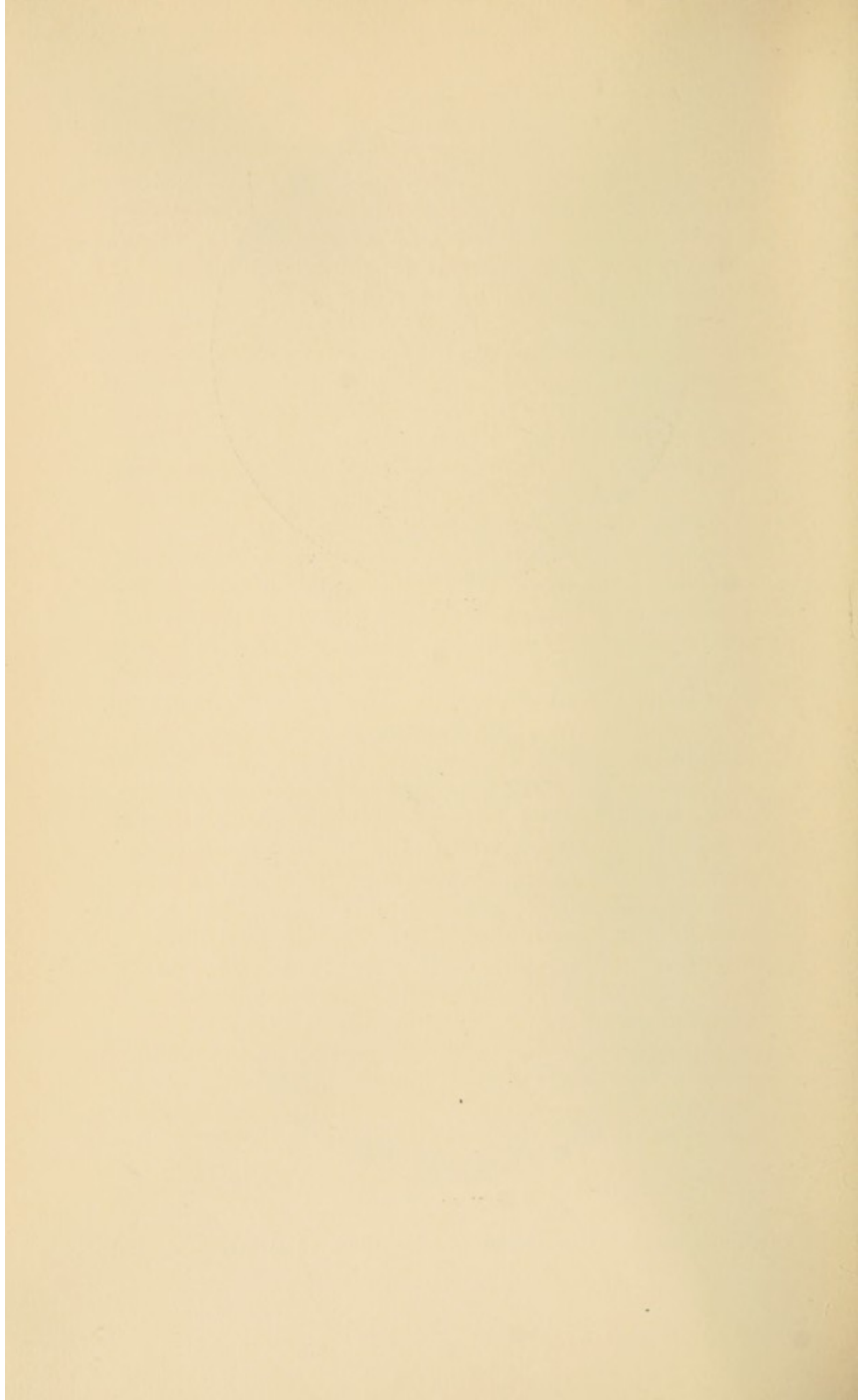
X 40.



X 40.

SECTIONS NORMAL LUNG OF A BIRD, (Martin).

(Anatomy of the Lung.)



rare, as shown by post mortems; there are but two cases reported clinically.

It is only in comparatively recent times that experiments have been made on the excision of the lung. Richard (1880) reported a penetrating wound of the thorax with immediate pneumocele. Excision of the lung was employed in this case, and the patient recovered. Schmidt (1881) gave the result of his experimental studies on partial lung resection; Block (1881) also made similar researches.

In 1881 appeared Marcus's researches upon the experimental extirpation of the lung. Biondi followed with his reports on the same subject, and in 1884 published the results of the extirpation of the lung, following the experimental localization of a tubercle.

Récherches expérimentales et critiques sur l'absorption et l'exhalation pulmonaires are none the less interesting because Pagenstecher (1895), by his work upon rabbits, disproved those of Eintrich (1854), in which the latter found that blood introduced into the pleura would become absorbed without pleuritic adhesions after the eighth day.

Mechanical injuries of the lung due to manipulation, contusion, stab wounds, gunshot wounds, et cætera, on the whole seem to affect the heart more than the respiratory organs. There is great difficulty in making satisfactory observations on this point. Some observations showed very marked "Vagel" heart beats on pinching the lung with the fingers. (Crile, "Surgical Shock," 1899, p. 129.)

Mammals have a diaphragm, but the amphibia and lower orders of animals do not. (Byron Robinson, "Peritonæum," 1897, p. 120.) Pinching the lung near the base of the heart produces irregular heart and a slight decline of the blood pressure. (Crile, "On Shock," 1899, p. 80.) The rhythm of the lung is controlled by the peripheral ganglia, or the automatic pulmonary ganglion which is situated in the lung substance.

Crile ("Surgery of the Respiratory System," 2d edition, 1900, pp. 32-33), reports the results of his experiments upon a dog. He gave a blow over the right side of the chest during chloroform narcosis. He found that the respiratory action became irregular, with a marked fall of blood pressure.

Reinboth's (1896-97) experimental study in lung dilatation, Crile's (1899) summary of an experimental research in the surgery of the respiratory system, and Carraras's (1898) mechanism of pulmonary lesions, are the only publications which have appeared in the last few years.

Dr. S. P. Kramer, of Cincinnati, in 1900, injected agar-agar into the pleural cavity to fix the lungs. The success of this procedure encouraged him to inject it into hernial sacs to prevent recurrence of the hernia. There has not been sufficient time since to determine just how successful this method has been. But enough is known to urge him to carry on his experiments. Dr. Kramer claims that not only is the agar-agar absorbed, but there is evidence from microscopical examination that reorganization takes place. The cavity fills with connective tissue, at least there is new cell formation, which in structure resembles connective tissue. (*Annals of Surgery*, August, 1901, p. 273, Vol. XXXIV, No. 2.)

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CHAPTER IV

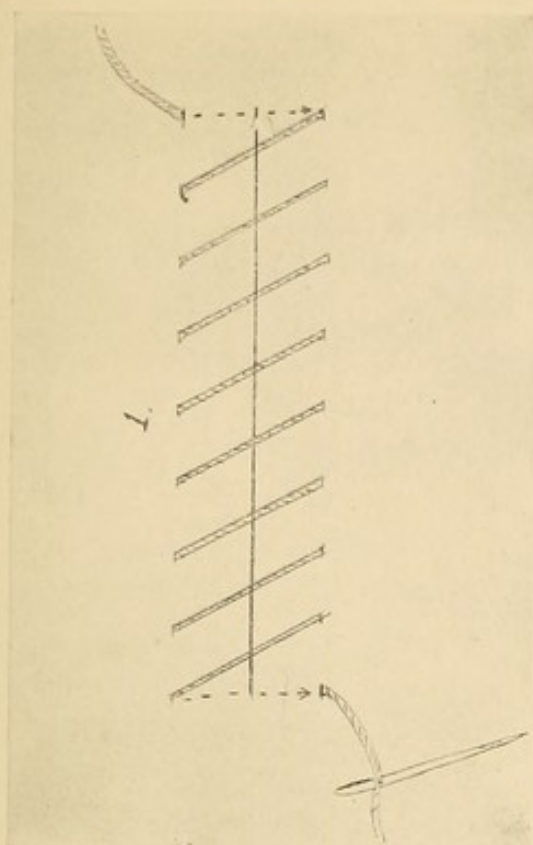
HISTORY OF LIGATURES AND SUTURES

SUSRUSTAS (1500 B. C.) was the first to apply a ligature. He tied the umbilical cord of new-born babies before severing it. A passage in the writings of Hippocrates has been interpreted to mean that the Father of Medicine was familiar with the use of the ligature. Archigenes (100 B. C.) was the first to use ligatures in amputations.

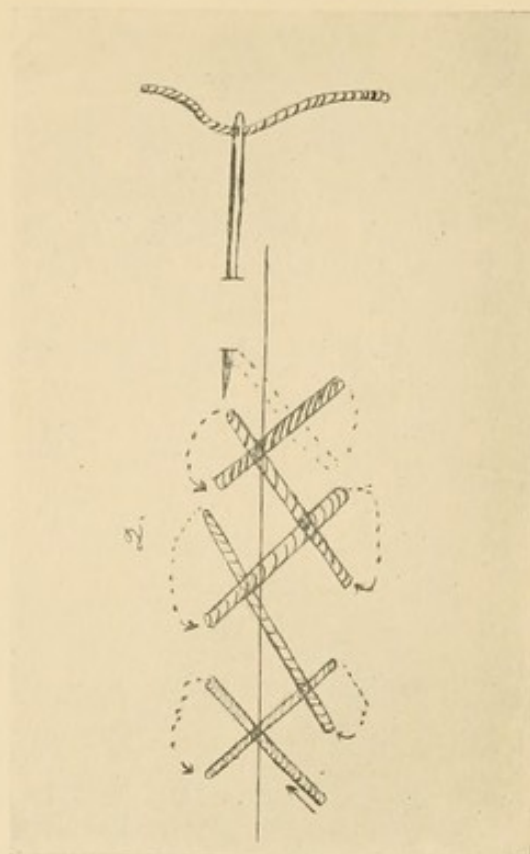
Celsus (30-25 B. C., A. D. 45-50) speaks of the ligature as something well known; he used ordinary linen thread. Galen (A. D. 131-211) advised ligatures to be applied at the proximal end of injured vessels; he favored the use of silk or fine catgut.

Paulus Ægineta (A. D. 625-690) was one of the first to use the double ligature; he passed two ligatures beneath the vessel, which was then cut with a needle, each end of the vessel being closed separately. Jones, in advocating the use of the double ligature, only revived a method which had been practised twelve centuries before his time! Albucasis (died A. D. 1105) recommended that a double thread of silk, or a cord used in instruments of music (catgut), should be employed in ligation, especially in case of large vessels. The use of catgut is not, therefore, such a modern practice as some seem to think.

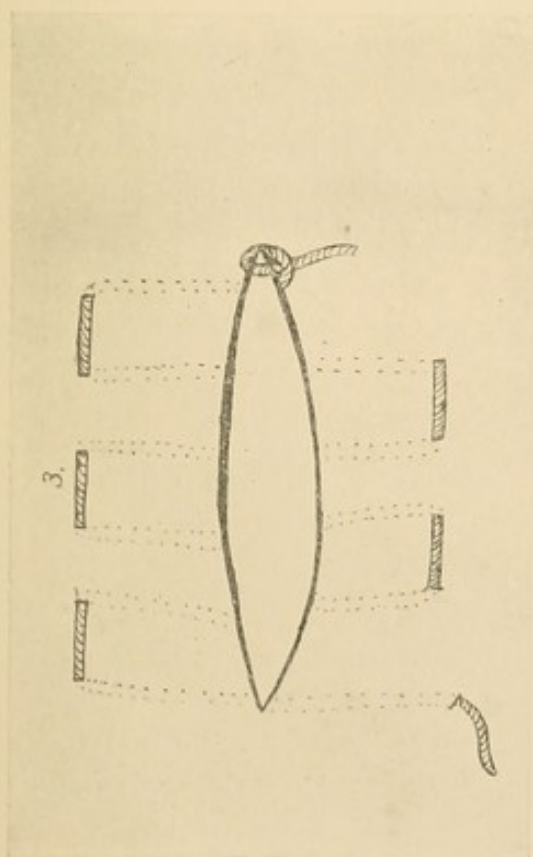
Guy de Chauliac (1300-1363) exerted great influence in the domain of surgery during the dark ages. He taught that the artery should be tied at the end that was nearer the heart or liver. Some of his remarks concerning the sects of his time are apropos to-day. He says: "The fifth sect is of



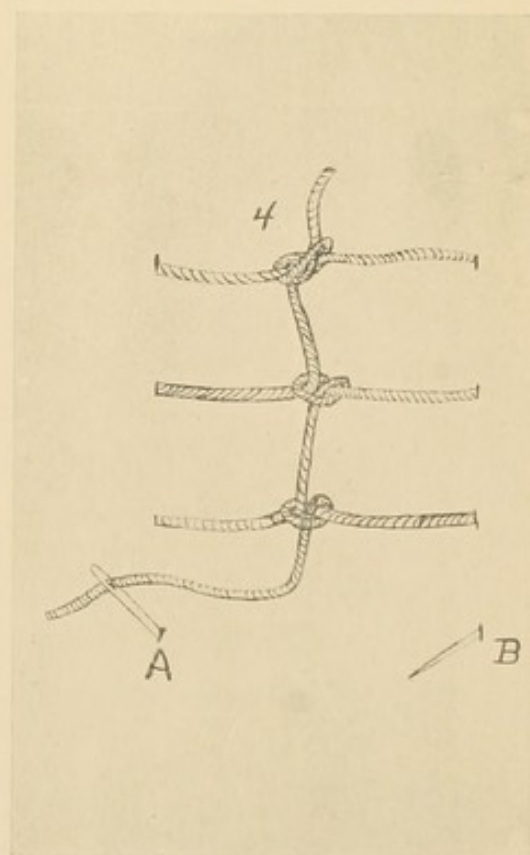
WHIP STITCH.



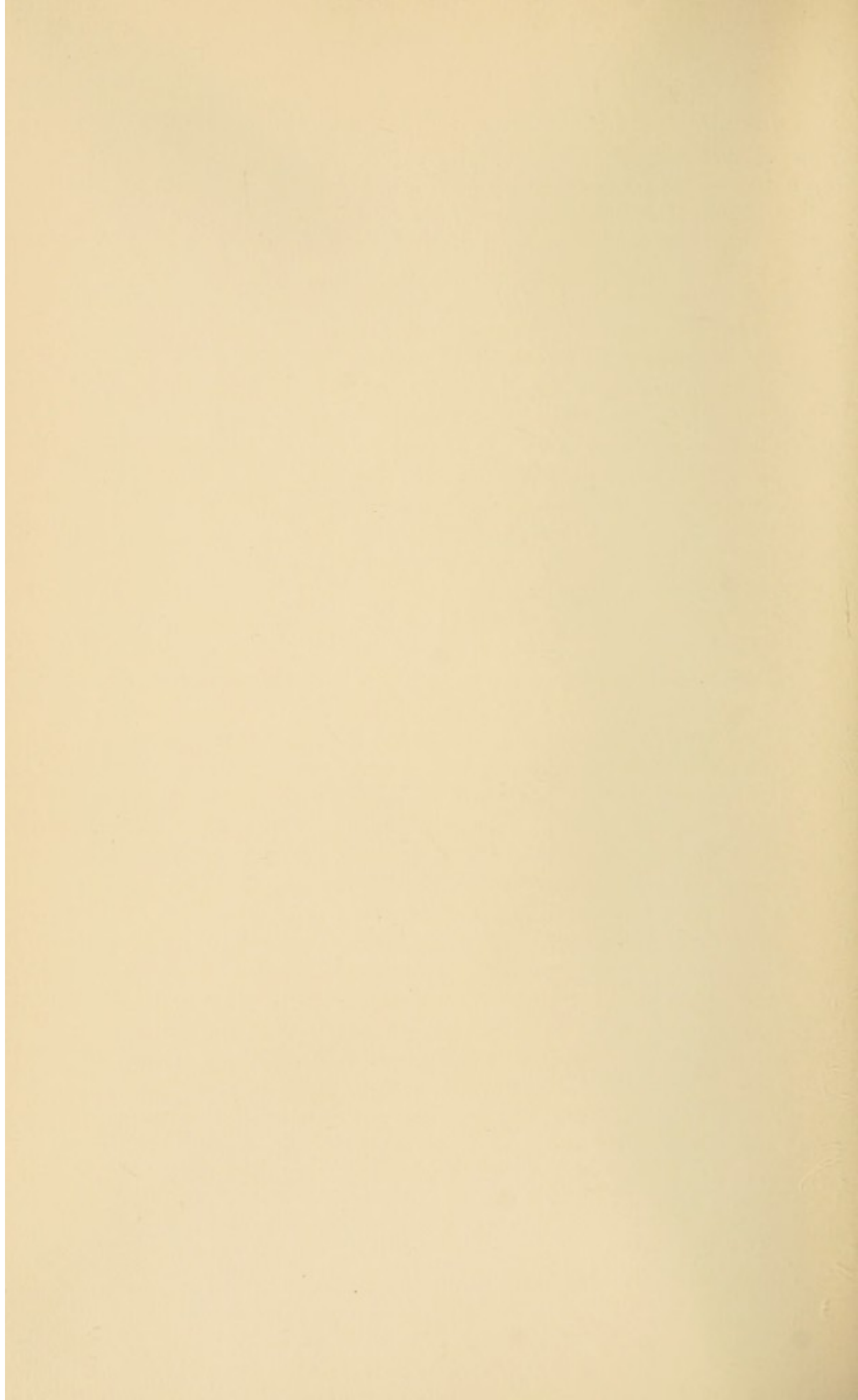
HERRINGBONE STITCH.



MATTRESS OR QUILTED STITCH.



BELL SUTURE.



women and many fools, who refer the sick of all diseases to the saints solely, saying, 'Le Seigneur me l'a donné ainsi le nom du Seigneur soit béni. Amen.' "

Leonardo Bertapaglia (died 1460) passed a needle, armed with a double thread, through the artery, tying both ligatures firmly over each other. Alfonso Ferri (fifteenth century) claimed that the best ligature needle was one curved only at the point, with eye at the opposite end; the point should be quadrangular, and the needle not over three inches in length.

Hans von Gersdorf (1517-1590), a German military surgeon, applied ligatures in cases of vessel wounds, but preferred styptics and cautery for amputations. Ambroise Paré (1517-1590) made free use of the ligature in amputations. But his great authority was not sufficient to secure the abolition of the barbarous treatment by styptics and actual cautery. Such was the power of ignorance and prejudice that these methods continued to be employed at the Hôtel Dieu until the time of Dionis (1718). Paré was the first to use the twisted suture in hare-lip.

Fabricius von Hilden (1560-1634) is said to have introduced the use of the ligature into Germany. Hemp was the material employed by him. In England the ligature did not come into common use until some time after Harvey's great discovery of the circulation of the blood (1619), although introduced some years before by Wiseman (1566-1625). A surgical treatise by Peter Lowe, published in London (1596), is the first English work to mention ligatures.

The old surgeons were haunted by the fear that the ligature would cut through the walls of the artery. Many devices were employed to prevent such accidents. Lorenz Heister (1683-1758) used a stout ligature tied over a small cylinder of lint. All kinds of substances have been used for ligatures in an effort to secure a ligature that would not produce the ill effects of the ordinary ligature. The old German

surgeons used hemp or linen ligatures. These substances are coming in use again; the French are making extensive use of hemp in the Parisian hospitals. P. F. von Walther was the first to propose the use of silk in Germany; but before Lister's great discovery all kinds of material proved more or less unsatisfactory.

The use of the animal ligature was introduced in America by Dr. Physick in 1814. McSweeney brought the employment of silk-worm gut for ligatures into prominence in 1818, although Wardorp had used it some years earlier. Sir Astley Cooper believed that catgut would give the best results. Dr. H. S. Levert, of Mobile, used elastic rubber rings. He also experimented with ligatures made of various metals. He secured primary union in every case in which he used metallic ligatures, or rather, metallic sutures. The expressions used seem to indicate that he sewed wounds with wire.

Human hair was used by Porta. Paul Eve made use of the fibres of the tendons of deer. Dr. Stone, of New Orleans, tied the common iliac artery with a metallic ligature in 1859, and afterward he tied the femoral. Mr. Barwell used ligatures made of the aorta of the ox. He tied the ligature only tight enough to approximate the intima. Dr. Ishigaro, a Japanese army surgeon, used a ligature made from the tendon of a whale.

Marcy (1871) used kangaroo tendon for buried sutures, while Mr. Croft, in 1881, used it for ligatures. He tied the external iliac artery with kangaroo tendon during that year.

Until the end of the eighteenth century the ends of the ligature were brought out through the wound. The practice of cutting the ends short is due to the efforts of Lawrence, although it is said that Haire, of Essex, had practised this procedure in 1786. Lawrence used dentist's silk for ligatures. An American naval surgeon, however, in 1798, adopted the practice of cutting short the ends of the knot. For many years it was held that it was the division of the two inner

coats of the artery which caused the adhesive inflammation that obliterated the vessel. Antonio Scarpa (1747-1832) proved, however, by his experiments, that the division of the coats of the artery was not necessary to produce this adhesive inflammation.

The search for a material that would give the best possible results as a ligature has been the "Philosopher's Stone" to surgeons. The good results that follow the use of a strictly aseptic ligature have been apparent to all, but animal ligatures are claimed by some to be the ligature *par excellence*, while others say that silk or silk-worm gut, or metallic ligatures are the best. Again, others say that any absorbable ligature will produce good results, while still others pin their faith to non-absorbable ligatures. Silk and hemp have been objected to on the ground that they are liable to produce suppuration. Since the discoveries of Lister, Pasteur, and Koch, such objections have lost all force.

The claim has been made in behalf of animal ligatures that they resemble in structure the tissues in which they are placed. For this reason they are the best for permanent ligatures, and also because the continuity of the vessels is not necessarily destroyed. The extra-vascular cicatrix is also strengthened. By the use of the animal ligature the internal tunics of the artery remain intact, yet cicatrization occurs; hence they need to be tied with only sufficient force to approximate the surfaces of the intima. All that can be said in favor of the animal ligature or suture has been found true with kangaroo tendon, but catgut is not reliable. There is great difficulty in securing catgut than can be thoroughly sterilized or that will stay where it is placed, or that will not break at the most inopportune time.

There are other objections to the use of catgut. It has been claimed for catgut that it will not divide the tunics of an artery. Both Brun and Stimson proved by their experiments that it will divide the tunics. Stimson adds that the

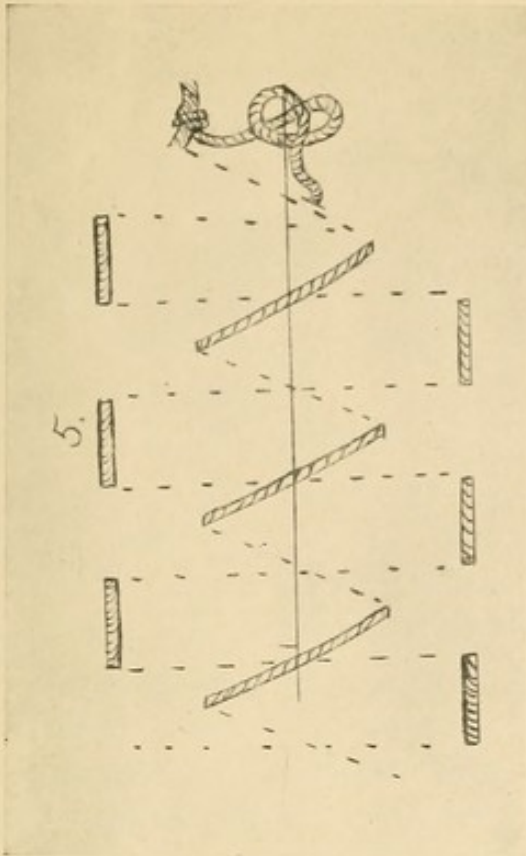
adventitia also gives way under the pressure of the ligature.

Mr. Barwell, who introduced the use of ligatures made from the aorta of the ox, claims that this material is not absorbed, but becomes organized and forms an integral part of the neighboring tissues. Dent claims that his experience with ligatures of this material corroborates that of Barwell. Lister, however, thought they had misinterpreted the process observed. One prominent surgeon says, in reference to non-absorbable ligatures, that "all ligatures, however, which permanently resist absorption, destroy the continuity of the vessels and weaken the vessel-walls at the seat of ligation." Silk when used for ligatures does not cause this injury to the artery, but is partly absorbed and finally encysted, first being infiltrated with new cellular elements.

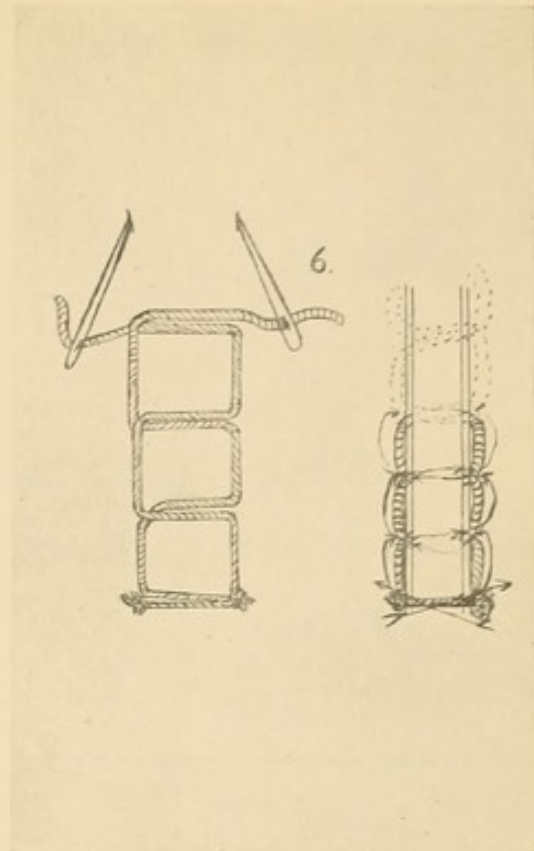
It is true that non-absorbable ligatures, if aseptic, remain in the wound and become encysted, but it is not true that they are prone to destroy the continuity of the vessel-walls. Sometimes the adventitia is constricted to such a degree that vitality is suspended. In such cases the inner tunics, if healthy, are transformed into connective tissue, forming a band that closes the vessel. Under these circumstances the adventitia, after a slow process of disintegration and absorption, is replaced by new cellular elements that are finally converted into similar tissue. There is nothing in these two processes that would interfere with the continuity of a vessel.

A well-known surgeon of great experience says that injured veins are very liable to become infected. If this statement be true (and there is no reason to doubt it), every precaution should be observed to secure asepsis. At least every instrument or object used in operating and in dressing the wound must be thoroughly sterilized. Special care should be exercised to have whatever material is employed in ligating or suturing perfectly aseptic.

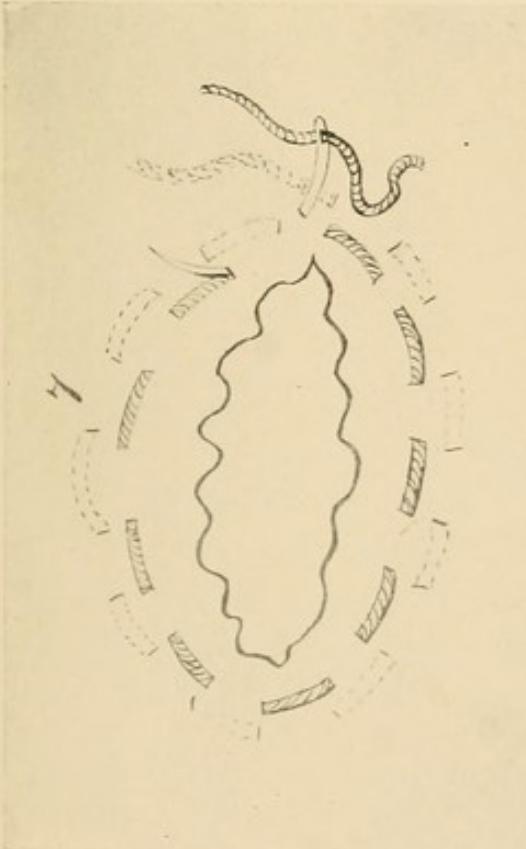
In addition to ligatures there are various methods to se-



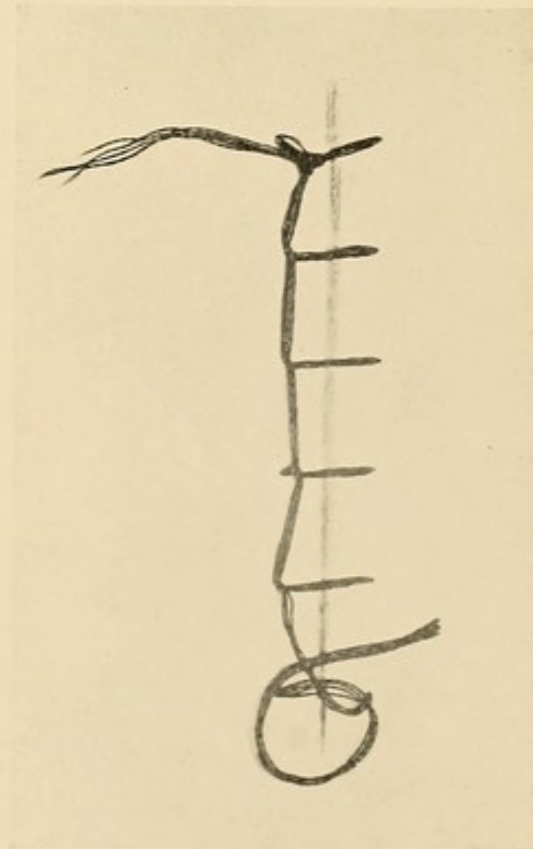
COMBINATION OF MATTRESS AND
CONTINUED STITCHES.



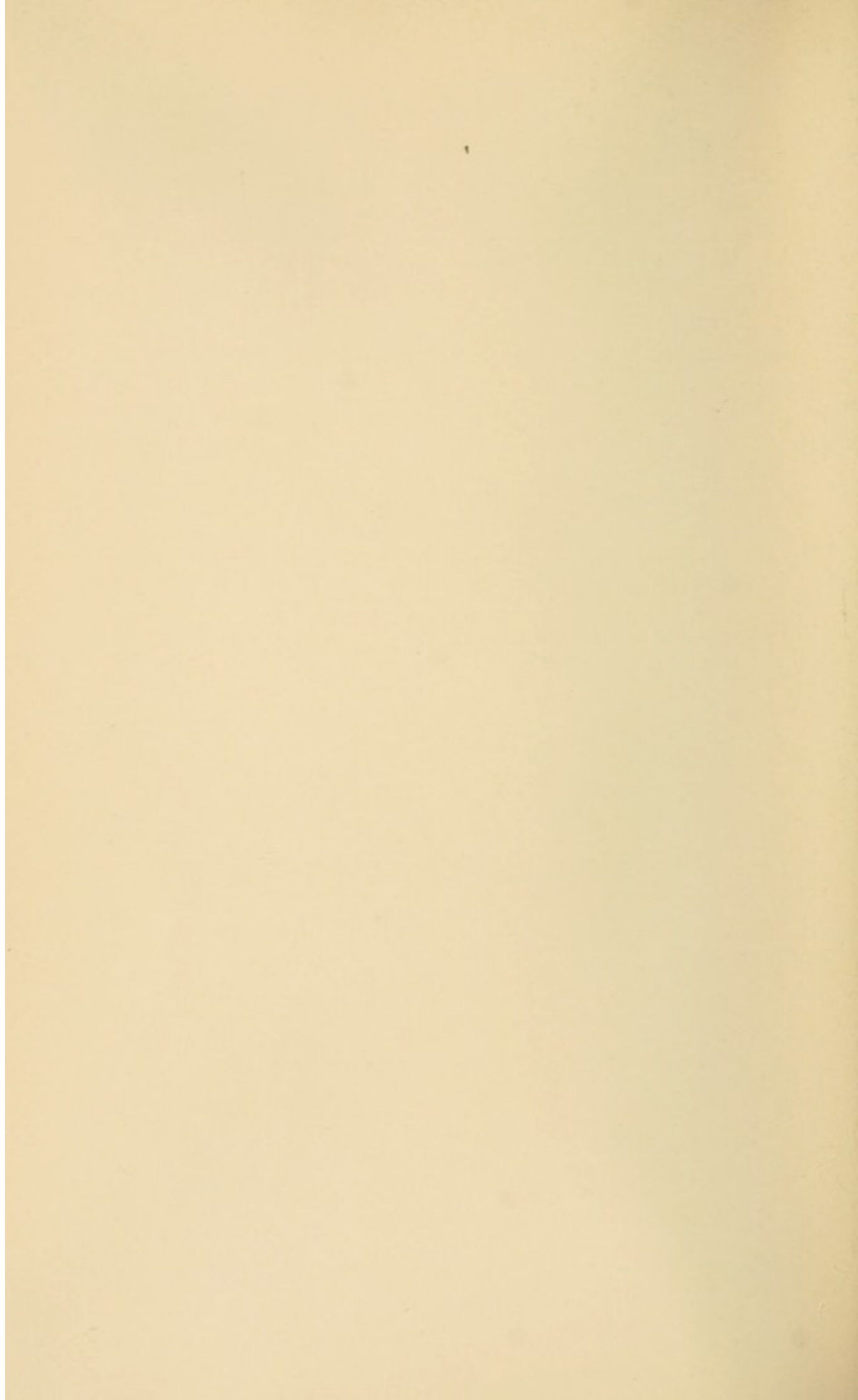
TUG STITCH.



COMBINED TUG AND TOBACCO
POUCH STITCH.



GLOVER'S SUTURE.



cure bleeding vessels. Torsion and acupressure are the two principle modes, but neither is reliable. Torsion vessels will give way to a very slight increase of pressure, about six and one-half pounds; vessels closed by acupressure will stand an increase of about twelve to fifteen pounds to the square inch. But both methods would be useless in certain cases, especially in the lungs.

Pollard, in 1869, devised a method similar to acupressure. He substituted a silver wire for the ligature, and brought the ends out through the skin covering the edges of the wound; the ends were then twisted together.

Two other methods are of historical interest. R. N. Smith passed a wire (iron) through a silver tube to constrict the vessels. Six hours were sufficient to secure obliteration of fourth and fifth size arteries, and two days for the large vessels (femoral artery). Fabricius, however, anticipated Smith in the use of iron wire; about the middle of the seventeenth century he recommended that an iron wire should be used for ligation. One end of the wire, which had been tempered, was to be sharpened and used as a needle.

The so-called filo-pressure method was introduced in 1868 by Brun. A silk ligature, which had been passed around an artery, was brought out of the wound through a silver cannula having a cross-bar, the silk being fastened to the cross-bar. This method was used by Brun in his clinic for six years, and he claimed that it was perfectly satisfactory.

There have been disputes also concerning the proper material to use for sutures. At this time there can be no question of the advisability of the closure of wounds with sutures. Now, only a smile of amusement is provoked by statements like Velpeau's, "if the employment of the suture . . . was not necessarily accompanied with much severe pain; if the union of the teguments was the most important part of the operation . . . (sutures) would have been long ago adopted . . . [the objections omitted], in-

duces us to believe that for the future, except in a small number of cases, the adhesive plasters will continue to be substituted.

There have been many efforts directed toward securing a material that would give satisfaction. It is not held by anyone to-day that any particular material is the cause of suppuration, although the ordinary explanation of the cause of infection may not be accepted. All will admit the good effects following the employment of aseptic material in suturing. Catgut has its advocates for suturing, who, as a rule, insist more strongly on it being the best material for suturing than for the ligature; but all that has been said against its use as a ligature holds true as regards a suture. Even greater objections can be urged against its use.

The use of wire or animal material for suturing is not altogether a new thing. Fabricius, of Aquapendente (1647), recommended metallic sutures. The other Fabricius (1537-1619), a century earlier, in referring to intestinal wounds, speaks of animal sutures. The systematic use of animal, or rather catgut sutures, is said to have been due to Lister.

John Morgan (1797-1847) is said to have been the first to employ metallic sutures. (Dennis's "System of Surgery," Vol. I, 1895.) A London surgeon, Mr. Gossett, in 1834, used silver-gilt wire for suturing in a case of vesicovaginal fistula. The publication of the results of Sir J. Simpson's experiments on animals drew attention to the use of metallic sutures in this country. Dr. J. Marion Sims employed metallic sutures in 1849. He is said to have been the first to use them in America.

The use of metal for this purpose has been condemned, but like all non-absorbable material, silk-worm gut, et cætera, metallic sutures do no harm. In some cases they are of great utility in preventing after trouble. It is only in a few positions that metallic sutures could cause any inconvenience. Silk or wire very rarely cause trouble by working out to the

surface. The most important point in their favor is that they can be perfectly sterilized.

In a work dealing with the surgery of the lung it may be of interest to give an account of certain methods that have been used to secure arteries of the chest, especially the intercostal. Goulard, of Montpellier, invented a special needle for this purpose. This needle formed three-fourths of a circle, with the eye near the point, which was somewhat blunt. The ligature lay in the concavity of the needle; to facilitate its use, the needle was attached to a long handle. Lottery, of Turin, constructed for this purpose a steel plate, which was narrower at one end than at the other; at the narrow part it curved in two directions. Holes were punctured in the curved part of the plate, to fasten the compress for the artery. The instrument was secured by narrow strips of cloth which passed through slits in the broad end of the plate. The plate was introduced into the wound in such a manner that the lower edge of the rib rested in the concavity of the plate, and, of course, the compress acted on the edge of the rib and artery.

Quesnay employed a piece of ivory covered with lint. The instrument was drawn from within outward, compressing the artery by means of a ribbon. Belloc also invented an instrument for the same purpose. It consisted of two plates, padded, which could be approximated by a screw.

CHAPTER V

PNEUMONOTOMY—PNEUMONECTOMY—PNEUMONORRHAPHY — PNEUMONOPEXY — BRONCHOTOMY — GENERAL AND LOCAL ANÆSTHESIA

PNEUMONOTOMY is a compound Greek word, *πνεύμων τομή*, meaning a cutting of lung. It is more descriptive and should supplant all other words for cutting operations upon the lung. Pneumotomy, pneumonectomy, and various other terms and expressions have been applied, but not until 1890 was the word pneumotomy adopted, and then by De Forrest Willard. Since that time it has only been occasionally used by various operators for the opening of cysts and abscesses.

Pneumonectomy means the removal of a part or all of one or more lobes of the lung. It is resorted to in many cases of laceration, new growths, hernia, and gangrene of the lung.

Pneumonorrhaphy (suturing the lung) has been successfully accomplished many times for injuries and after operations, for the removal of foreign bodies, hernia, gangrene, cysts, and new growths. Absorbable and non-absorbable sutures are either absorbed or become encysted in the lung tissue, so that one need not hesitate to use sutures of any accepted material in emergency surgery of the lung.

Pneumonopexy (anchoring the lung to the chest wall) is sometimes desirable in dealing with the lung stump after amputation for hernia or laceration, or after an abscess or cyst has been opened for drainage; also where there is doubt as to securing pulmonary vessels in injuries or operations

upon the lung. There are but few cases where it would probably be best to anchor the lung to the chest wall, thus requiring two sittings for opening cysts or abscesses.

Bronchotomy (cutting into the bronchus) is done for the removal of foreign bodies and polypi. The point of attack may be through the anterior or posterior chest wall. This is one of the most difficult operations of the lung, because the lung itself must be divided before the bronchus can be opened.

Historical (1714-1903).—Fabricius Hildanus (*Opera omnia*. Francof. A. M., 1646) and Ruysch (*Opera omnia*. Amsterodami, 1737) have recorded cases in which large portions of the lungs have been excised and patients recovered. Baglion advocated operations on the lungs as early as 1714, and Barry indorsed the doctrine of Baglion ten years later. ("Treatment of Consumption of the Lungs," p. 217, Dublin, 1726.)

Hale (*Medical Exam.*, Philadelphia, 1851) referred to a case of penetrating wound in the chest in which recovery followed the removal of a piece of the lung. Willard (1891) made an intrathoracic bronchotomy from behind for a foreign body impacted in the bronchi. Even though he was not permitted to complete the operation, owing to the exhausted condition of the patient, he demonstrated beyond peradventure the feasibility of the operation under proper environments. His experiments were especially valuable in that many vexatious problems concerning the suturing of lung tissue were solved.

One prominent writer says: "Although some animals have survived complete extirpation of a lung, man has not." Although there is but one case recorded where man has survived a primary operation involving the extirpation of either the right or left lung, there are many cases on record where one or the other of the lungs has been destroyed by disease or trauma and the patient has survived. There are, too, cases

lately recorded of the extirpation of a lung, but it is not clearly stated whether the patient recovered or not.

Kurz wrote extensively upon lung surgery. Grumwald and Manquat each speak of lung surgery during the year 1891, which saw so much published concerning surgery of the lung. Krecke during the same year gave a most interesting history of lung surgery. Bechini (1891) published a paper on the application of surgery to the lung in grave cases, as did Roux. Guermontprez (1892) described a new method of suturing the lung. Tuffier (1892) added much to this special department of surgery by his research. Wills (1892) described his experimental study in pneumonectomy and lung suturing. Richerôle (1892) mentions "pneumonectomie" in an address upon lung surgery. Delagnère (1894) contributed an essay on his observations on the surgery of the pleura and the superior lobes of the lung, as did Heydweiller (1894) in a work on the surgery of the lung.

Rodman (1894) made a pneumonotomy. Tuffier (1895) again mentions a new method for the surgical exploration of the lungs. Artman (1897) also published a critique on lung injuries and on the present status of lung surgery. Beck (1897) published his technique of pneumonotomy. Merelli (1898) resected the pulmonary cartilages. For other observers who have reported new methods and interesting cases see Bibliography.

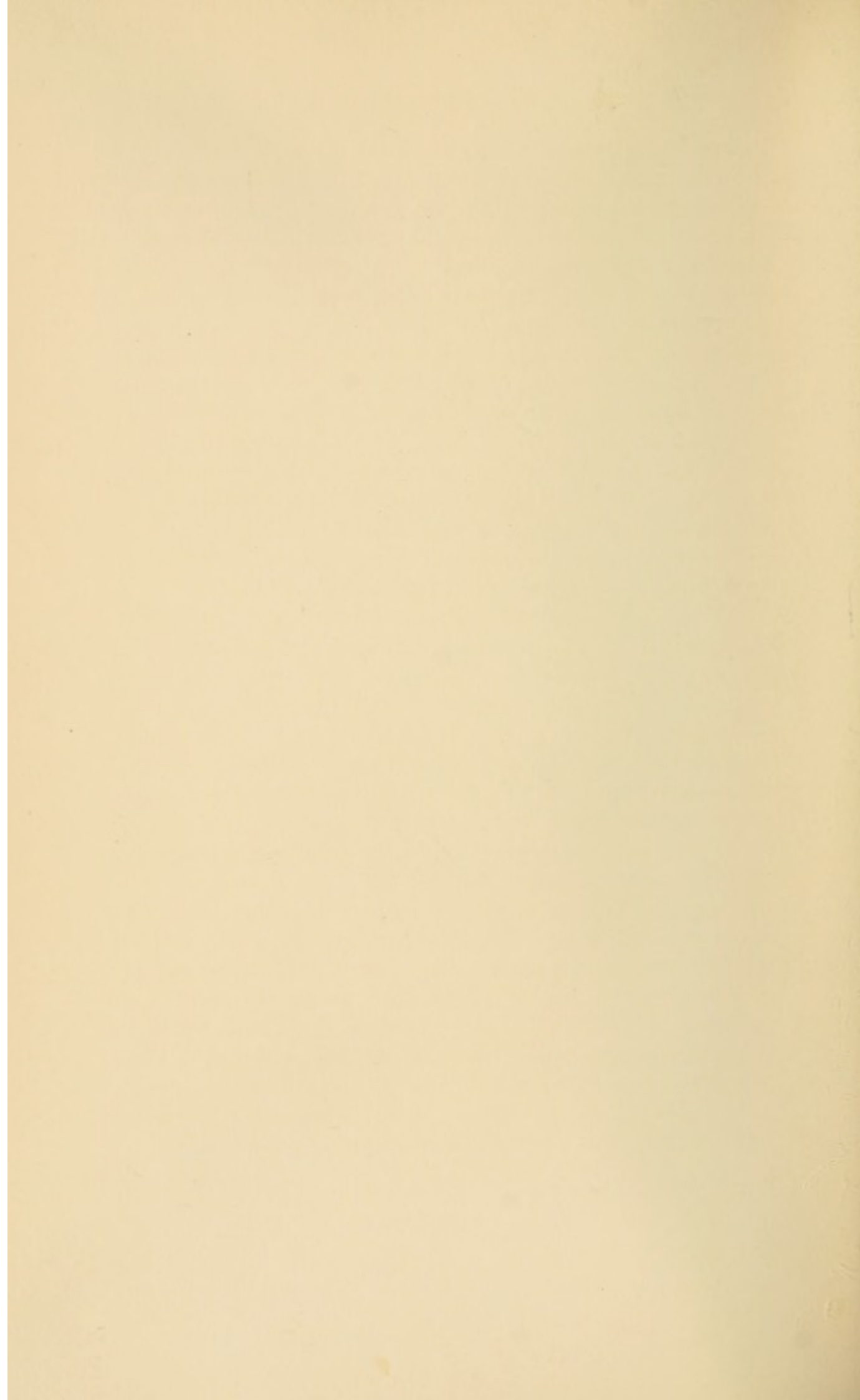
Karewski (1898) and Kopstein contribute valuable thoughts on lung surgery. Herzfeld (1898) and Mayo (1898) also reported cases of pneumonotomy. Malbot (1898) published a paper on the surgery of the lung. Kohler (1898) published a work on pulmonary surgery; those interested in this branch of surgery will find this work very valuable. Riedel (1898) published his observations on lung surgery. Augros published a paper (1898) on the treatment of chronic empyæma.

Sonnenberg (*American Medicine*, July, 1901) has formu-



X 45.

ANTHRACOSIS IN CANCEROUS LUNG.



lated the following law regarding pneumotomy: "If the pulmonary tissues are hard, divide them with a knife, as there is no danger of hæmorrhage; if the pulmonary tissues are soft, divide them with the cautery, as there is great danger of hæmorrhage." It has been the author's experience that the use of the fingers to divide the tissues gives the best results in the latter case.

When pneumotomy or pneumonectomy is undertaken for tumors or tuberculosis, Koenig says: "To perform such an operation the surgeon must ignore absolutely all his knowledge of pathology." Tuffier, in his Moscow address, gives an analysis of three hundred and six pneumotomies. There were ten recoveries in fifty-five cases of metapneumonic gangrene; three in four cases of gangrene with ectasia of the bronchi; two recoveries in seven cases of embolism; one from a gunshot wound. In forty-nine cases of abscess of the lung, mostly encapsulated intralobular suppurating pleuritis, twenty-three per cent. succumbed to the pneumotomy; three cases of incipient tuberculous foci were cured, but the operation in cavities was followed by death in thirteen out of twenty-six cases operated on.

Ombonin and Michaux's cases were gunshot wounds; De Lormes's a stab. The first died from infection; the second from exhaustion, thirty minutes after the operation; and the third made a perfect recovery, the wound having been packed with gauze to prevent hæmorrhage. The open cavities rarely cicatrized, and only one or two were improved. Intraparenchymatous injection in tuberculosis also proved ineffectual. No primary neoplasms have yet been operated upon, but seven cases of sarcoma that have extended to the wall over the lung were operated on. For these difficult operations he resorts to trachæal insufflation with respiration by pressure through a tamponed cannula introduced into the larynx. He rejects puncture in hydatid cysts, as unreliable and dangerous, from possible perforation of the bronchi.

There are twenty-nine operations on record for aseptic lesions of the lung, with twenty-two recoveries, seventy-five and eight-tenths per cent., and seven deaths, twenty-four and one-tenth per cent. This includes traumatic lesions, herniæ, neoplasms, and tuberculous nodules. Sixty-one operations were performed for hydatid cysts, with fifty-five recoveries and six deaths. The remaining two hundred and fifteen were performed for septic lesions, with one hundred and forty recoveries, or sixty-four and eight-tenths per cent.; seventy-five deaths, or thirty-five and two-tenths per cent. This includes tuberculous cavities, thirty-six cases with thirty-six deaths; abscess, forty-nine cases with twelve deaths; bronchiectasis, forty-five cases with thirteen deaths; foreign bodies, eleven cases with four deaths; gangrene, seventy-four cases with thirty deaths; actinomycosis, one case, not fatal. Total, three hundred and six cases; cured, two hundred and seventeen; died, eighty-eight. (*Journal American Medical Association*, January 15, 1898, p. 169, Vol. XXX.)

B. Bell fearlessly and successfully opened abscesses in the lung, no matter at what depth they were situated. Sapiejoks stated that he located adhesions with an exploratory needle, connected with a manometer; when the point of the needle projected into an open space, the manometer was lowered, while it remained stationary if the needle encountered adhesions.

Operative Technique.—*Emergency.* In this class may be included the cases of severe hæmorrhage (due to injury or disease), hernia, foreign bodies, and those surgical conditions produced by, or resulting from, delay in advanced pathologic changes.

Election. In this class are to be included those cases in which ample time is given to analyze conditions and decide upon a certain definite course to pursue.

There is but little variation in the course to pursue for

the incising of lung tissue, removal, suturing, or anchoring to the chest wall (internally or externally), so far as the preliminary work for their performance is concerned. The same surgical principles should be maintained in asepsis, opening and closing the chest, with or without drainage, together with the postoperative treatment. The operator should prepare for artificial respiration in all cases of operations on the lungs. He should have a supply of oxygen at hand, with the necessary apparatus to use it. He should also have a number of assistants present, in case it should be necessary to employ artificial respiration. The surgeon must also be prepared for tracheotomy if other means fail. In asphyxia a laryngeal cannula may be used, with bulb to produce strong artificial respiration. (*Journal American Medical Association*, January 15, 1898, p. 169.) It is well to have strychnine, a battery, bellows, hot water, etc., at hand, with means of rectal divulsion.

Pneumonotomy is the only probable means of relief in cases of hydatid cysts, localized gangrene, and abscess. When resorting to this operation, the exact seat of the disease is first determined by the usual means. If adhesions are present, aspiration is, perhaps, a most important means. Then the superficial tissues are divided and one or more ribs resected, as may be necessary, care being taken not to injure the pleura. (In case of adhesions, it is the practice of some to discard the knife and use actual cautery heated to a dull red glow.) The seat of the disease having been freely laid open, the patient is rolled over to encourage the outflow of fluid. Drainage by gauze or tube is established and hæmorrhage is checked by pressure. When there are no pleural adhesions, the operation is more difficult and the prospect poor. Suturing the lung to the chest wall before making an incision of the pleura is difficult, and does not always prevent partial pneumothorax. Do not irrigate, as it is liable to drown the patient.

Sterilization may be general, local, or both. It is especially desirable that the field of operation be cleansed. However, there are cases where necessity and environment will preclude the possibility of the least attempt at cleanliness, which might result in the loss of a life, or serious complications that would overshadow the benefits to be derived. This is especially the case when the internal mammary and larger blood-vessels have been injured. If time is sufficient, every precaution should be taken. The field of operation should first be cleansed with soap, water, alcohol, turpentine or benzine, and not only the skin, but the fabrics to be used in the operation and in the care of the case should also be clean.

General and Local Anæsthesia.—No anæsthesia is necessary when a state of unconsciousness prevails. General anæsthesia is to be employed in emergencies as a rule, if patient is conscious, and also in the majority of cases of election. Chloroform is to be preferred because narcosis is obtained quickly and with less resistance. Local anæsthesia can seldom be employed in emergencies owing to its uncertainty and the time required to be effectual. Ethyl chloride and cocaine are the most desirable agents. Local anæsthesia may, however, be frequently employed in cases of election.

Opening in Chest. A curved cutaneous incision (with the point of entrance of the weapon in the chest and the point to be attacked in the centre of the circle) will enable one or more ribs to be divided by the forceps in a semicircle; its extent and direction must be governed by the necessity for drainage. Great care should be exercised in not allowing instruments to enter the pleural cavity before the lung has contracted upon itself, as the result of air entering the chest. If the chest remain open, the lung will be contracted, but if the opening becomes closed by clots or otherwise, the lung will again expand. A contracted lung is desirable at time of opening the chest because of the danger of injuring it. It



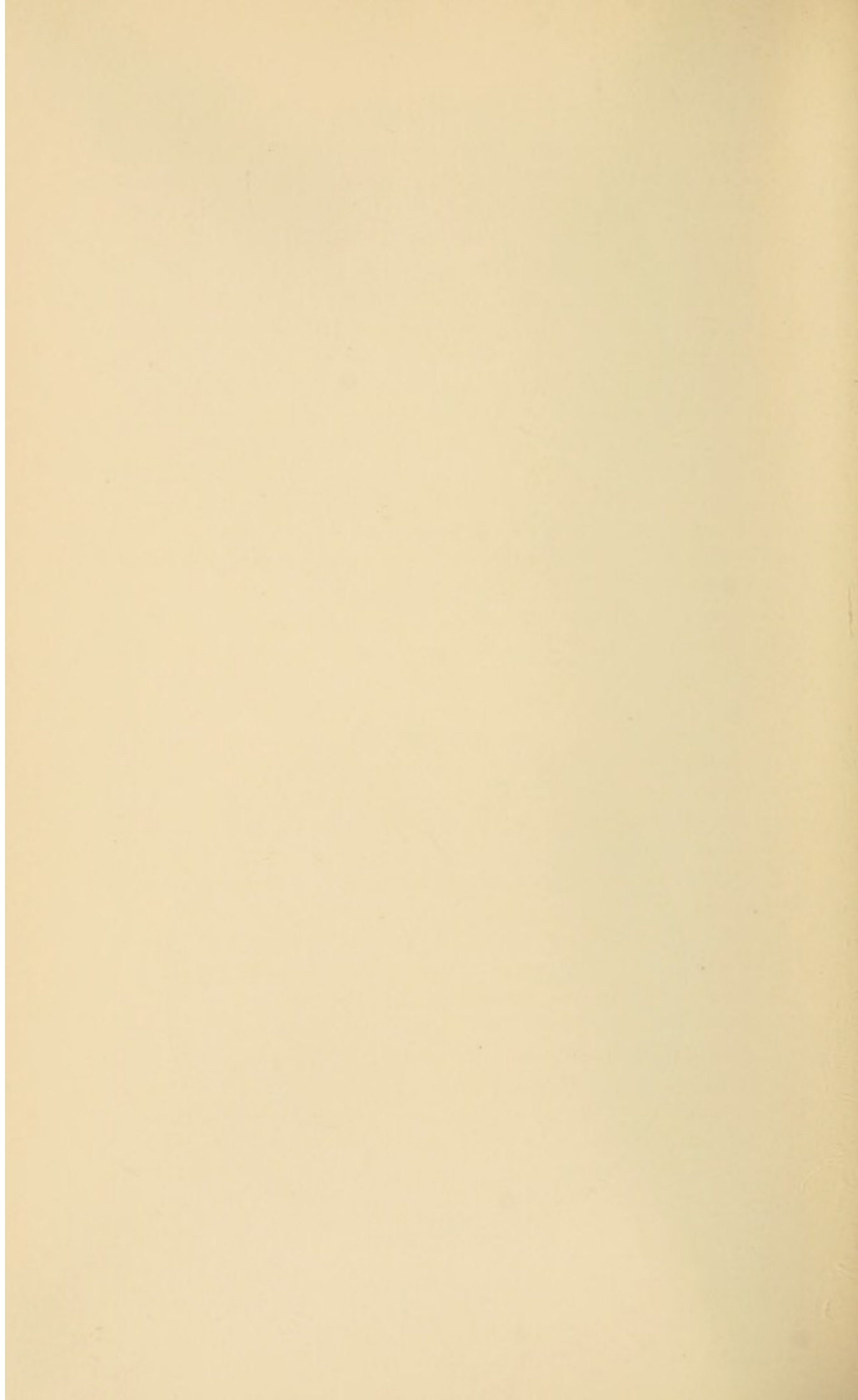
X 257.

ŒDEMA OF LUNG.



X 105,

POLYPUS.



can be made to contract by reopening the wound and allowing air to enter the chest, just previous to operating.

There is but little bleeding in dividing the soft and bony structures of the chest, unless the internal mammary artery is severed. The intercostal arteries cause but little annoyance. If they do, they may be ligated, or crushed with forceps. Both the distal and proximal extremities of the internal mammary artery should be ligated. The existence of adhesions of the parietal to the visceral pleura is desirable when the lung is to be incised for cysts, or for the removal of foreign bodies, but their induction is not necessary before opening the chest.

An opening in the chest permitting ample space for work is essential, and no time should be lost in accomplishing it. All clots within the pleural cavity should at once be removed with the fingers, and gauze used to keep the lung clean until the wound can be found. Once discovered, a pair of long-handled artery forceps may be applied. If the bleeding is not severe, it may be controlled by firmly packing gauze into the open wound of the lung. Either one of these procedures will permit of ample time to decide upon the proper course to pursue. The situation well in hand, a silk ligature may be applied to the artery, and a suture of the same material used to close the laceration in the lung tissue, if it be proper.

If the laceration involves the border of one or more lobes, the lung may be brought out of the chest cavity and the work completed before it is returned. The ragged portion of the lung may be ligated *en masse* by transfixion, and the lung returned to the pleural cavity. All bleeding vessels being secured, the pleural cavity freed from all clots and foreign material, the chest may be temporarily closed for a few moments, by coapting the cutaneous structures, or by placing the hand over the opening in the chest to allow the lung to expand, and to be assured that all ligatures are in their

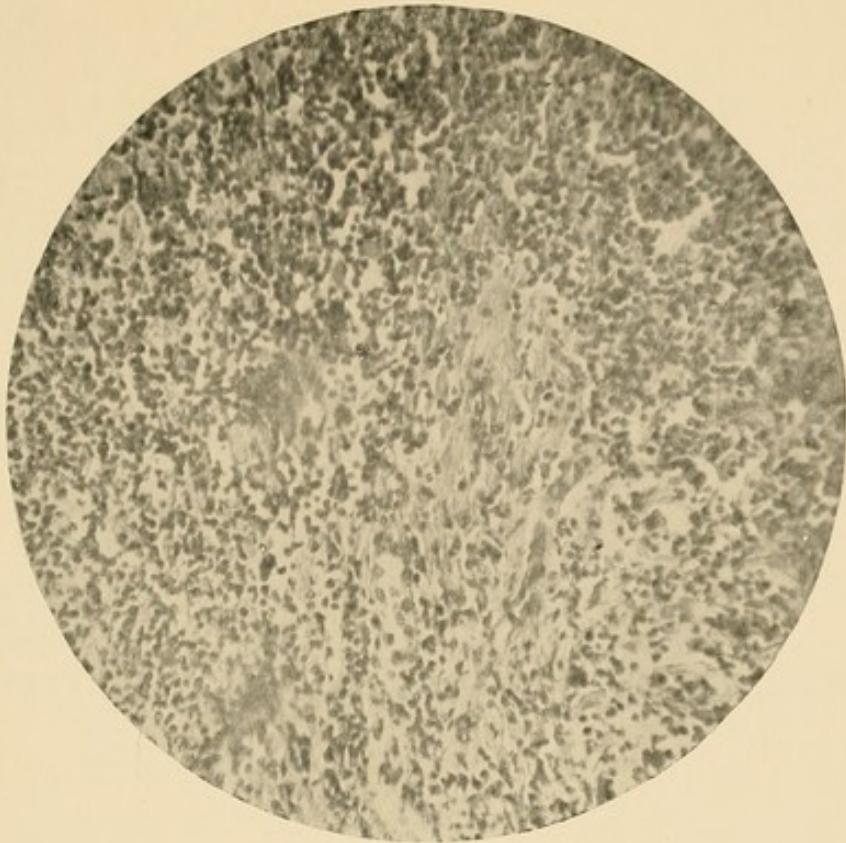
proper places. This once determined, the chest can be at once closed, with or without drainage, as the case may require.

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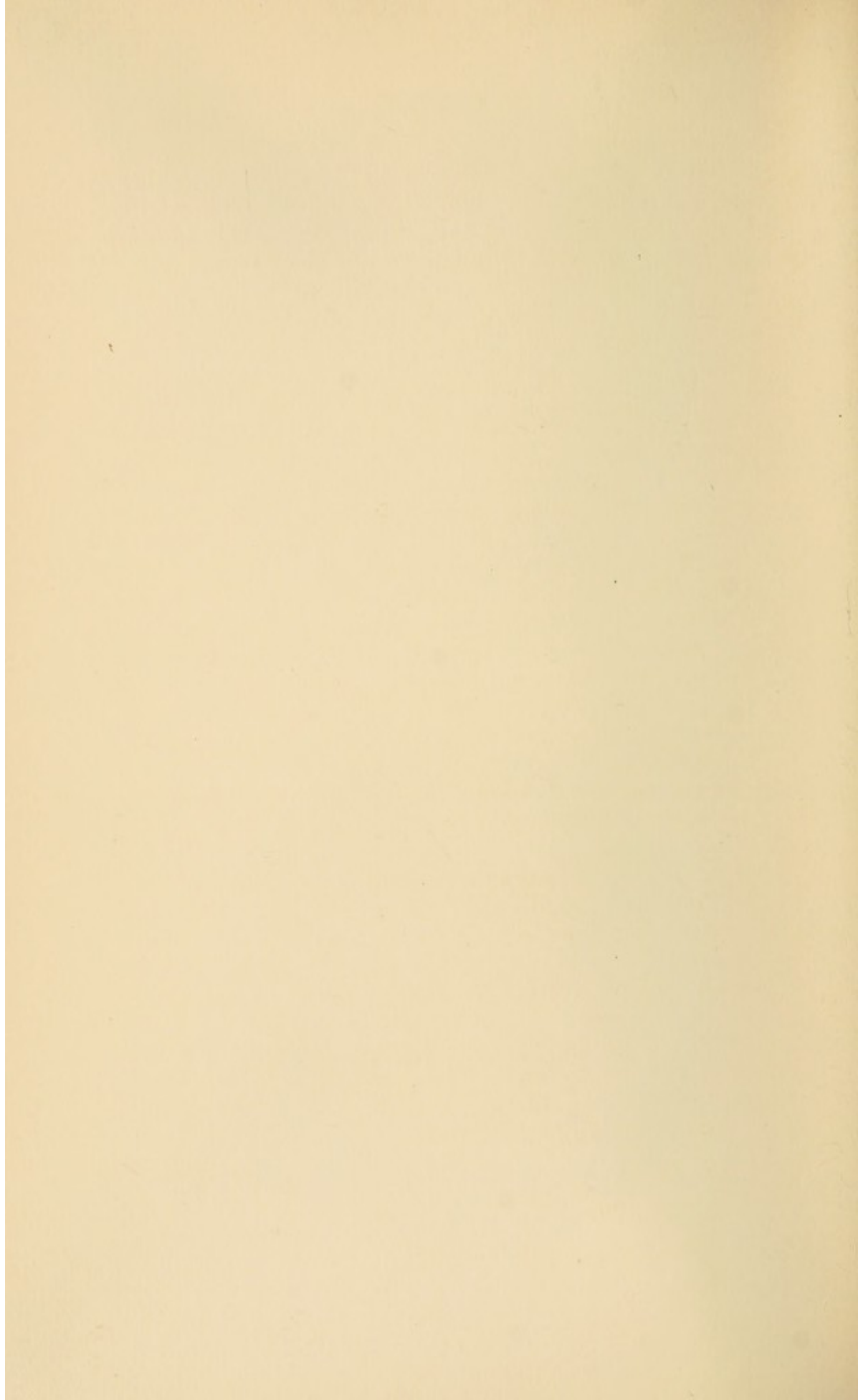
X 175.

LYMPHOMA.



X 250.

CHONDROMA.



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CHAPTER VI

GUNSHOT, LACERATED AND INCISED WOUNDS

GUNSHOT WOUNDS.—Injuries of the lungs, due to gunshot and explosive missiles, are more common than those of any other type, and their character has changed materially within the last twenty-five years. The quality of the explosive, the kind of weapon, the size, quality, shape, and velocity of the ball, have all undergone a great evolution. The ball is smaller, harder or softer, travels further and faster, so that its destruction to soft tissues is greater or less than formerly. If the ball is harder, the destruction is less; if softer, the destruction is greater under the same circumstances. The velocity and distance being so greatly increased cause the ball to become heated to such a degree as to make it aseptic at the time it comes in contact with, and continue so until after it has left the body. In consequence of this heat the walls of the tract through which it has passed are also made aseptic.

The small modern steel ball has been known to pass through every organ, including the heart and brain, without producing death. The kidneys, lung, liver, spleen, and pancreas have each been perforated in such a manner without fatality.

Historical.—One of the earliest accounts of such wounds is that of Mallet (1743), who published a report of a lad who was shot through the lung. Rigby (1790) reported a case of recovery after a ball had passed through the lung.

In 1800 Home's very satisfactory account appeared. This

was a case of a person who was shot through the lung and survived for thirty-two years. The account contained a description of the appearance of the contents of the thorax after death.

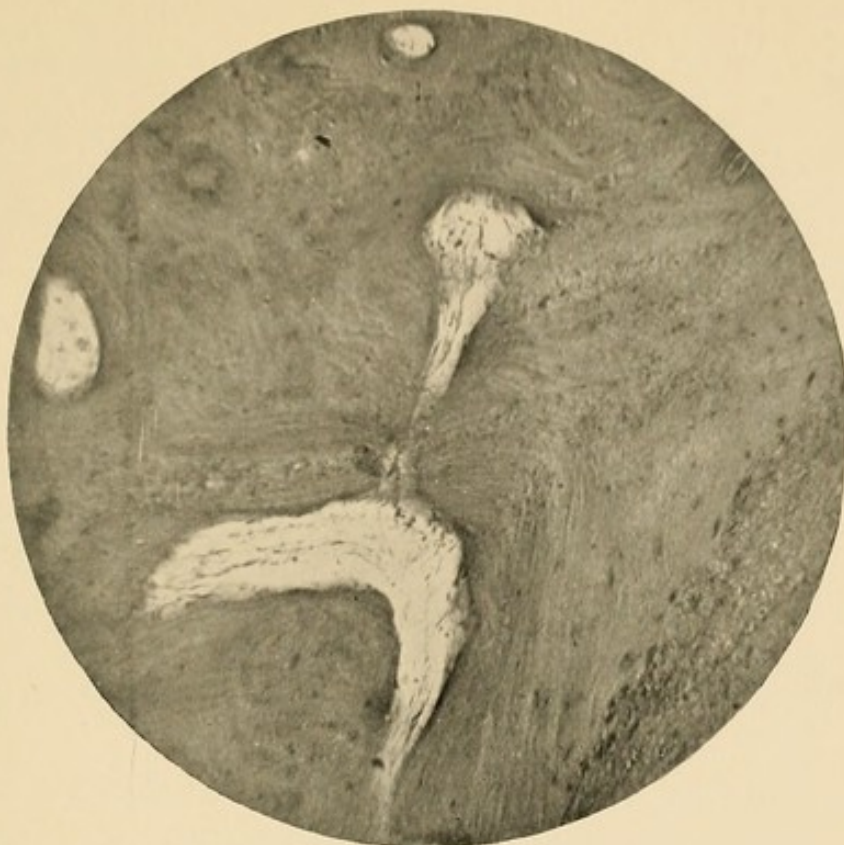
Keys (1845) reports a case where balls perforated the diaphragm and left lung in two places. Campbell (1846-47) had a case of gunshot wound of the lung, in which the patient recovered. Moore (1847) tells us of a case where the ball was lodged fifty years in the lung. Beal (1847) observed a case of gunshot wound where a portion of the right clavicle was carried away, and the bullet passed through the summit of the lung and scapula; the patient recovered. Eve reported the well-known case of General Shields, who was shot through the body by a grape-shot at Cerro Gordo. In this case the grape-shot had evidently entered the right nipple, passed between the lungs, through the mediastinum, and emerged a little to the right of the spine. Longmore (1855) also reported a recovery from a severe injury to the chest and wound of the lung by grape-shot. Upshur (1855) reported a case of gunshot wound of the lung. Warren (1857) described a case where pistol balls were suspended within the chest by the pleura; also the appearance of the thoracic cavity eight years after the gunshot wound. Peters (1860) had a case of severe gunshot wound of the left lung, in which the patient recovered.

In 1861 the treatment of gunshot wounds of the lung was given an impetus by Clapp's publication of cases of gunshot wounds of the right lung and their treatment. The same year Sinn reported a case of gunshot wound of the right lung with discharge of pieces of lead from the mouth, seven weeks after the injury; recovery took place. Farnsworth (1865) had a case of gunshot wound through the chest. Roustan (1865) reported a case of gunshot wound of the lung, in which the lead ball became encysted. Forments (1866) had a case of gunshot wound penetrating the left lung; the ball

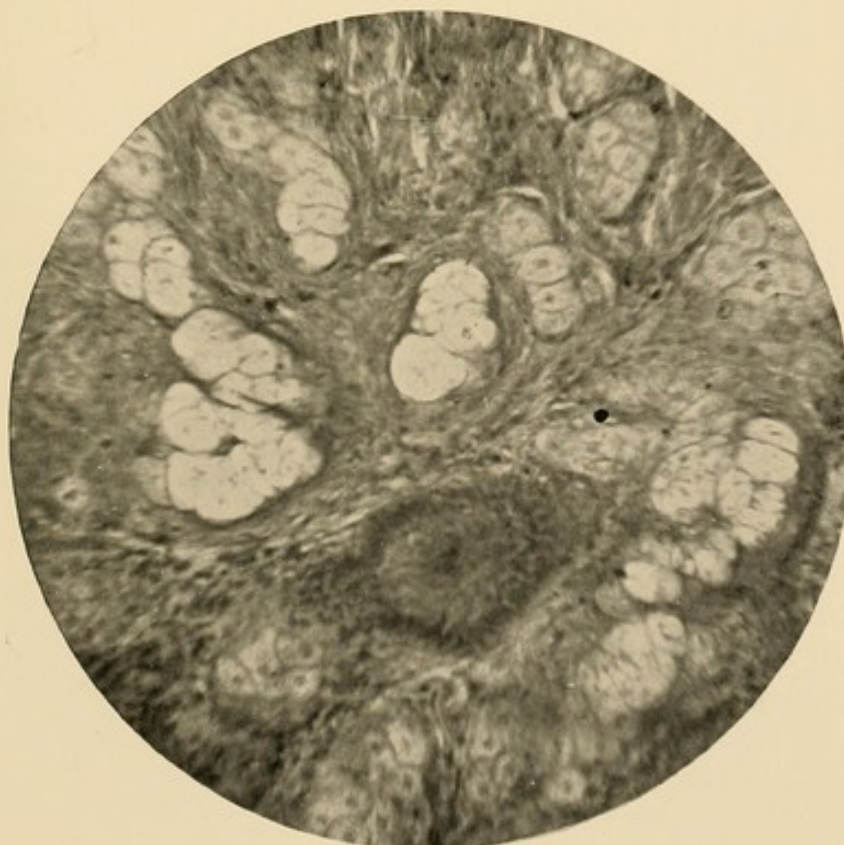
remained. There was apparent recovery, with recurrence of symptoms two years after the injury.

Johnson (1867) noted the absence of symptoms in a case of gunshot wound through the bottom of the lung. Eve (1867) reported a case of penetrating wound of the left lung in an infant, the ball passing near the heart; the patient recovered. (Circular No. 3, War Department, Surgeon-General's Office, August 17, 1871, may be consulted for reports of cases of penetrating gunshot wounds of the chest with recovery.) Woodson had a case of gunshot wound of the right lung and shoulder joint. Wright reported a case of bullet wound of the right lung in a child three and one-half years old. (An interesting work on this subject is that of Chaplain on Lung Wounds by Firearms.) Keller (1874) reported a gunshot wound of both lungs, and Lewis (1874) reported a case of gunshot wound of the left lung, producing large pleural effusion; *paracentesis thoracis* was performed by the aspirator, followed by free incision of the chest wall and convalescence of the patient.

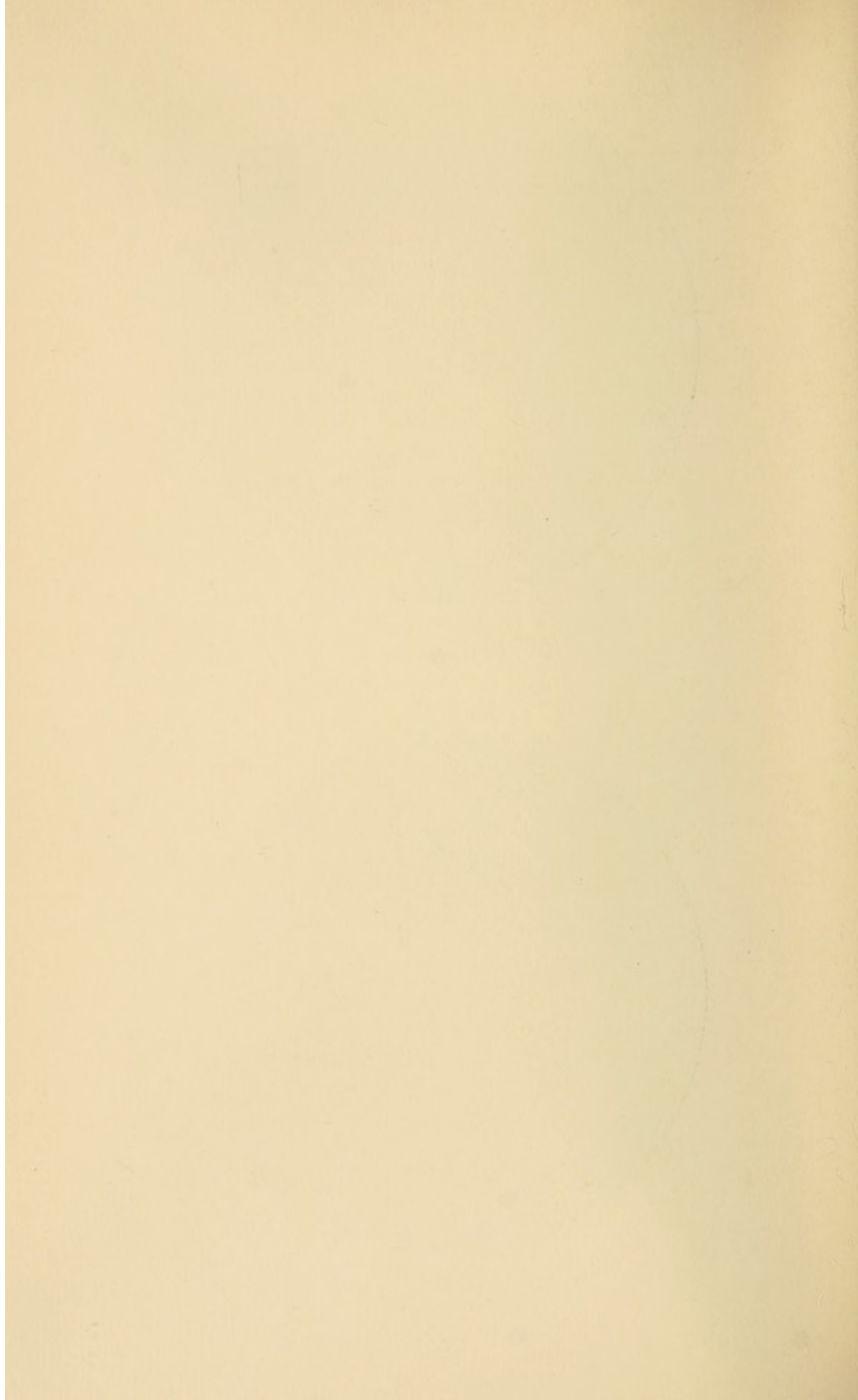
Crawford (1879) reported successful treatment, by blood-letting, of a gunshot wound of the chest, involving both lungs, and complicated with fracture of the scapula, with paralysis of the left arm. Ombonin, of Cremona (1885), De Lormo (1893), and Michaux (Congrès Français de Chirurgie, 1895), are among the first to report pneumonotomies for traumatic injuries of the lungs. Albuerne (1890) reported a case of gunshot wound of the lung which healed by first intention. Hauson and Coe reported a case of gunshot wound of the lung in which septicæmia occurred and was treated by resection of the rib; recovery followed. Macwatt (1891) reported two cases of severe gunshot wound of the lung in which the treatment resulted in recovery. Bickle (1891-92) reported a case of gunshot wound of the right lung, and Gonda (1891) had a case of gunshot wound of the lung with fistula remaining. Pinquard (1893) also reported a case of gunshot wound of the lung. Wilson (1897) reported a case where



X 180.
OSTEOMA.



X 180.
DERMOID CYST.



three links of a trace-chain passed through the lung, and Da Costa (1898) reported a case of gunshot wound of the lung.

Hermetically closing the chest was suggested by Paré, Larrey, La Motte, and again in 1863 by Dr. Benjamin Howard, just before the battle of Gettysburg, after which a report of sixty-seven cases so treated for injured lung is found. Twenty-five recovered and forty-two died. Fifteen out of the forty-two were found upon autopsy not to have received lung injuries. In the absence of statistics, it is safe to say that the same per cent. of those that recovered did not have lung injuries. It is also probable that the same rule could be applied to all chest wounds, viz.: that only about thirty per cent. of undetermined chest wounds do not involve the lungs.

Dr. Orpheus Evert (Assistant Surgeon Twenty-second Indiana Volunteers) was among those who sealed chest wounds at Gettysburg, having closed five, with death resulting in each case. (This incident was communicated personally to the writer.) Only three recoveries took place out of two hundred chest wounds at the battle of Sebastopol, treated by the administration of digitalis, while twenty-seven recoveries ensued in one hundred and twenty-seven wounds of the same character among the English at the same battle, treated by venesection.

These reports, like all statistics of this character, while very interesting, do not add much to our knowledge of lung injury, as many of them are injuries of the chest wall alone. It is highly probable that the greater number of recoveries among the English was due to better care and skill, and not to venesection. Then, too, there was a difference in the character of the missile used.

About sixty-two and a half per cent. of the wounds received during the Civil War, United States, 1861-64, were of the chest, while sixty-five and one-half per cent. constituted the combined chest wounds of the French at Sebastopol, the British in the Crimean War, 1855; Italian-French War,

1859; Austrian-French, 1859. In more recent years the rate has been higher than this, as shown by McCormac (Sédan), Fischer (Metz), and Beck (Strassburg), during the Franco-Prussian War.

The upper lobe was most frequently wounded, the ratio being one to two. Of eight thousand seven hundred and fifteen chest wounds (Civil War, 1861-65), four hundred and ninety-two, or five and one-half per cent., spat blood, and sixty per cent. of the total number died. Nélaton (Thèse de Paris, 1880) reports eighty-six cases of chest penetration, with twenty-two recoveries, without operation. In twenty cases he resorted to puncture or incision of the chest to remove clots; four died from hæmorrhage, without operation. Siege wounds of the chest varied from one to twelve, and one to sixteen, while open field wounds of the chest averaged about one to twenty.

These percentages have, perhaps, been increased by improved firearms and workmanship. W. C. Borden (*Philadelphia Medical Journal*, Vol. VI, No. 7, August 18, 1900, p. 302) gives the following as a comparative study of gunshot injuries, both penetrating and non-penetrating wounds of the chest in the Civil and Spanish-American wars. While they show nothing definite as to lung injuries, they are exceedingly interesting. It is to be regretted that more definite statements are not made concerning lung injuries in both private and public practice.

	Total No. of cases.	Per cent. of fre- quency.	Recov- eries.	Deaths.	Undeter- mined re- sults.	Per cent. of mor- tality
CIVIL WAR:						
Non-penetrating. 11,995	.....	487	} 823	13,921	5,373	870
Penetrating 8,269	20,264	336				
SPANISH-AMERICAN WAR:						
Non-penetrating	61	436	} 815	99	13	2
Penetrating	53	379				

Ratio of number of recoveries to number of deaths, in war :

	Recoveries.	Deaths.
Civil War.....	6.7	1
Franco-Prussian	8.0	1
Spanish-American War.....	14.1	1
Anglo-Boer War.....	19.0	1

These are the tables to January 27, 1900, by Captain and Assistant Surgeon W. C. Borden, U. S. A., *Philadelphia Medical Journal*, August 18, 1900, p. 302.

Table showing the percentage of mortality in penetrating wounds of the chest :

	Name of Authority.	Per cent.
French in Crimea.....	Chenu	91.6
English in Crimea.....	Matthew	79.2
French in Italy.....	Chenu	46.48
Civil War (U. S.).....	Otis	62.66
Prussians in Schleswig.....	Löffler	41.6
Danish in ".....	Löffler	67.2
Germans in Franco-Prussian War.....	Fischer	56.7
Japanese in Chinese War.....	Haga	34.7
Americans in Spanish-American War...	U. S. Gov.	24.5

CIVIL WAR. CHEST WOUNDS—TOTAL NUMBER.

	Deaths.	Per cent. of fre- quency.	Recov- eries.	Undeter- mined re- sults.	Per cent. of mor- tality.
11,995 Non-penetrating....	5,373	487 } 8.26	13,921	870	27.85
8,265 Penetrating.....	.....	336 }			

SPANISH-AMERICAN WAR.

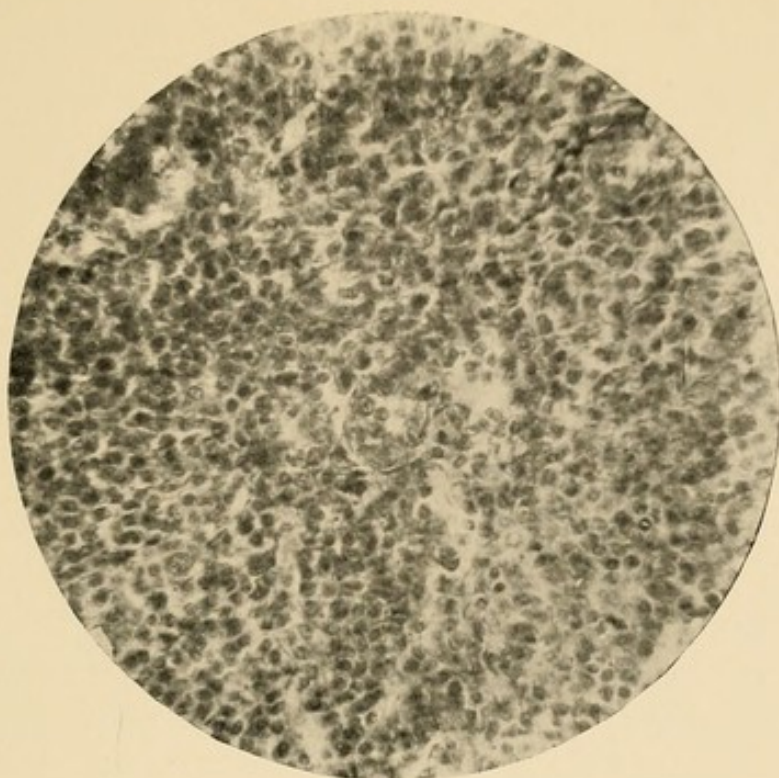
61 Non-penetrating	13	436 } 8.15	99	2	11.6
53 Penetrating (114) .....	..	379 }			

(W. C. Borden, M.D. (Edin.), Captain and Assistant Surgeon, U. S. A., in the *Philadelphia Medical Journal*, August 25, 1900, Vol. IV, p. 334.)

(For diagnosis and treatment, see under that heading in the chapter on Lacerated and Incised Wounds.)

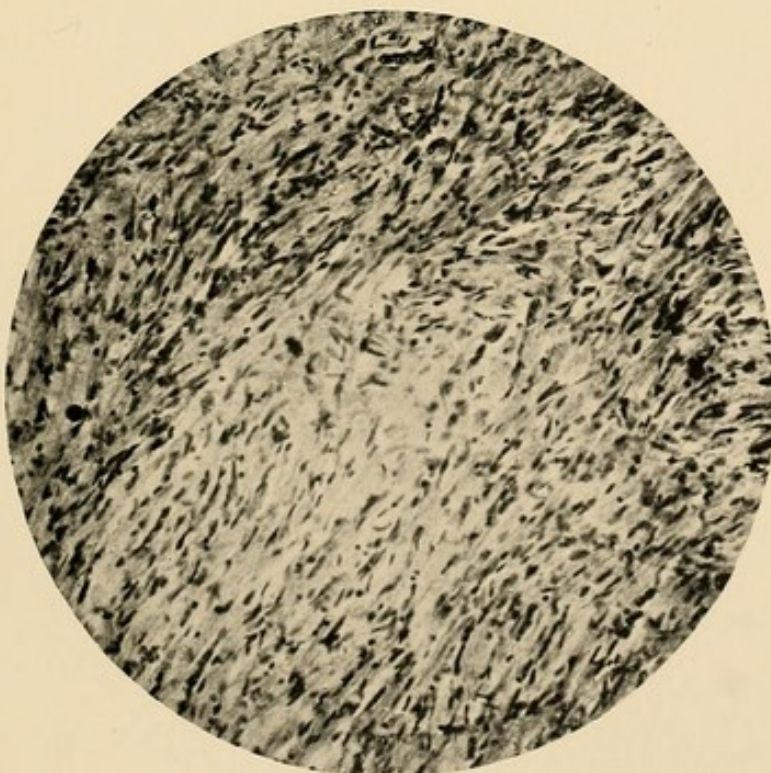
In *Annals of Surgery*, February, 1901, Dr. E. F. Robinson, late Acting Assistant Surgeon, U. S. A., gives his experience in treating gunshot wounds in the Philippines. He says that seventy-eight cases of gunshot wounds of the lungs were brought to his hospital. Of these, ten were dead when they arrived or died within twenty-four hours, leaving sixty-eight cases that were treated. Forty-four of the wounds were caused by Mauser or Krag bullets, twenty-four by Remington or revolver bullets. Five of the forty-four high velocity wounds were infected. Of the twenty-four low velocity wounds, five were infected and died; six others were infected, but having been sent home were lost sight of. He claims that fifty per cent. of the low velocity wounds become infected, and only twelve per cent. of the high velocity. He gives one case as a sample; this was one of attempted suicide. The bullet entered the third interspace one-half of an inch to the left of the sternum; the exit was one-half inch external to inner border of the scapula. The ball perforated the chest, lung, and probably the pericardium. The patient recovered. Dr. Robinson, in his conclusions, says that the modern gunshot wound (by Mauser, Krag, Lee, etc., rifles) is generally aseptic, and should be treated on this supposition. He claims that the asepsis is due to the character of the bullet and to its high velocity. The explosive effect of the modern high-velocity bullet is not so common as generally supposed. The peculiar effect depends upon the kind of tissue and the velocity. Gunshot wounds were treated by applying an occlusive antiseptic dressing.

"The thorax was injured in one hundred and ninety-eight cases, eighty-four non-penetrating and one hundred and thirteen penetrating wounds. Of the non-penetrating wounds, one proved fatal after an operation for traumatic aneurysm, and one recovered after a ligation of the subclavian artery. Of the penetrating wounds thirty-six cases, or thirty-one and nine-tenths per cent. of the penetrations, were fatal. The bullet



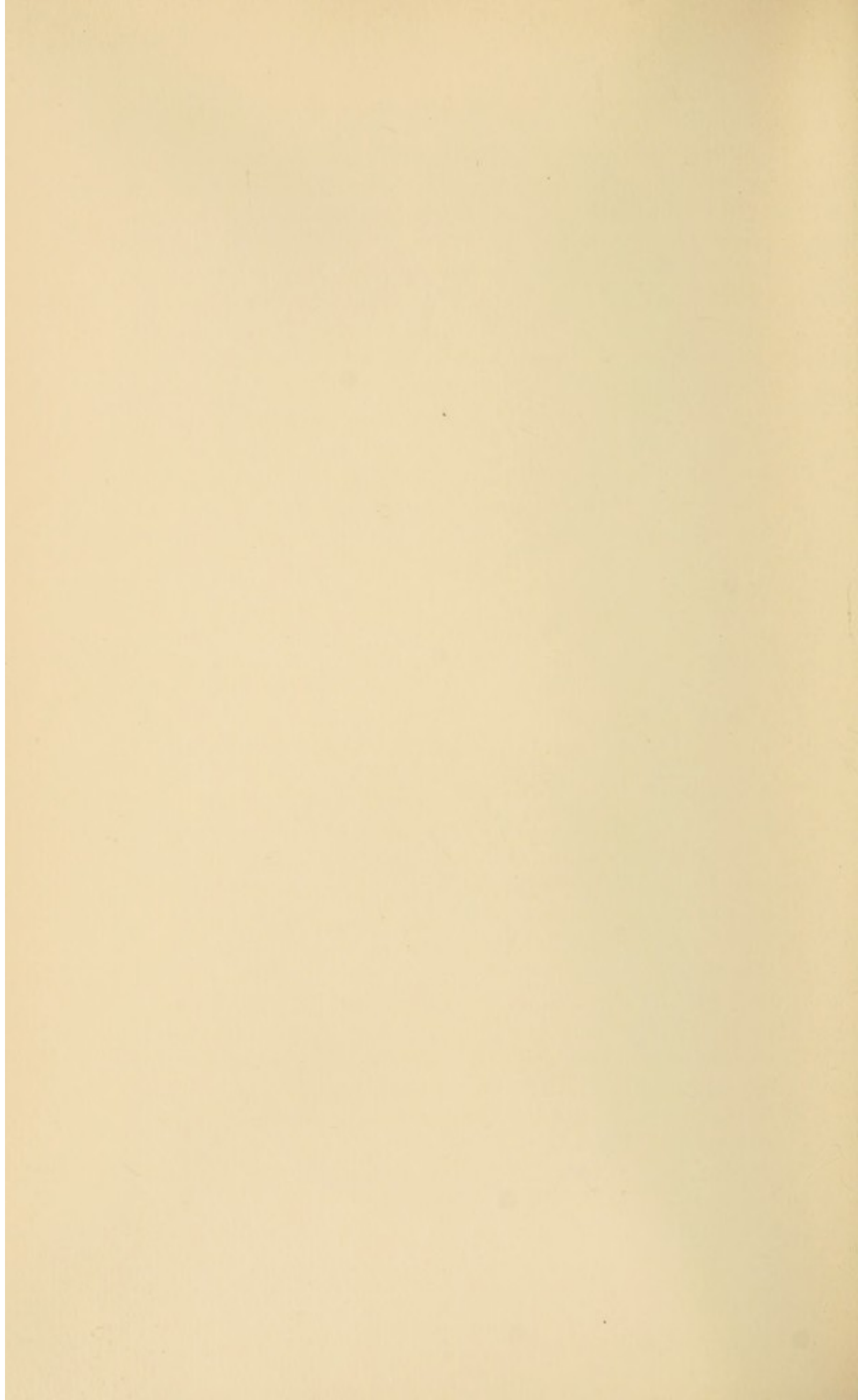
X 300.

SARCOMA, (Small Round Cell).



X 120.

SARCOMA, (Small Spindle Cell).



was removed in one case which ended fatally, and in six cases which recovered. The seventh rib was resected in one case, and the axillary artery was tied in one case with favorable result.

"If the penetrating wounds of the thorax reported in 1898 be added to those just mentioned, the fatal cases are found to constitute twenty-seven per cent. of the aggregate. . . . The aggregate number of deaths, fifty-five, forms twenty-seven per cent. of the aggregate number of cases, one hundred and ninety-eight." (Report of the Surgeon-General, U. S. A., June 30, 1900.)

(For Symptoms, Diagnosis, and Treatment, see Chapter on Lacerated and Incised Wounds of the Lung; also Chapter on Foreign Bodies.)

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LACERATED AND INCISED WOUNDS.—Under this caption are considered all those varieties of lung injury which have not been treated elsewhere. This is in accordance with the classification commonly employed.

Historical (1770-1903).—A fellow-officer wounded with General Wolfe at Quebec, 1759, is said to have recovered after the removal of a large portion of the injured lung. (Gould and Pyles's *Anomalies and Curiosities of Medicine*, Philadelphia, 1897.) As early as 1777, Pew gave an account of a most wonderful recovery after a wound through the lung. Ruddock mentions cases of penetrating wounds of both lungs with recovery. A paper in the *London Medical Times* (1844) gives the particulars of a penetrating wound of the right lung with

emphysema. Sewell (1849) reported a case of transfixion of the chest of a youth eighteen years old, who accidentally fell on a scythe blade, the point passing under the right axilla, between the third and fourth ribs straight through the chest. There was no hæmoptysis, and the patient soon recovered.

Core (1859) reported a case of laceration of the lung and collapse of the organ without fracture of the ribs. In the Sydenham Society Transactions (1860) appears Casper's report (pp. 1-165) of two cases of wound of the lung; in one case a carriage pole and in the other the end of a mast passed through the lung. Both cases recovered. Finnell (1861) had a case of a man struck by an iron bar. It penetrated the thorax three inches into the floor, having entered posteriorly between the ninth and tenth ribs of the left side, coming out anteriorly between the fifth and sixth ribs. There was but slight constitutional disturbance, the man soon recovered.

Chicon treated a wound of the lung, where there was much purulent matter, by thoracentesis. Adams (1867) reported a case of penetrating wound of the right lung with external emphysema. Longmore (1871) gives a case where a lance transfixed the right side of the chest and lung; the soldier recovered. Rivington (1871) reported an interesting case of an incised wound of the shoulder and chest; the lung was penetrated. There was paralysis agitans, apparently hereditary; recovery ensued. Pozzi (1873) reported a complicated case of wound of the lung; there was no hæmoptysis, but ossiform concretions formed, simulating fracture of the ribs. There was also supuration of the pericardium, resulting in death. De Morgan (1874) reported a case of penetrating wound of the chest with an iron rail, with laceration of the lung and death.

Richards (1875) reported a wound of the lung with recovery, and (1880) an equally interesting case of recovery from a penetrating wound of the thorax with immediate pneumocele, requiring excision of a portion of the lung. Brown reports a case of a boy, who, while running to a fire, struck the point of

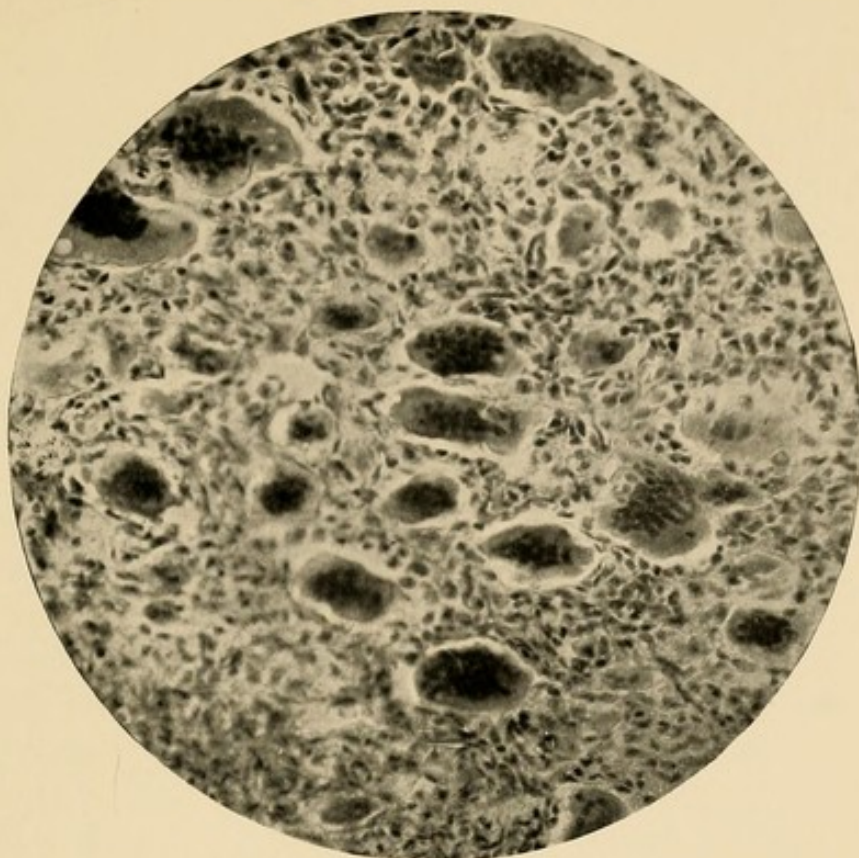
a carriage shaft, which passed through the left chest below the nipple. There was no hæmorrhage; the boy recovered. Inglott (1890) reported a case of wound of the right lung, followed by immediate recovery.

Brokaw reported the case of a shipping-clerk, who received a thoracic wound, extending from the third rib to within one inch of the navel, thirteen and one-half inches long, completely severing all the muscular and cartilaginous structures. In addition, there was a terrible abdominal wound, causing almost complete intestinal evisceration. The lung partially collapsed. The cartilages were ligated with heavy silk, and hæmorrhage checked by ligature and by packing gauze in the interchondral spaces. The patient was discharged in a little over a month, the only evil result remaining being a small ventral hernia.

Sadler (1891) reported a case of stab wound of the lung. Montel (1891) reported a lung wound and Reading (1891) reported a case of perforating wound of the right lung with recovery. Hodenpyl (1893) reported a perforating wound and Alexander (1893) had a case of a stab wound of the lung. Lopez (1894) reported a recovery in a case of penetrating wound caused by a sword.

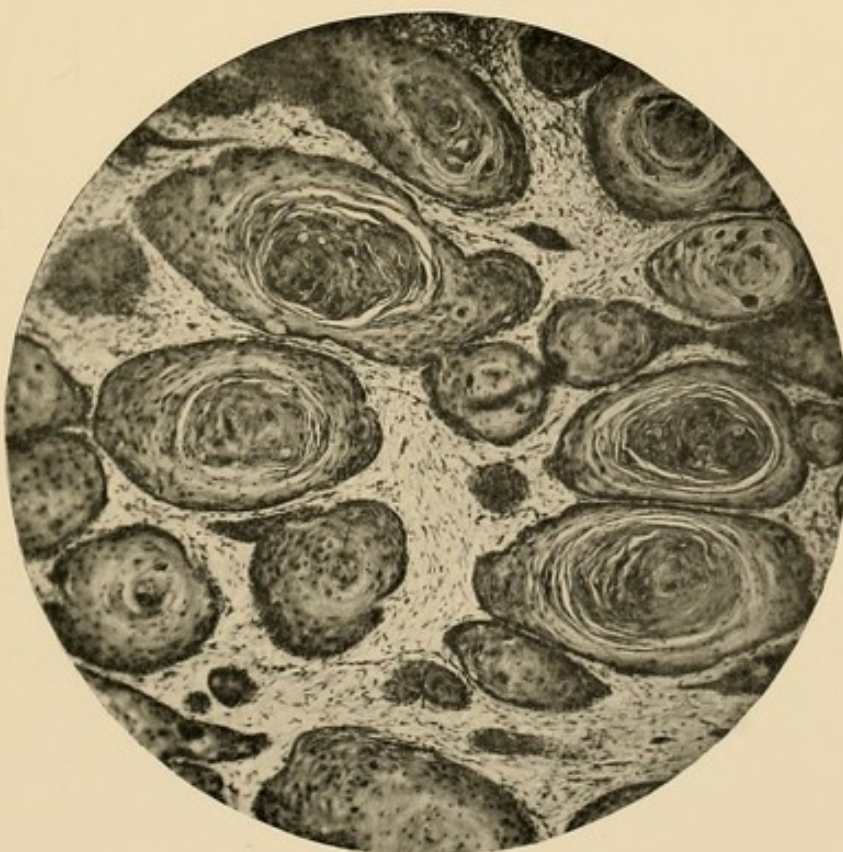
Pyle (1894) reported a case of a boy who had been run over by a hose-cart. There were no signs of external injury and no fracture of the ribs. There was marked emphysema; the neck and side of face were greatly swollen by the extravasated air; the tissues of arm were also infiltrated with air; consciousness was never lost. On the eighth day, the temperature was normal. The boy left the hospital apparently well, without evidence of pulmonary embarrassment. He developed diaphragmatic breathing which seemed fully sufficient.

In the *Annals of Universal Medical Science* (1872), there appeared an extraordinary case of a boy, fifteen years of age, who, by falling into the machinery of an elevator, was severely injured about the chest; there were six extensive lacerations, five through the skin, about six inches long, and one through



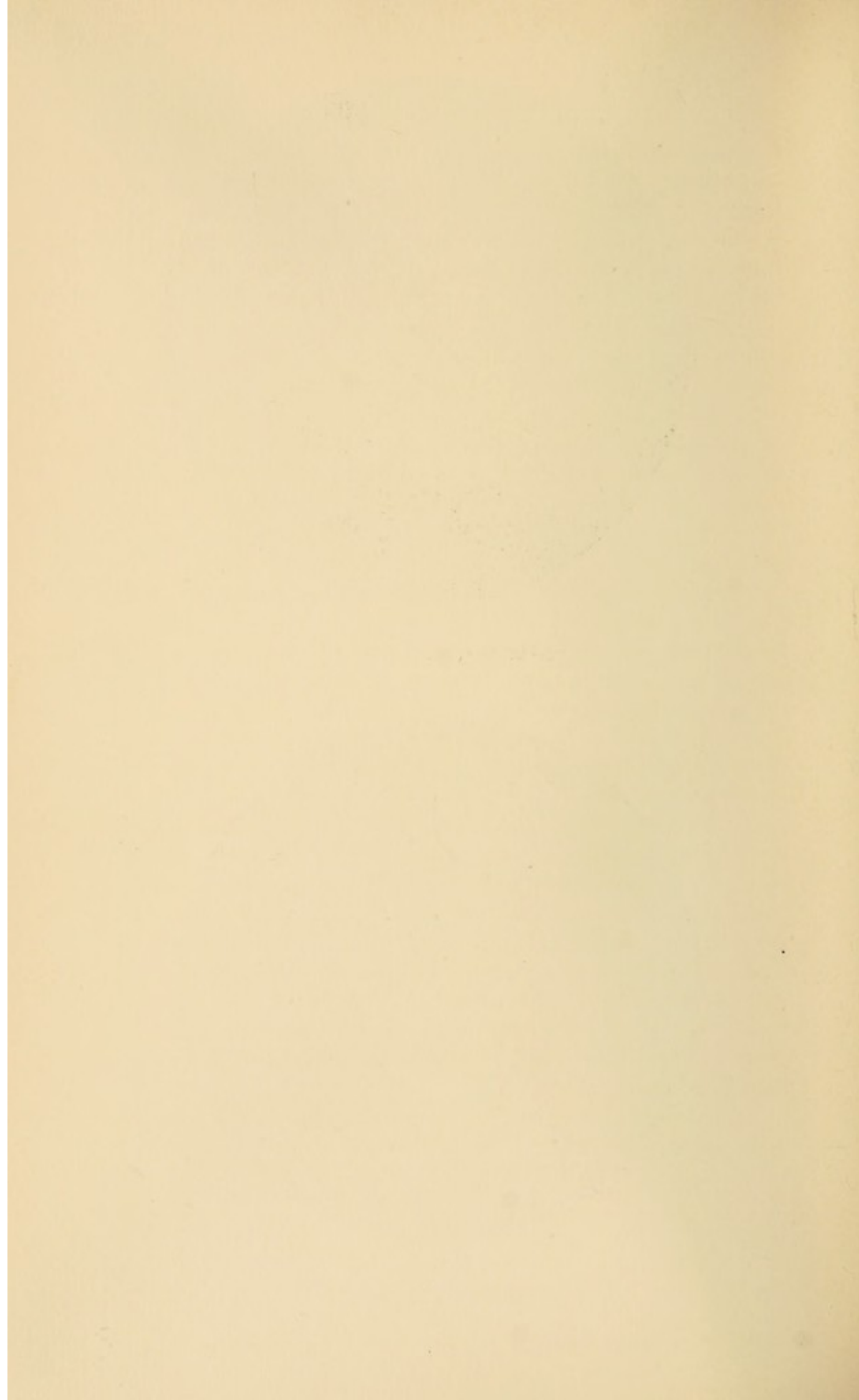
X 110.

SARCOMA, (Giant Cell).



X 70.

CARCINOMA, (Epithelial).



the chest about eight inches long. The third, fourth, fifth and sixth ribs were fractured and torn apart, and about an inch of the fourth rib was lost. Several jagged fragments were removed. A portion of the pleura, two by four inches, had been torn away, exposing the pericardium and the left lung, showing the former to have been penetrated, and the latter torn. The lung collapsed completely, and for three or four months no air seemed to enter it, but respiration gradually returned. The patient finally recovered, without lateral curvature.

There is an Indian report of penetrating wound of the lung by Roy (1895). Gazotti (1897) also reported his operation for a traumatic injury of the lung. Tunnin (1897-98) wrote on surgical intervention in grave injuries of the lung, and also on lung surgery in general. Hadra (1898) indorses pneumonotomy, as does Doyen (1898) in an article on surgery of the lungs. Tait (1898) uses the word "pneumonotomy" in reporting a case.

In 1894 the author had a patient, who, in 1887 had been stabbed with a knife. The wound, three inches long, extended through the intercostal space. Six ribs were resected and the lung was found atrophied to the size of a man's fist. No normal lung tissue remained. Patient was in excellent condition April 1, 1903.

In 1869 G. R. Ricketts was called to treat a man who had been thrown on a circular saw. It was found that all the ribs on the right side had been divided, within two inches of the spinal column. The scapula was divided also. The teeth of the saw penetrated the lung itself, severing the second branch of the right bronchus. The wound was cleaned of débris (part of the man's shirt had been forced into the thoracic cavity), and closed with sixty-nine sutures. In spite of infection, which occurred, the man recovered. He is alive and well thirty-four years after the accident.

Only penetrating wounds and injuries of the chest wall involving the continuity of the lung are herein considered. All

other wounds of the chest wall have been disregarded. Research work to determine what can, and what cannot be done with the lung, has been slight in comparison with the work done on other organs of the body. However, enough has been accomplished to establish many important facts. The surgery involved in this class of cases is, perhaps, more interesting, although less frequent, than tuberculous abscesses. More hope, however, can be given. In one, a chronic condition, which has become desperate and hopeless, is encountered, while in the other, a healthy subject is usually the victim.

Of rupture, gunshot wounds, and injury to lung from laceration, hæmorrhage is one of the most important symptoms. It may be rapid or slow, primary or secondary, or it may be latent from any of the thoracic or pulmonary vessels. If hæmorrhage be latent, it may in most cases be from the thoracic or pulmonary vessels. If the hæmorrhage be external, the intercostal or internal mammary, or both, are injured. The signs of lung bleeding are dyspnœa, rapid and difficult breathing, amphoric sound, metallic tinkling, faintness, pale, livid lips, pain, cough, cold sweat, vomiting, anxiety, oppressed circulation, engorgement of lung, dusky countenance, and hard pulse.

Air in wound or the expectoration of froth may confuse diagnosis. Blood may escape from the lobe into the pleural cavity, and thence through the chest wound, bronchus, or mouth, into the pericardial or mediastinal space, the œsophagus, or into the peritoneal cavity. Each or all of these conditions may exist at one and the same time.

When the hæmorrhage is intrathoracic there is frequently hæmoptysis. This may be distinguished by the presence of râles in the bronchi of the affected lung, history of injury, etc. Hæmopericardium causes an increase in the area of cardiac dullness and interferes with the heart's action. Hæmomediastinum produces physical signs similar to those of abscess. If hæmothorax or pneumothorax be present without hæmoptysis the

lung is intact, and, usually, the bleeding parietal. Hæmopericardium is not always proof of injury to the heart itself. If there is hæmoptysis, there are more râles in the injured lung than in the sound one.

One of the curious facts noticed by ancient writers was the amelioration of the symptoms caused by thoracic wounds after hæmorrhage from other locations, and naturally in the treatment of such injuries, this circumstance was used in advocacy of depletion. (Gould and Pyle, 1897.)

Hæmoptysis may be due to a blow upon a pathologic lung where cysts, abscess, tumors, etc., are present, and may, therefore, be confusing. It may also come from the trachea, nose, or mouth. The patient may not spit or cough blood in severe laceration of the lung, especially, in gunshot or penetrating wounds, other than that from a knife or sharp-pointed instrument. Contusion may cause emphysema, and it is always more or less present in the lung to which it is confined, unless the parietal pleura is lacerated, in which case the emphysema may extend to the chest wall and become local or general. Subcutaneous emphysema rarely occurs after a rupture of the lung, unless there is pneumothorax. Pneumothorax, hæmothorax, pleurisy with or without effusion, rupture of lung or diaphragm, may appear alone or together soon after injury. Emphysema and pneumothorax are of little importance, especially the latter. Percussion is of little or any value if air is in the pleural cavity, or a large bronchus be severed, in which case, the lobe which it supplies would be retracted upon itself.

Senn claims that a rise in temperature during the first forty-eight hours is no indication of the existence of sepsis, as with few exceptions, it indicates a febrile disturbance, caused by the absorption of fibrin ferment, the so-called "fermentation fever." He also claims "That rest in the recumbent position, with the chest slightly elevated, is essential in aiding spontaneous arrest of hæmorrhage, and in preventing complications." (*Journal American Medical Association*, July 9, 1898.)

Others claim that in cases where there is fluid in the pleural cavity a rise in temperature indicates infection.

When the laceration of the lung is extensive, there is immediate hæmorrhage into the bronchi, and hæmoptysis, immediate and copious. There is severe shock and collapse, thready pulse, labored and irregular breathing, and subnormal temperature. Physical examination reveals evidence of pneumothorax. The first twenty-four hours are full of danger. The patient may die of shock, loss of blood, or by drowning in his own blood. After the shock has passed away, the case is that of pneumothorax with a tendency to secondary inflammation of the lung and pleura. If the injury be kept free from infection, and, if there is no large hæmatoma, recovery will take place in a few days.

The prognosis depends on the reaction of the vital forces of the patient. But it must be remembered that where there is a large external wound, there is danger from external hæmorrhage and sepsis, as well as from internal hæmorrhage and sepsis. In such a case there may be traumatopnœa instead of emphysema.

When the lung has been injured, whether the wound be a simple rupture or laceration of the lung, there is often injury to the mediastinal and thoracic vessels. In such cases, if the great vessels are injured, immediate and fatal hæmorrhage results. There may be later complications, such as aneurysm and mediastinal abscess.

In case of injury to the thoracic duct, it is said to heal if the duct is not completely divided. Thorough examination should be made of the mediastinal space. If clots be present, they must be removed, incising the chest wall if necessary.

Treatment.—Venesection is especially desirable when asphyxia is present; it will relieve dyspnœa, as shown by actual experiment. Although it has been stated that about one in ten cases of lung injuries should be venesected, none has as yet been reported treated in this way.

Dissect bronchus and ligate, using small needle with kangaroo tendon. Dissect out all bleeding vessels, ligate and pack with gauze. Adhesions are greater in the aged. Take temperature before and after in axilla. Catgut, unless chromicised, should not be used in lung surgery. Air must be excluded from chest, which necessitates complete closure of bronchi, which is difficult with ligature. Palpate lung with the finger.

Small balls from small-bore guns are more likely to lodge in the lungs. Such cases are more favorable, as the bullets are more likely to become encysted. Mortality is higher when bullets pass through the chest from side to side, or at the base of a lobe. But the nearer the diaphragm the wound may be, the more favorably is it situated for drainage, and the more favorable is the prognosis.

The care of wounds of the lung, whether gunshot, incised, or lacerated, has been the subject of great controversy. Dr. Antona recommends in rupture of the lung to provoke coughing, compressing the sound lung at the same time, which causes the diseased lung to bulge out through the wound, and prevents pneumothorax. (Surgery of the Lung, *Journal American Medical Association*, January 16, 1898, p. 169, col. xxx.)

Do not move or examine the patient; never place the patient erect, nor percuss, or cause deep inspiration, or expiration. Prevent coughing by giving codeia, or morphine if necessary. Watch color of skin, expression of face, and pulse. Determine, if possible before operating, whether or not the diaphragm is injured, as it may be necessary to open both the thoracic and abdominal cavities.

Gunshot wounds, sometimes simulate those from a knife. The mortality is about sixty per cent. on the field of battle.

Dupuytren, Pirigoff, Gross, Erichsen, and others used the probe. Daunne, Legonest and the more modern writers do not use the probe or finger. Dessault, Richter and B. Bell raised serious objections, and Foulmart opposed sounding in all cases of penetrating wounds. The external wound should never be

hermetically sealed, as suggested by Howard. Deunne says, "Examine the chest," old masters say not to do so. This is a matter of judgment on the part of the surgeon.

Wound of the diaphragm should not, however, prevent the adoption of surgical measures. (*Journal American Medical Association*, Vol. XXX, p. 140, Vol. XXIX, p. 1207.)

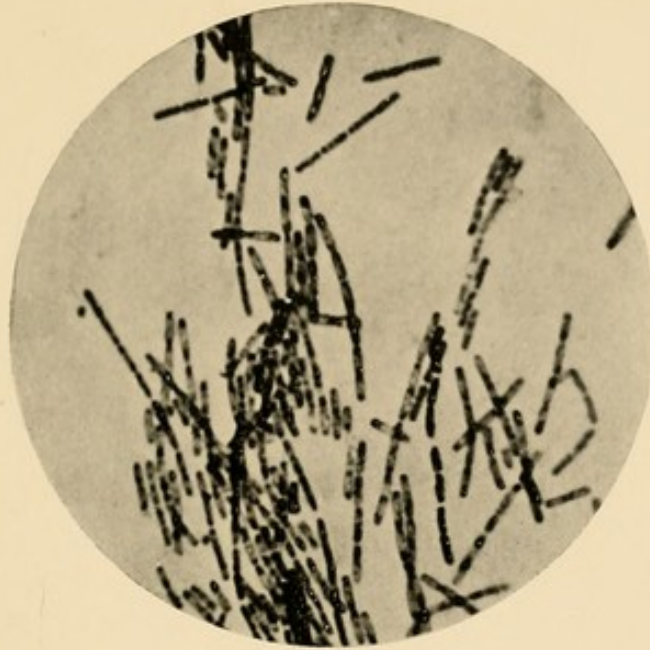
The treatment of hæmorrhage is of great importance in this connection. To stop hæmorrhage from the great vessels, all that can be done is to keep the patient absolutely quiet, using morphine liberally, and possibly gelatine in one per cent. solution hypodermically or in the rectum.

For hæmorrhage from the lung the expectant course is advocated by most surgeons, although some say to cut down upon and pack the visceral wound. If nothing is done, the lung will bleed until it has completely retracted; that is, if there be no adhesions, and if the pleura be not full of blood.

Some writers favor "splinting" the lung by the injection of air into the pleura. One prominent writer makes the astounding assertion that "clotting" seems not to occur in the pleura of man. But experiments and observation prove that this statement is untrue. The blood does clot in the pleura as in any other part of the body.

In case of laceration of the lung, where there is a large external wound, local therapeusis is required to prevent external hæmorrhage and sepsis. The wound of the thoracic walls should be treated as an ordinary surgical wound. Endeavor to obtain asepsis by removing foreign bodies and by copious irrigation with sterile solutions. Pressure or ligature will secure hæmostasis. Do not allow any of the solution that is used to get into the pleural cavity. Only simple aseptic, and *not* antiseptic, solutions should be used; so that if any part of the solution does get into the pleural cavity, it will do as little harm as possible.

Bandaging with adhesive plaster, muslin, or plaster of Paris, in an attempt at fixation of the chest to place the lung at rest



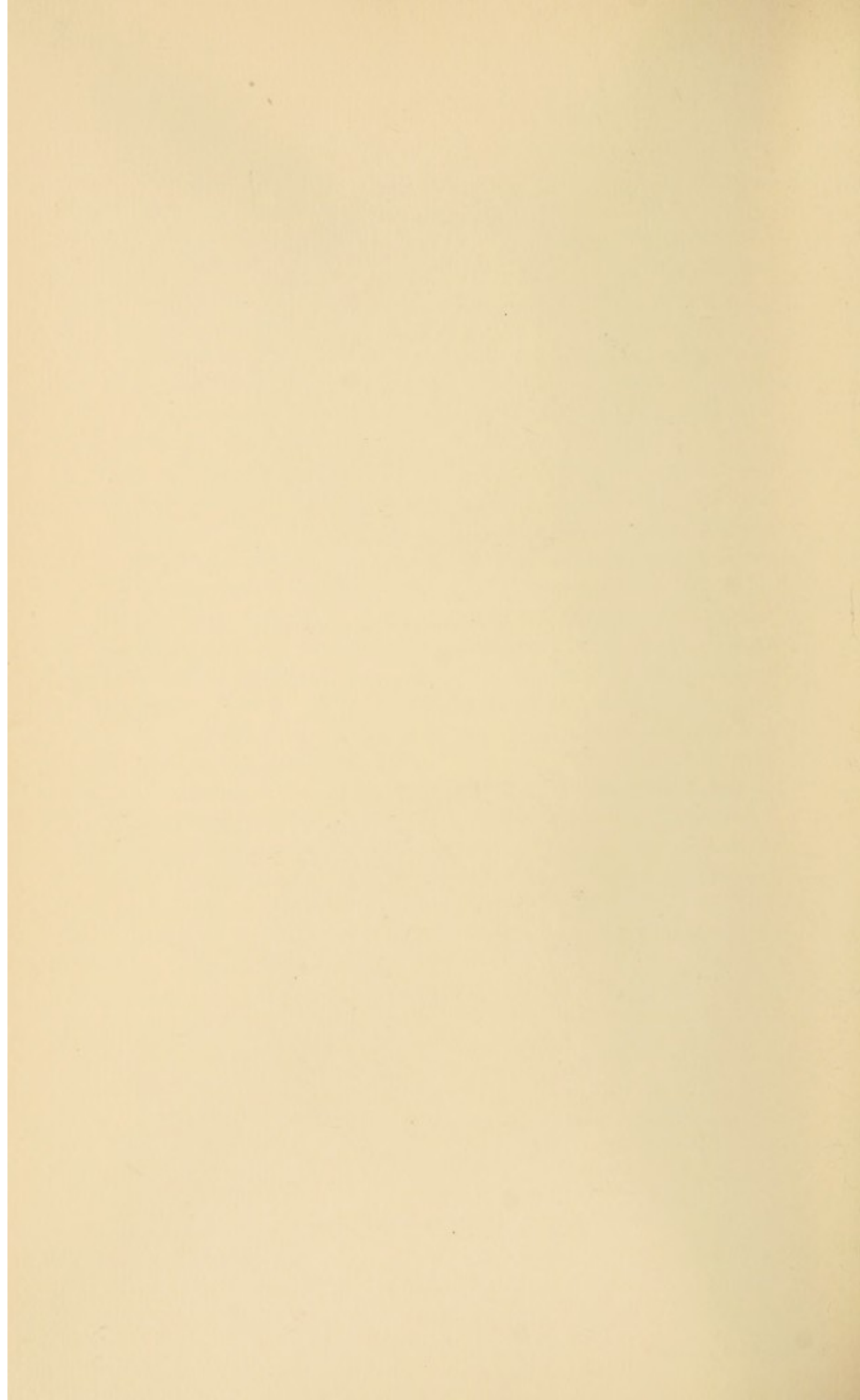
X 1000.

BACILLUS ANTHRACIS, (Spores).



X 1000.

BACILLUS AEROGENES CAPSULATUS.



is useless, for it cannot be done. The lung when inflated, presses upon the chest wall equally in all directions so that if the bony chest could be prevented from expanding in any of its diameters, the diaphragm would give compensation. The lung cannot be put at perfect ease even when the chest wall is open, for even then there is slight motion.

(See chapters on Foreign Bodies, Surgery of the Lungs, and Gunshot Wounds.)

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CHAPTER VII

FOREIGN BODIES

FOREIGN bodies in the lung or bronchi may be removed by coughing, and may escape through the chest wall into the trachea, œsophagus, or through the diaphragm, and from the subcutaneous tissue at almost any point upon the body. Small foreign bodies, such as bird-shot, may become encysted in the lung and remain harmless, while others may gravitate, from their excessive weight, through the entire lobe and drop into the pleural cavity, to cause subsequent serious trouble. Foreign bodies may enter the chest cavity, and only the chest wall be injured. Their course depends upon the angle described by the missile.

Experiments with the x ray show that the position of a foreign body in the lung, when expanded, is changed when the chest is opened and the lung contracts. The foreign body may not be in the bronchus but in the lung tissue.

Historical (1671-1903).—Buchtfield (1671-72) was among the earliest writers who published anything with reference to foreign bodies in the lungs. Tillingius (1688) refers to calculi having been expelled from the lungs. Kirby (1700) wrote on the same subject and Arnot (1742) published cases of bone having been removed by coughing.

De Carendeffez (1803) gave an analytical description of certain stony concretions coughed up from the lungs; Valentine (1807) reported his observations on stony concretions expectorated by a phthisical patient; Gilroy (1831) reported a case of pulmonary abscess caused by the lodgement of a chicken-

bone in one of the bronchi. Graham-Craig (1834) reported a case of the deposit of charcoal in the lungs of a miner (*anthracosis*). Brigham (1838) published a case in which a brass nail was found in the lung; Burford (1838) reported cases of concretions in the lungs. Judd (1838) reported on calcareous and bone-like concretions, and Barker (1842) reported a case of foreign body in the lung.

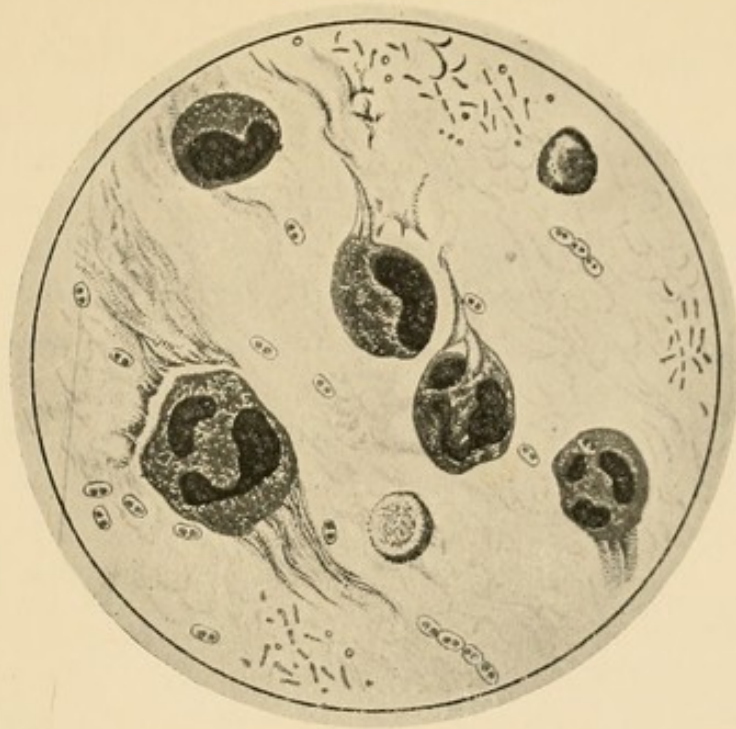
Maikeller (1846) reported a case of black phthisis, or ulceration, induced by carbonaceous accumulations in the lungs of coal miners. There are numerous reports of cases of bones, and various kinds of foreign bodies having been expelled from the lungs, one of which is that of Struthers (1852), where a foreign body was in the bronchus for four and one-half years. The case terminated fatally by gangrene.

Wales (1854) reported a case of bronchitis occurring in the person of a muslin gassurger in whom the expectoration was so charged with charcoal as to resemble that of pneumonia.

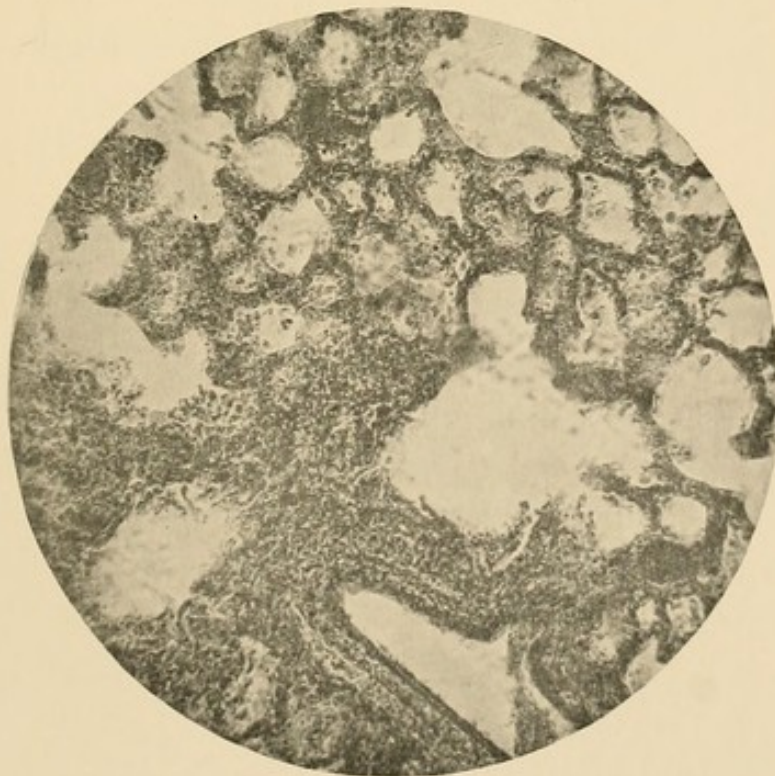
Hamilton (1854) contributes to the literature of the expectoration of calcareous bodies. The calcareous bodies are formed in the pulmonary veins and are about the size of bird-shot and yellowish-white in color. They are composed of carbonate or phosphate of lime.

Emison (1856) had a case in which a bullet was expelled by coughing, two weeks after it had entered the thorax. Leach gave a case in which a bullet was impacted in the chest for forty-two years. Hamilton (1858) reported a case in which he removed a knife from the left pleural cavity by the exsection of the sixth rib, and the introduction of the hand. Bristowe (1857) reported a case of a foreign body in the lung. Evan (1861) gave an account of a case of abscess of the lung from the presence of a foreign body, which was evacuated through the bronchial tubes and through the thoracic walls; the patient recovered.

There seems to be no way by which small foreign bodies, such as coal deposits, can be removed from the pulmonary

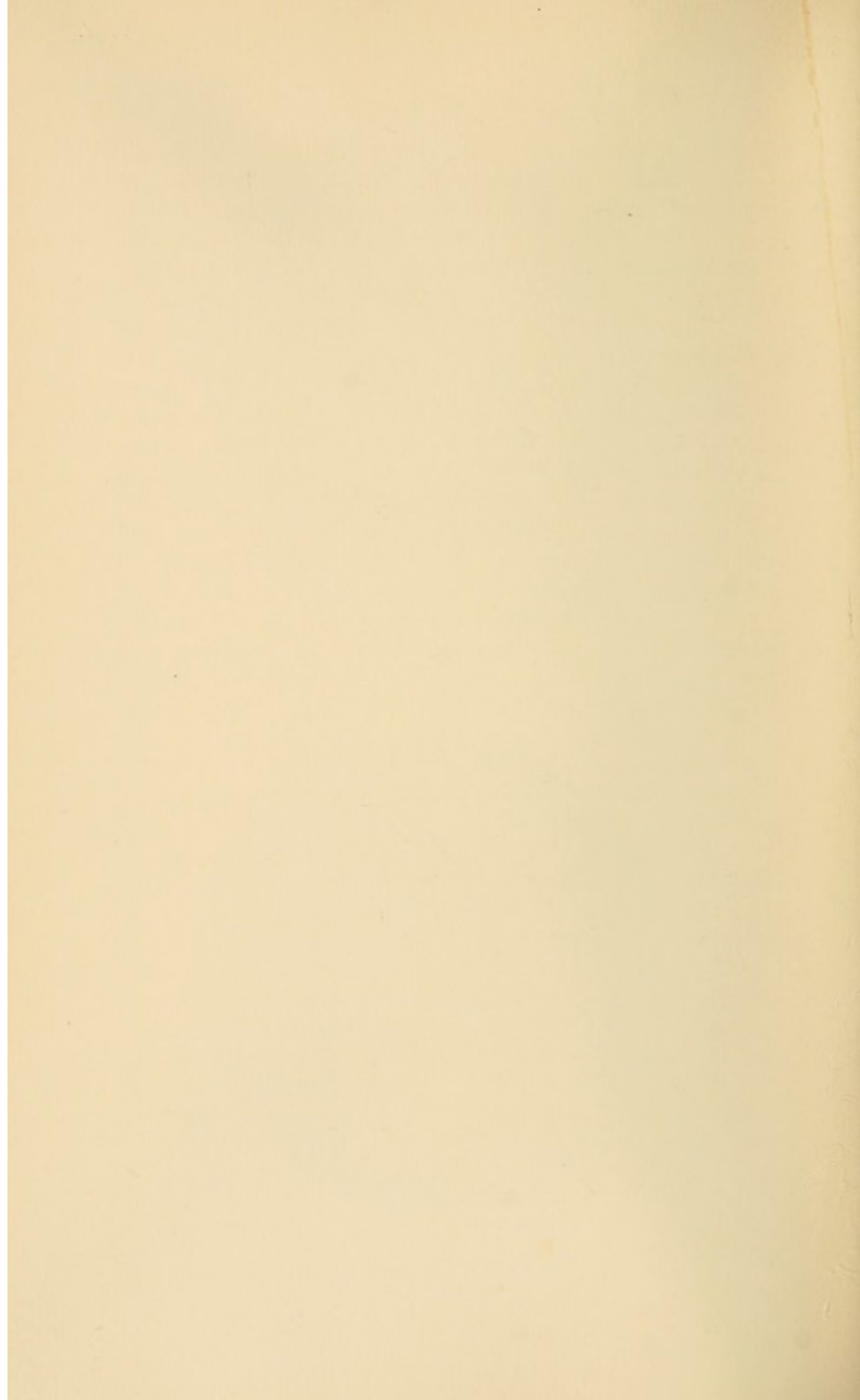


BACILLUS FRIEDLANDER, (Acute Croupous Pneumonia).
(Copied from another publication.)



X 65.

PNEUMONIA, (Human Lung).



tract. They are, no doubt, a prominent factor in the causation of bronchitis and tuberculosis, especially.

Greenhow (1864) reported on specimens of coal miners' black lungs. Bruce (1866-67) reported a case of necrosis of the rib, encapsuled for three years in the lung. Snyder speaks of a piece of a knife blade which was lodged in the chest twelve years and finally coughed up. J. P. Logan (1872) had a case of pneumonia in a child, following an abscess caused by a cantaloupe seed in the lung. Day (1873) gives a case of the passage of a foreign body through the right lung with recovery.

Johnston of Baltimore (1876), in the presence of Sir Morrell Mackenzie, removed a toy locomotive from the subglottic cavity by tracheotomy and thyrectomy. G. R. Ricketts (1873) had a case of a girl, six years old, who had a pebble in the right lung; it was never expelled. The child died two years later from tuberculosis.

On page 372, Volume II, Gross's "Surgery," is found the case of Arnot, where recovery ensued after the removal of a piece of iron hoop which had remained in the lung fourteen years. On page 371 of the same volume is found a case, mentioned by Bayer, of a man wounded at the battle of Novi who lived seven years with a ball in the base of the left lung. Guillon's case of a piece of fence nail remaining eighteen years in the lung, is given on page 372 of the same volume.

Knox (1885) also reported a case of a foreign body in the lung, and Bloxam (1886) mentioned a case resulting from the swallowing of a fish-bone.

Lapeyre reported a case of an elderly gentleman who was suddenly slapped on the back while smoking a cigarette. This caused him to give a start, and the very deep inspiration which he naturally took caused the cigarette to be drawn into the right bronchus. Here it remained two months without revealing its presence in any way. Then circumscribed pneumonia and cardiac dropsy set in, and two months afterward the cigarette was expelled during a violent fit of coughing.

Dr. N. K. Moxley personally communicated to the author an account of a case that came under his care in which the silver tip of a spray tube was coughed up after having been forty days in the bronchus.

Kocher (1890) published his method of extracting foreign bodies from the lungs. Epler (1891) reported a case of foreign body in the lung.

Braun's work on treating cases of foreign bodies in the lungs appeared in 1891. Perez Valdes the same year had a paper on foreign bodies in the lungs and Middleton (1892) reported two cases. Smyth (1892) reported a similar case.

Rehtenbacher (1891) published his method of treatment and Schild (1893) wrote a paper on the same subject. Overall reported the presence of a silver tube in the lung for twenty years.

During the years of 1897-98, Farmer, Hogner, Yarbat, and Aynoly reported cases of foreign bodies in the lung; usually recovery followed treatment. Smith (1899) had a case of a foreign body in the lung, simulating tuberculosis. Winter and Coon have each reported cases, and Moffatt had a case of cartridge in the right bronchus.

Weist's record of one thousand cases of foreign body in the lung are very interesting; of one hundred and seventy-seven cases, sixty-six were expelled with recovery, twenty-six died without operation, and eighty-five underwent tracheotomy. Of the latter, sixty-six recovered, and nineteen died.

In one hundred and nine cases due to watermelon seed, seventy got well without operation, three died without it, thirty-four had tracheotomy performed, of which twenty-six recovered, and eight died. Coffee beans caused fifty-nine cases, most of which recovered without operation. In three hundred and seventy-one miscellaneous cases, two hundred and sixty-three had no operation, and one hundred and nine recovered; one hundred and eight had tracheotomy, and seventy-seven recovered. Of one thousand other cases, ninety-three had

tracheotomy performed, but foreign bodies could not be found in seventy-three of them. In five of these, the body was expelled through the mouth after the wound had closed. In sixty-three of the one thousand cases, forceps, hooks, etc., were used successfully to remove the body. The total number of operations was three hundred and thirty-eight, of which two hundred and forty-five recovered, and ninety-three died. The voices of ten were lost, and impaired in thirty-eight.

Where laryngotomy was performed, out of thirty-six cases, thirty recovered, and six died. Under laryngo-tracheotomy, out of twenty-six cases, nineteen recovered, and seven died. Under tracheotomy alone, of two hundred and seventy-six cases, one hundred and ninety-six recovered, and eighty died.

Durham compiled a list of five hundred and fifty-four cases. Of these two hundred and eighty-three were operated upon, and 24.8 per cent. died. Two hundred and seventy-one were not operated, and 42.5 per cent. died. There were one hundred and sixty-seven tracheotomies, of which thirty-seven, or 22.15 per cent., died. It was his opinion that the greater number of fatalities was not due to the operation, but to delay in its performance, or deficiency in the after treatment.

Gross tabulated one hundred and two cases. All of these were operated upon, with a mortality of 14.11 per cent. In eighty-one cases not operated, 35.91 per cent. died.

Combining both Durham's and Gross's tables, 24.48 per cent. of those operated died. The statistics of Gross and Durham favor operation, while those of Weist favor the expectant treatment.

Réclus states that if the foreign body becomes encysted, operation is not necessary; but if suppuration sets in, it must be treated surgically. Quincke believes that foreign bodies should be removed immediately; of seven cases two were cured, two improved, and three died. Hoffman reports one hundred and forty-seven cases; forty-six were cured by coughing up the foreign body; seven by the foreign body rupturing externally;

twenty-six through tracheotomy and extraction; eleven died in spite of tracheotomy; one died in spite of pneumonotomy; fifty-two were unoperated; one improved unoperated; and three uncertain were unoperated.

Freyan collected nine operated cases; four died, four improved, one was cured. Fowler (1874) had a case of aspirated tooth, with formation of abscess at base of right lung; pneumonotomy was performed, followed by recovery.

Nothnagel's "Encyclopedia of Practical Medicine," American Edition, 1902, p. 39, records thirteen cases of metal, glass, coins, and bullets in the bronchus; there were eight tracheotomies, with no deaths; no treatment in five, with one death. It also records sixty-five cases of needle, bone, or splinters, with twelve tracheotomies and five deaths; twenty-five cases without treatment and fourteen deaths; two where the foreign body was extracted with forceps through the mouth. In fifteen cases of hard-fruit seeds that do not swell in water, there were five tracheotomies with three deaths; three cases without treatment, and two deaths.

In seventeen cases of other foreign bodies, there were two tracheotomies with one death; six cases without treatment, and five deaths. The report of ninety cases of miscellaneous foreign bodies, gives thirty-five tracheotomies with five deaths; one case of laryngotomy with recovery; four cases of laryngo-tracheotomy with no deaths; thirty cases without treatment and twelve deaths; five cases of thoracoplasty with one death, and finally four cases of removal of foreign body with forceps, where all recovered.

Diagnosis.—Goodlee's contribution "On the effects produced by retention of foreign bodies for lengthened periods in the bronchial tubes," shows that the symptoms usually follow a definite course; cough, expectoration, which becomes foetid, pleurisy, emaciation, bronchopneumonia, and gangrene. These observations are corroborated by those of Fowler. But some of these symptoms are variable. That is, there may be,

or there may not be, expectoration of any character. There may be temperature, with or without pus, accompanied with rigors, occasionally. There may be no emaciation, but the rule is, emaciation, if the foreign body is allowed to remain. When a foreign body is of a sufficient size to remain fixed in the air passages, "there is great dyspnœa, violent cough, lividity of the countenance, writhing of the patient." Until the body is expelled, or descends into the lung, there will be variable lulls, followed by a recurrence of symptoms.

F. T. Stewart (*Philadelphia Medical Journal*, December 15, 1900, p. 1131) says: "Diminished inspiratory dilatation of one lung, and retention of resonance, with diminished vesicular murmur and vocal fremitus can only be caused by the constriction of a bronchus, or pneumothorax. The exact spot may be determined, if on repeated examinations, a whirring bronchus occupies the same place, together with fixed pain and palpable thrill over a spot corresponding to a bronchus."

The presence of a foreign body in the lung can usually be detected by auscultation. There is but little difference in this respect whether the object enters the lung by passing through the trachea, or passing directly through the chest wall. Percussion of the affected area will at times elicit dulness. There may, or may not be mucous râles, or pain. The respiratory sound may be present, or it may be absent. If the foreign body completely closes the bronchus, the respiratory sound is lost beyond the obstruction, but the pulmonary resonance will be normal. The same thing is true if an abscess, or a cyst of any character, has resulted from the presence of a foreign body. Under these circumstances the object will, almost invariably, be found within the cavity. There is also more or less induration in the neighborhood of the body, during the earlier stage of its presence. This is especially true in cases where an abscess of any character has formed.

Rushmore was among the first to attempt to remove a foreign body from a lung by opening the chest wall, and, although

the patient's condition would not permit him to complete the operation, due credit must be given him. This operation should be attempted only after all other methods have failed.

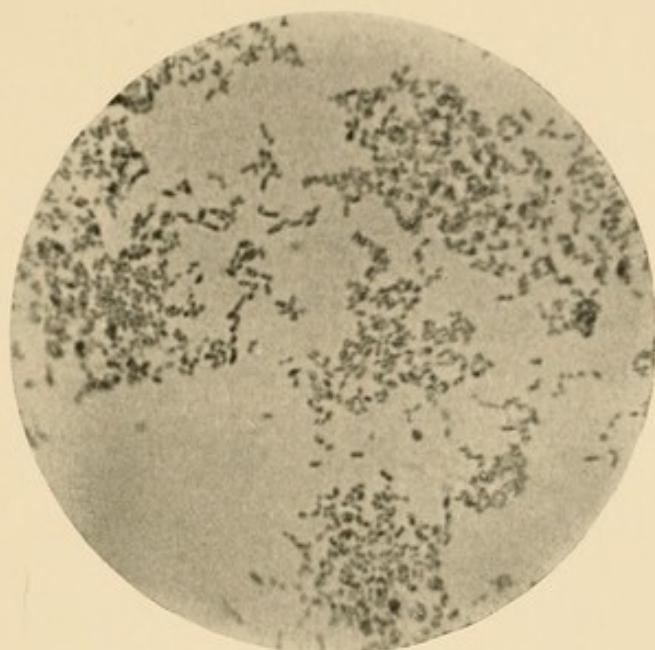
The x ray will, perhaps, locate the body, and if once located, all other things having failed, and there being great danger of death, then the chest wall should be opened.

Bronchiotomy must have been done very early, for we are told that Aretæus of Cappadocia, A.D. 50-80, brought the operation into disuse.

The possibilities of bronchiotomy in the right side are greater than in the left, as shown by anatomical research. Whether the bronchi should be reached from in front, or behind, is perhaps a question. However, the incision should be made in the long axis of the tube; the tube once opened, should not be closed except by packing, and the use of a drainage tube.

In this connection the experiments of Dr. De Forrest Willard with reference to opening the bronchi for the removal of foreign bodies should be consulted. ("Transactions of the American Surgical Association," Volume IX, p. 345.)

When it has been decided that an operation (brochiotomy) is necessary, the incision in the chest wall should be made as near as possible, and over, or above, the approximate position of the foreign body. In order to determine the exact location of the foreign body, the lung should be palpated with the finger, unless the body is exceedingly small, or near the base of the lung. The induration of the lung tissue, which always occurs in the area surrounding the foreign body, will also aid in locating it. When the area has been found by palpation, or by introducing a very small exploring needle here and there, that portion of the lung should be brought to the chest wall and allowed to unite. The union will be completed in four or five days. In doing this a good opportunity is offered to open the lobe and remove the foreign body. It also offers greater advantages for controlling hæmorrhage directly, by packing. The cut surfaces of the lungs would sooner or later become adherent



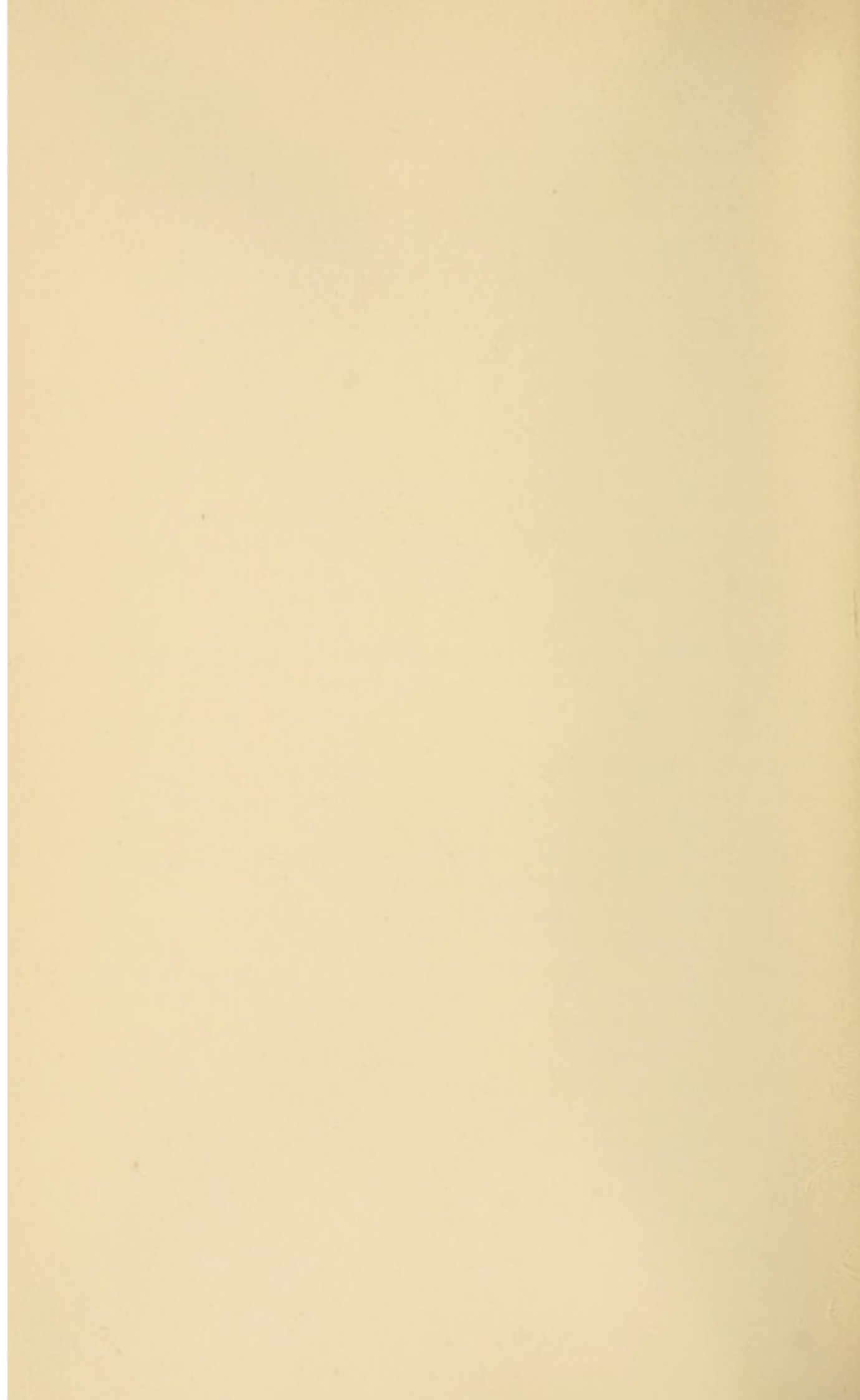
X 1000.

DIPLOCOCCUS, (Fraenkel).



X 1000.

BACILLUS TUBERCULOSIS.



in any case. This mode of procedure also allows great facilities for subsequent exploration. The amount of rib tissue to be removed depends upon the size of the area affected, and its location in the lobe.

For an explanation of the frequency of foreign bodies in the right and left lungs, one must refer to the combined tables of Gross, Cheedle, Saunders, Beleg, and Bourdillat, in which one hundred and fifty-six cases are given, with ninety-eight in the right lung, and fifty-eight in the left. The right bronchus is wider and shorter than the left, and is made up of from four to six rings. There can be no special reason given why foreign bodies should lodge oftener in the right than in the left. The left, however, is more perpendicular than the right, although slightly smaller in circumference. This difference should cause foreign bodies to enter the left bronchus more frequently from gravity alone. (See Chapter on Anatomy.)

Christovitch (*Revue de Chirurgie*, Paris, July 10, 1900), removed a ball from the lung, six days after its entry. He resected the fifth and sixth ribs at the point of the lung containing the ball, and delivered it; the wall of the cyst was incised and blood and pus escaping, the cavity was tamponed with gauze and the chest cavity drained; recovery ensued in sixty days.

Curtis in 1896 employed posterior thoracotomy for a foreign body in the bronchi. He resected portions of the fourth, fifth and sixth ribs subperiostially and outwardly from the tuberosities. He divided the periosteum and intercostal muscles so as not to injure the pleura. The latter was detached to give access to the root of the lung. The bronchus was not opened until the following day because of patient's condition. Not succeeding with the forceps, he incised the lung down to the object. He was again forced to discontinue the operation. The patient died forty-eight hours later from pre-existing pneumonia. ("Annals of Surgery," Volume XIII, 1895, p. 605.)

Dr. E. D. Ferguson (*American Medicine*, February 1,

1902, p. 194) records a case of a Durham tube in the right bronchus. It was removed through an incision in the right neck extending through the isthmus of the thyreoid to a point near the bifurcation of the bronchus. The patient recovered.

(See Chapter on Lacerated and Incised Wounds.)

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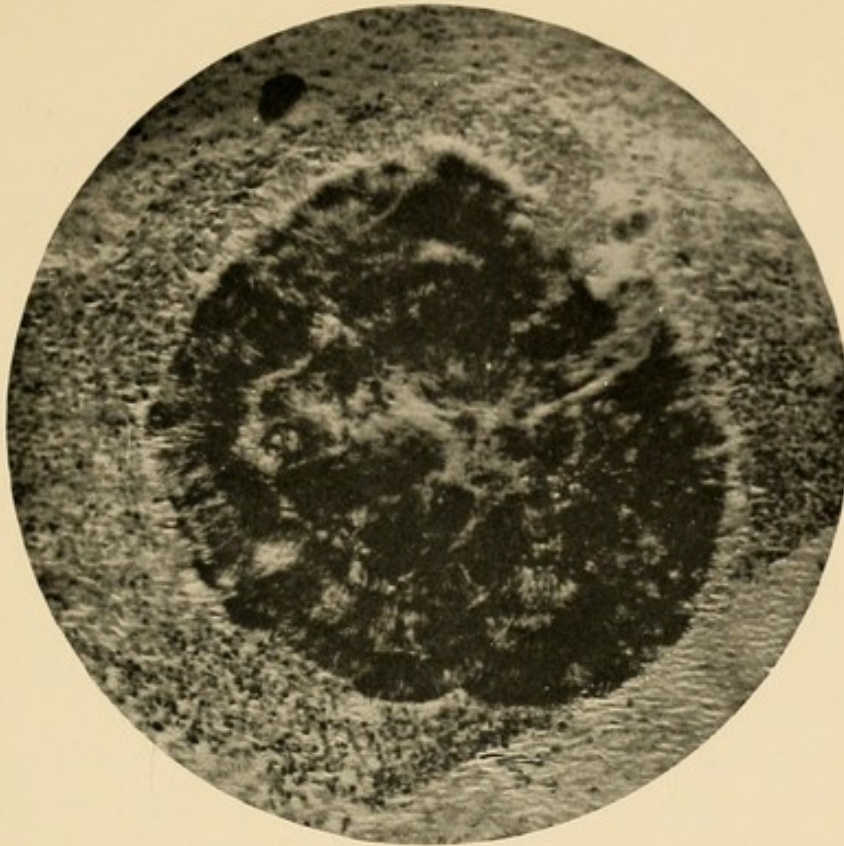
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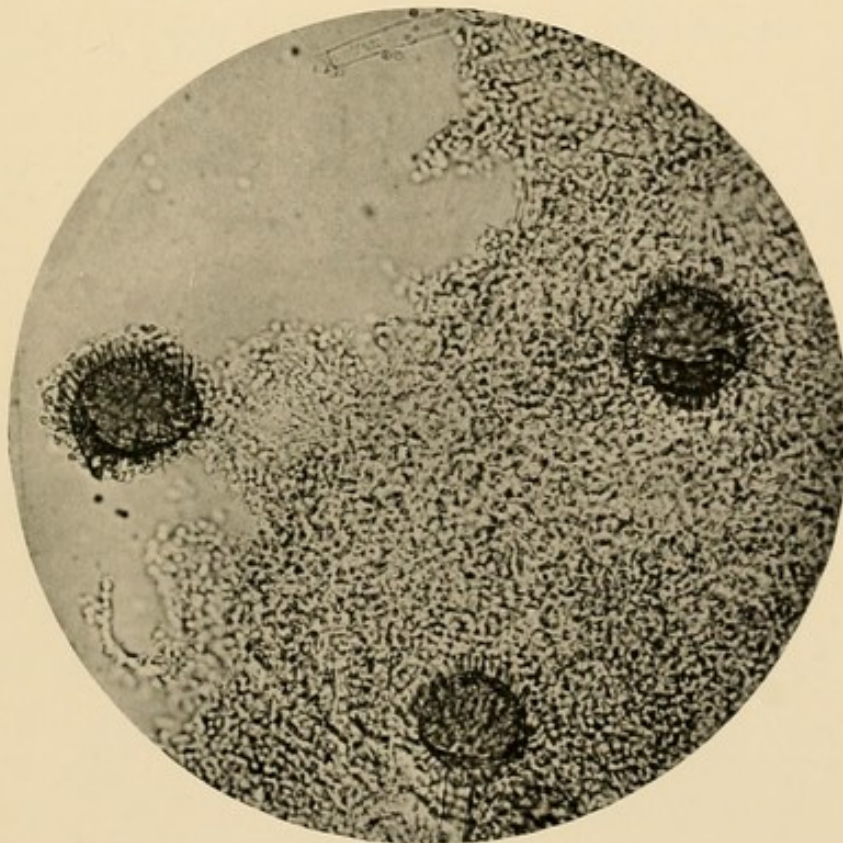
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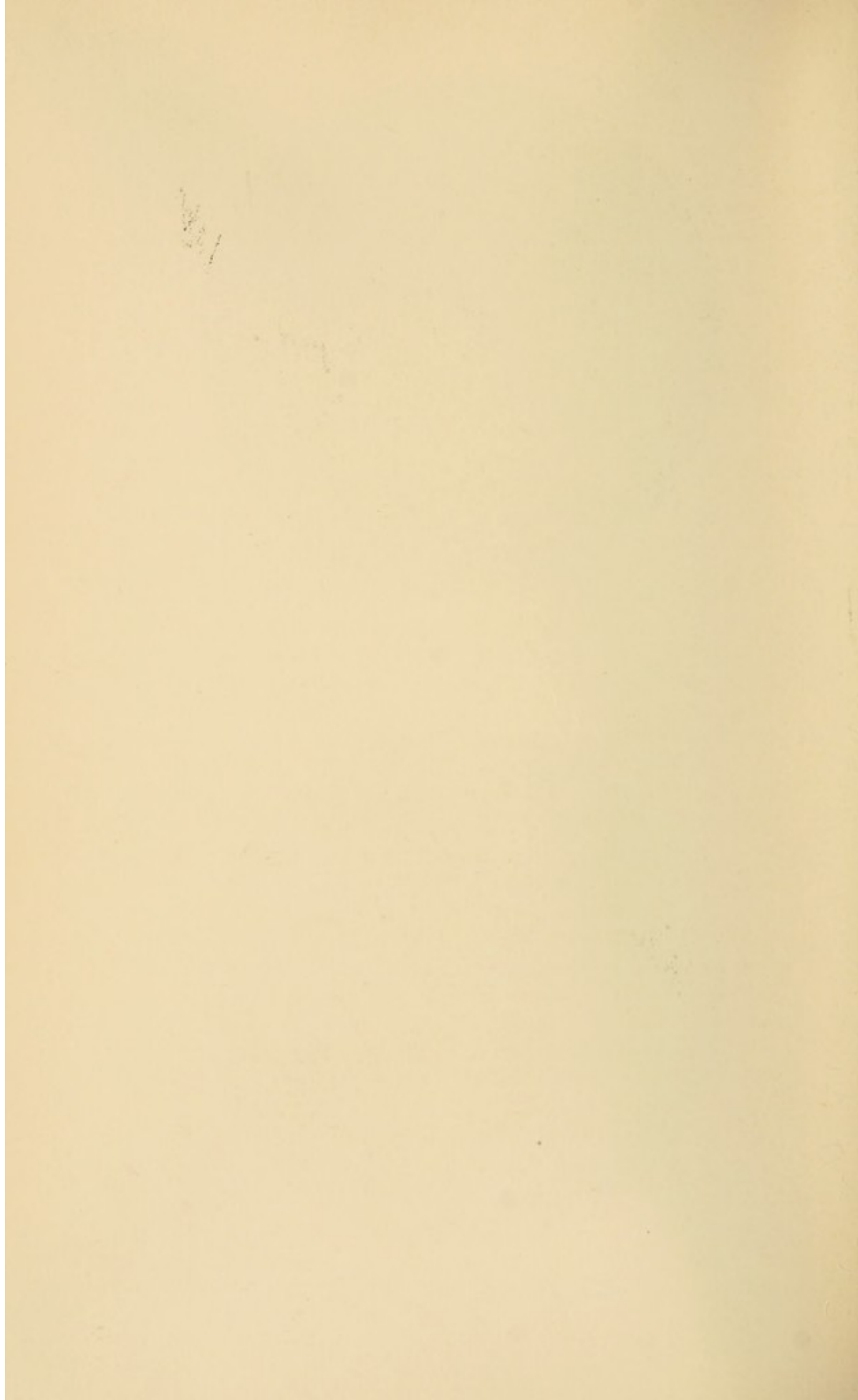
X 200.

ACTINOMYCES.



X 380.

ASPERGILLUS, (In Lung of Cow).



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CHAPTER VIII

ABSCESS—BRONCHIECTASIS

ABSCESS of the lung may be due to many causes, foreign bodies received through the trachea, infected cysts or otherwise, but more especially to tuberculosis.

Abscess is one of the most frequent surgical lesions of the lung. It is also the one pulmonary disease which yields most readily to surgical treatment. It may be single or multiple when due to any cause, and is more frequently multiple when of tuberculous origin. The base of the lungs is the most frequent location when tuberculous, while non-tuberculous abscess is less frequently found in this locality. One or all lobes of one or both lungs may contain one or more abscesses at the same time.

Historical (1710-1903).—Purman (1692) says that chest and lung incisions are necessary for hæmothorax, chest wounds, cavities of lung, etc. Bligny (1670) reports a case of phthisis which recovered after an accidental sabre cut. Balgious (1710) was one of the first to treat wounds of the lung by incising the pleura. He also advised the same for *phthisis ab ulcere pulmonis*. Bligny (1720), Barry and Boerhave (1726) advocated opening tuberculous abscesses; and Camparadon (1760) treated a case of abscess of the right lung and cured it by surgical intervention. Sharpe (1769) says severance of adhesions is not necessary; the cavity should be simply punctured with a lancet and drained. Pontean (1783) cured a case of abscess of the lung by incising it through the pleural adhesions as suggested by David (1780).

Among the first cases is one reported in 1753, in Porter's essay on "Abscess of the Lung." (*Journal American Medical Association*, March 7, 1891.) Gumprecht (1793) reported a case of abscess of the lung treated surgically. Richeraud incised a lung abscess with success. Faye (1797) cured an abscess by operation, but recovery was slow. Bell (1805) reports one cured case and several failures. Jaymes (1813) reports cured cases, while Callisen (1815), Nasse (1824-1844), advise operation for abscess; Nasse reporting successful cases.

Zaug (1818) reported eight cases of incised lung abscesses, Hawthorne (1819) reported a case of abscess cured by paracentesis, and Samson (1829) had a case of abscess in which he opened the lung; the patient died. Stokes (1832) cured an extensive pulmonary abscess by cicatrization; death resulted a year after from acute pleuropneumonia. It was found that a portion of the lung had been isolated, from the inflammatory action of the cicatrix.

Sayre (1842) reported a case of abscess from pneumonia of the left lung in a tuberculous patient, which terminated favorably by forming a fistulous opening between the third and fourth ribs, and an abscess in the substance of the lung. Hastings (1844) is the first to mention the treatment of tuberculous cavities. He reported two cases, entitling the first, "Tuberculous excavation of the lung, treated by perforating the cavity through the wall of the chest." The second case was treated by puncturing the tuberculous cavity.

Among the first to adopt energetic surgical treatment for pulmonary abscess was Robinson (1844). Graux of Brussels (1850) reported thirteen successive operations with fatal results. After the lapse of several years we find Dickson (1851) going back to Hawthorne's treatment of paracentesis for abscess of the lung. Fowler (1852) had a case of pneumonia terminating in abscess. From the autopsy it was found that rupture into the pleural cavity had occurred.

Hale (1855) gives details of a case requiring removal of

the left lung. Goodwin (1857) had a case of facial paralysis, followed by pleuropneumonia terminating in gangrenous abscess of the lung, opening externally. Bristowe (1857) reported a case in which a gangrenous cavity behind the root of the lung opened into the left bronchus and œsophagus.

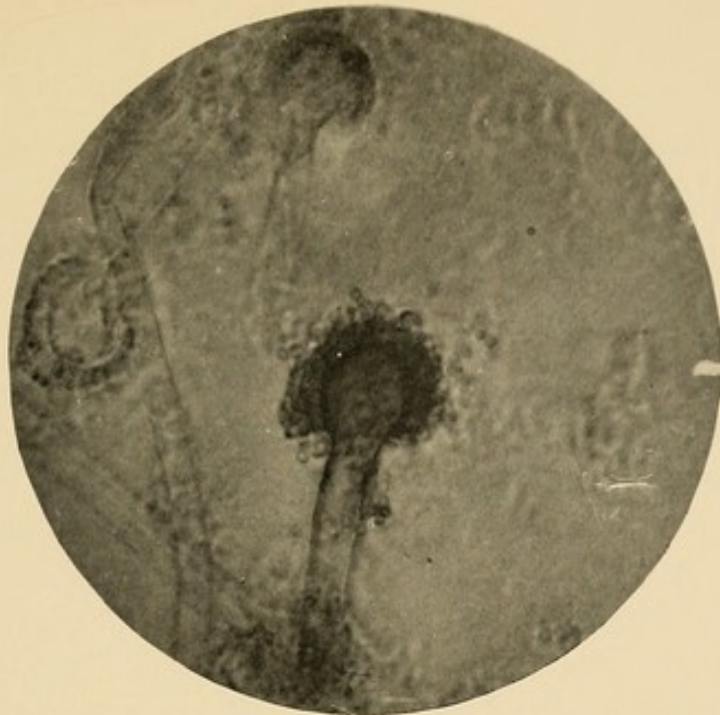
Catheterization of the air passages was done by Greene (1860). This, perhaps, influenced more or less the intrapulmonary injections which followed. Shann (1861) had a case of large abscess in the right lobe opening into the right lung, expectoration of large quantities of purulent matter, and subsequent external evacuation. The patient died.

Evans (1861) reports a case of abscess of the lung from the presence of a foreign body. Evacuation was practised through the bronchial tubes and through the thoracic walls. Sir H. Cooper (1861) had a similar case. W. Koch, Hiller, and Mosler injected medicaments into the lung. Mosler and Hunter (1873) opened an abscess cavity of the right upper lobe of the lung in the third intercostal space, and introduced a drainage tube, through which the pus escaped and through which a carbolic-acid solution was injected into the cavity.

Curran reported an abscess of the right lung bursting through the diaphragm and umbilicus. E. D. Payne (1873) reported a case of abscess of the lung, discharging by the mouth, and through an external opening in the walls of the chest. In this case the patient recovered.

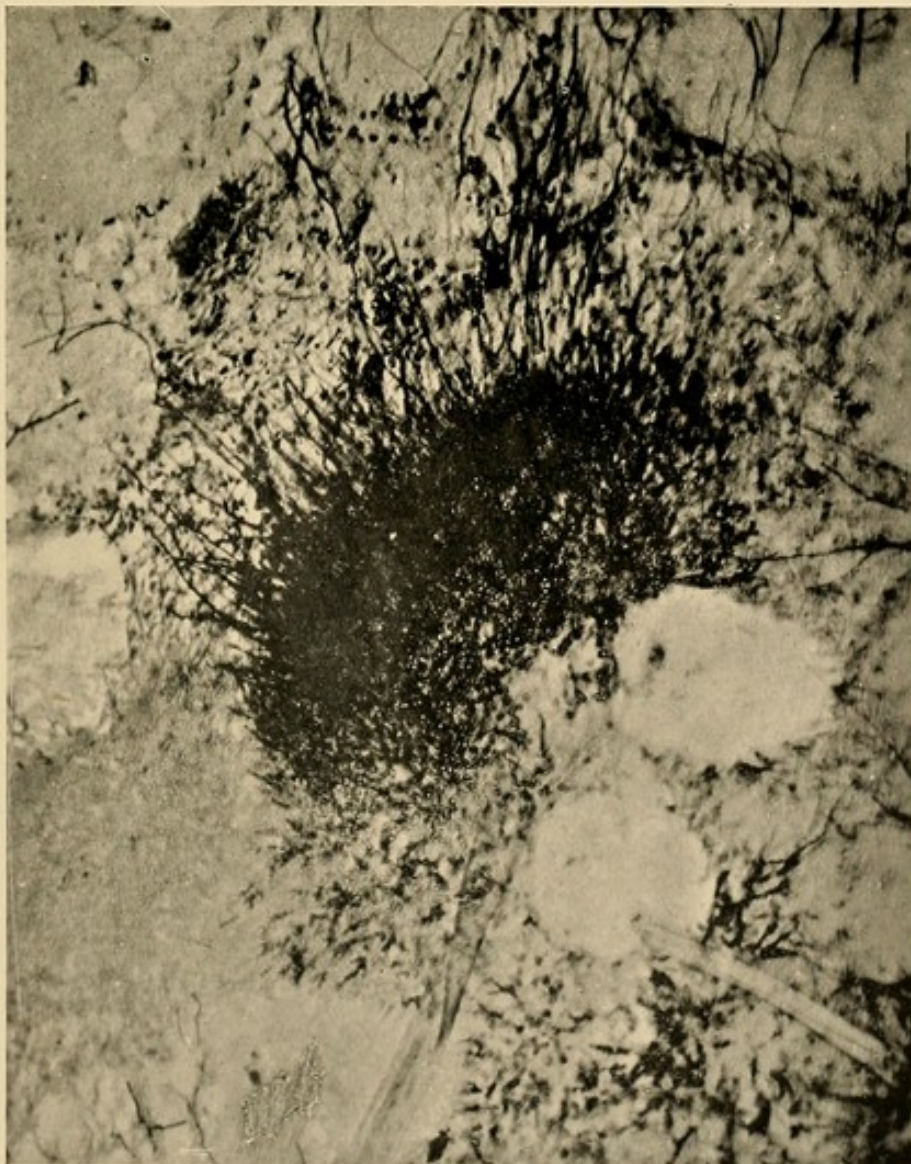
Saunders (1873) treated a traumatic pulmonary abscess by injections of carbolic acid. Hutchinson (1873) also advocated the local treatment of pulmonary cavities by injections through the chest walls. Pepper (1873) speaks of the local treatment of pulmonary cavities.

Aguilar (1876) reported a case of pulmonary abscess cured by a surgical operation. Previous to this, our knowledge of the surgical treatment of the lungs was greatly increased by the publication of Koch's "*Historische über die Chirurgie des Behandlung der Lungen Caverne.*" The use of antiseptic treat-



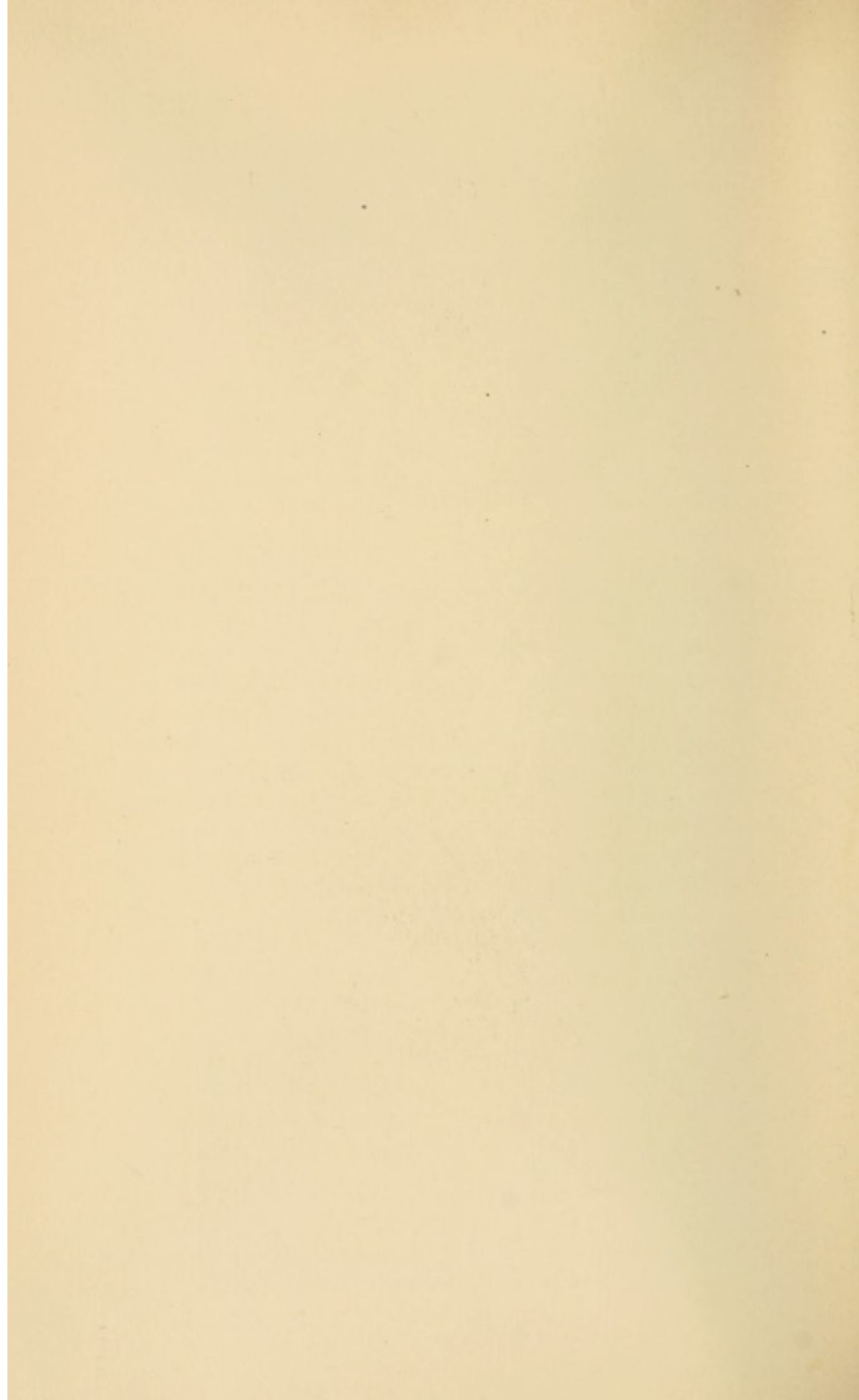
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ASPERGILLUS FUMIGATUS, (in Lung).



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MYCELIUM OF ASPERGILLUS, (in Lung).



ment following Lister's great discovery was not always successful at first.

Ferol and Gauze (1877) reported a case of granular perforation of a lung cavity, with general emphysema from an abscess in the neighboring intercostal space. Powell (1877) reports a successful case of excavation of the lung in phthisis. Ballin (1877) reported his observations of a case of pneumothorax in consequence of a lobular abscess of the lung that was spontaneously cured. Baldwin reported a case of abscess of the lung from mechanical irritation.

We have the report of Powell and Lydell (1880) on the treatment of a basic cavity by paracentesis. Sutton (1881) published reports of like cases, and Payne reported a case of pulmonary abscess opened antiseptically, which ended fatally. Beale reported a case which he treated by incising and dressing, and Fenger and Hollister opened and drained cavities (1881).

The Gulstonian Lectures of 1882 are valuable, as they give a résumé of the world's knowledge on the origin, growth and repair of the lungs. Ewart also reported cases of pulmonary abscess, and Grijourer (1883) reported two cases of pulmonary metastatic abscesses treated by incision around the bronchi. Phillips, however, goes back to a method favored greatly during the preceding decade, when he reports two cases of intrapulmonary injection.

Bull reports a large bronchiectatic cavity of the right base in the ninth intercostal space; he opened the lung with cautery and finger; pus escaped through a fistula and death resulted. At the autopsy, numerous bronchiectatic cavities were found. Bliss (1884) describes a similar operation, and Krimes, Brichton, and Brochert report operations for lung abscess.

Black (1885) was one of the first of recent operators to excise a tuberculous apex. The patient died, and on being censured severely by the coroner, Black committed suicide.

Somers and Hochsinger (1889-90) reported cases; Ricketts (1889) made three pneumonotomies to drain tuberculous

and traumatic abscesses. Osler (1889) reported a case of an abscess cavity, resulting from bronchiectasis in the left lung, being incised with fatal results. Standhartner (1890) had a case of metastatic pulmonary abscess which perforated the œsophagus; a very interesting paper was published by Taefurt (1891), entitled "Über Lungenchirurgie." Greene (1891) reported a case of pulmonary abscess cured by surgical treatment; Murram (1891) reports a case of peribronchial abscess; Porter (1891) a case of abscess; Tietze (1891) speaks of an operation upon the lung. Kerchoff and Rochard (1892) described their mode of aspirating the lung. Frey's contributions to the study of lung abscesses are of great value.

Jacobi's report (1891) shows that the Americans were actively engaged in lung surgery. Hawkins (1891) reported a case of abscess of the lung, probably of pneumonic origin, with drainage and recovery.

Huber (1892) wrote on "Abscess of the Lung;" Tuffier (1892) resected the summit of the right lung for tuberculosis, with recovery at the end of eight months; again in 1893 he made a pneumonectomy. Antony (1892) employed pleurotomy in a case of tuberculous pleurisy. Andrews (1892) employed the same operation in a case of abscess of the right lung, and secured removal of a large calcareous deposit through the chest wall. White (1892) also used pneumonotomy for the relief of a tuberculous abscess and gangrene of the lung tissue. Salmoni (1892) employed resection in a case of tuberculous ulceration of the right lung. Hofmohl (1892) devotes much thought to pneumonotomy for drainage in case of putrid bronchitis.

Tuffier mentions (1893) a "pneumonotomie" for bronchiectasis of the apices of the right lung. Pickard (1893) made a pleurotomy; while Trzebicky (1893) wrote a very interesting paper on lung surgery.

Pitt's (1893) address on the surgery of the air passages and thorax in children, was among the first on this branch of

surgery in the young. Matignon (1893) wrote a paper on pneumonotomy for abscess of the lungs. Shurly (1893) published his paper on the artificial opening of the pulmonary cavities, the insertion of a rubber tube, and the injection of chlorine gas. Huber (1893) reported a case of abscess in the lung of a child thirteen and one-half months old, with operation and recovery. Voje (1893) also reported a case of abscess of the lung.

Matignon (1894) wrote a second paper on pneumonotomy. Makay reported (1894) notes on a case of abscess in the lung; with hæmoptysis, followed by pneumonotomy and death. Leach operated upon a gangrenous abscess of the lung with perfect success. For those interested in this subject, Rochester's report will be found of value. He published an account of three cases of lung abscess, with comments upon the ætiology, diagnosis, and treatment. Apolant's name must also be added to the list of those reporting cases.

Kauffmann (1894) published cases of pulmonary abscess simulating empyema. Maragliano reported a case of pulmonary abscess, ulceration, and pleuropneumothorax. The surgery of pulmonary abscess was given prominence by Breiden's published works.

The knowledge of the surgical treatment of lung abscess was greatly advanced by the publications of Krause, Chadwick, and Kudintseff (1895).

Tuffier (1895) employed resection of apex of right lung for relief in a case of phthisis. Anderson (1895) reported a case of chronic abscess of the lung. Hitzig's paper on the influence of the influenza bacillus in causing lung abscess is of much interest. Webb treated abscess of the lung by drainage and iodoform; the patient recovered. Rody's case was an abscess of the lung following fibrous pneumonia (pyopneumothorax); thoracotomy was performed and was followed by recovery. Walton also employed pneumonotomy in abscess of the lung.

Sicard (1897) reported cases of pulmonary abscess. Beck's

diagnosis and treatment of abscess of the lung is of great interest. Matthew (1897) had a case of lung abscess and Reynaud reported a case of pulmonary abscess and connective sclerosis. Clark (1897) operated for abscess of the lung and Edwards (1897) reported favorable results from his operation. Northrop successfully operated in a case of abscess of the lung. Crespín reported a case of la grippe, bronchitis, pyopneumothorax ("pleurotomie"). Kijenski employed pneumonotomy with success in abscess of the lung. Moore operated successfully in lung abscess.

Withing (1898) reported on pulmonary abscess and gangrene. Lichtenauer (1898-99) reported a case in which he employed pneumonotomy for a case of cavity of the lung combined with a fistula of the lung. Solomon (1899) reported his contributions to lung surgery. Kar reported upon abscess and gangrene of the lung, while Burgess and Halstead both successfully employed surgery in the treatment of lung abscess. Mariani (1898) reported cases of pulmonary abscess and Alexsleyeff's report on this disease showed his great interest in all connected with the lung. Schmidt (1898) reports a case of lung abscess and Hobart operated for lung inflammation, and lung abscess.

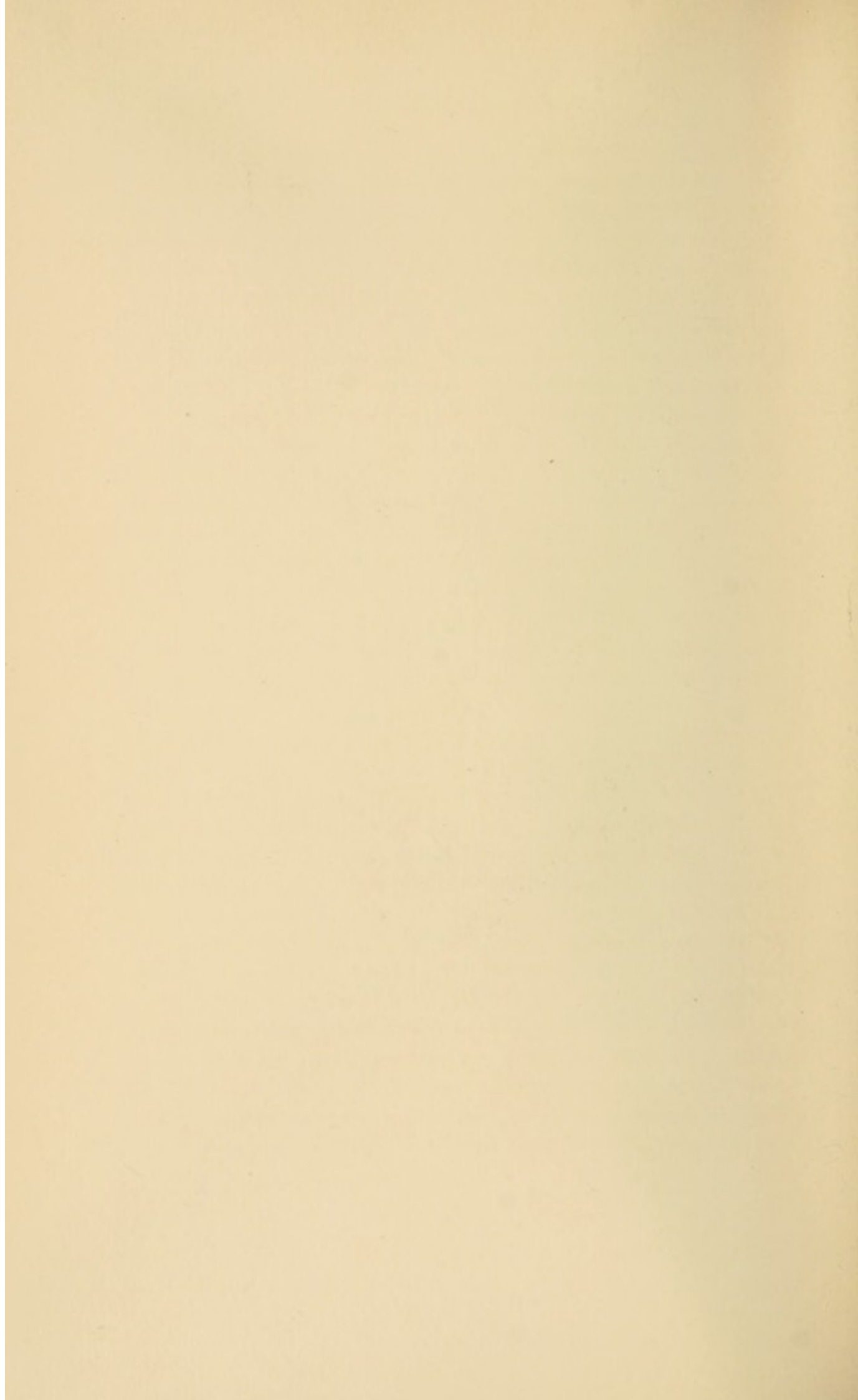
Lewis reported a case of infection of the lung as an accident in aspiration of the pleura, Gailliard employed pneumonotomy in multiple abscess and gangrene of the lung, Mariani reported a case of pulmonary fibroids in connection with lung abscess, and Goodlee, Kjos, and Elsner bring the subject up to date by their papers. Morelli (1898) employed resection of pulmonary cartilage in a case of abscess of the lung.

Dr. Le Moyne Wills of Los Angeles (1900) operated for abscess of the lung. His experience proves the advisability of surgical interference in such cases. Surgery, he claims, offers the only means of relief, and the only means of preventing death from the absorption of septic matter. He found that bruising the pleura with the fingers will produce the connection with the



X 50.

PNEUMOMYCOSIS.



external incision which some surgeons advise in lung operations. His experience shows, that in such cases, gravity drainage renders coughing unnecessary.

Gluck of Berlin has operated fourteen times on the lung; seven times for abscess, and seven times for bronchiectasis. All have recovered, or are recovering. At the Ninth German Medical Congress, April, 1901, he exhibited some of his patients. In several cases he removed several ribs and freely opened the lung, in some cases removing much of the lung tissue.

Safert says that tuberculous cavities in the lungs are not due to tubercle bacilli or streptococci alone; there must always be a primary tuberculous lesion. The streptococci will then colonize in it, and the combination of the two microorganisms results in the production of a cavity. His experiments on a great number of cadavers and one living subject have resulted in success. He resected the second rib from the sternum to the axilla, located the cavity by palpation, and incised its wall. There was only slight bleeding, and no disturbance of respiration (*Journal American Medical Association*, Volume XXXVII, No. 5, 1901, p. 355).

See chapters on Gunshot Wounds, Foreign Bodies, and Lacerated and Incised Wounds of the Lungs.

Symptoms and Diagnosis.—They are certain. The abscess may be in the pleural cavity or in the lung, or in both. It simulates tuberculosis, gangrene, and empyema. The presence of pus should be determined before opening the chest wall, without the use of an exploring needle if possible, as general infection of the pleura may ensue. One must depend upon physical signs so far as possible in locating the accumulation of pus. Temperature is not to be relied upon. Some writers hold bronchiectasis to be hopeless, but this is not verified by actual demonstration. Diagnosis is only certain when pus is found in the sputum. It is sometimes colored; the reddish or brownish tinge being due to elastic fibres. Blood-corpuscles, alveolar epithelium, crystals of margaric acid, or cholesterol, mould-fungi,

and various bacteria may be revealed by the microscope, depending upon the causative malady. When abscess of the lung is a complication of acute pneumonia, there is an intermittent rise in temperature and marked prostration.

Four forms of simple abscess have been recognized. In the first kind the symptoms remain obscure until there is a sudden discharge of purulent matter. The second form resembles pleurisy with effusion. The third form is closely connected with that form of pneumonia which skips from one lung to the other, or advances slowly from lobe to lobe.

The prognosis is usually unfavorable when the abscess occurs in the lung as a complication of abscess elsewhere. The presence of elastic fibres in the sputum always indicates abscess of the lung. The most frequent complication of abscess of the lung is pleurisy. Subcutaneous emphysema is occasionally found, as Senator observed; but this is only present when the lung is adherent to the costal pleura.

Abscesses due to pneumonia are the most favorable; abscesses due to foreign bodies in the bronchus most fatal. Tuffier reports twenty-three of forty-nine cases of abscess of the lung due to fibrinous pneumonia. He says that eighty per cent. of the abscesses are found in the lower lobes. Pneumonia more frequently follows injury and operation for foreign bodies in the lung, than for incision of the lung for abscess.

Staphylococcus pyogenes aureus can be many times detected by cultures in the blood, when it cannot be found in the sputum. Hitzig maintains that abscess in the right lower lobe, in which the sputum contains elastic fibres, alveolar epithelium, and crystals of hematoïdin is due to the action of influenza bacilli.

Treatment is the same whatever the cause may be, but it is, however, more favorable when but one bronchus is involved. It is safer to open the chest and palpate the lung with the finger, than to introduce an exploring needle through the intercostal space, and, thereby subject the patient to increased possibility of

infection with its subsequent results. Dr. J. B. Murphy says: "You can palpate the lung just as well as you can palpate in the pelvis, and you can locate your abscess exactly. Do not make the mistake of endeavoring to reach it with a Paquelin cautery, for you will find that the lung will retract in the chest out of reach of the cautery, unless an incision be made in the chest wall large enough to enable you to seize the lung, or unless it be adherent. You will have but little oozing in these cases and the abscess will heal perfectly." ("Medical Review of Reviews," Vol. VII, No. 1, p. 16.)

It has been suggested by one operator that the parietal and visceral pleura should be permitted to become adherent before incising with, or without the cautery. The knife is made to follow a hollow needle which has been inserted into the cavity, from which pus has been removed through the needle. Paracentesis is to be condemned for the purpose of aspirating pus or injecting antiseptics. It is, however, proper to use paracentesis through adhesions or an open chest, but incision should always be employed for treatment. There is less difficulty in locating pathological lesions of the lung with the finger in an open chest, when there are no adhesions than with them, because the lung does not contain air. In such a case another opening in the chest wall can be made directly over the lesion, and thus allow it to be brought into or out of the chest opening for drainage.

A counter opening in the chest should be made at the lowest point for gravity drainage, which is to be governed by the position which the body is to assume. Opoland claims that drainage of a pulmonary abscess is better when the patient is recumbent with the chest lower than the body.

Abscess of the posterior surface of the lung is very inaccessible, but like all other forms, it must be found and opened. If in the apex, a portion of the first rib should be removed, the pleura incised, and the position of the pus cavity determined. Resect one or more ribs posteriorly, the fifth, sixth, or seventh, or all, if possible, within the area of adhesions (a condition al-

most universally present). Open the cavity with a thrust of the finger, and drain with the use of as little gauze as possible, unless unusual bleeding should occur. Follow the same principles of drainage as in radical operations for empyema.

Lister (1873) added much to encourage the opening of lung abscesses, and since his time there has been no hesitation on the part of the modern surgeon in attacking abscess cavities of the lung, as evidenced by the numerous reports that have appeared. Of course this was made possible by Lister's great discovery of the antiseptic treatment of wounds and incisions.

In the *Medical News* (Vol. LXXVIII, No. 24), Fowler reviewed forty-one cases of decortication of the lungs. He favors Estlander's operation, and claims that decortication is indicated in all cases of empyema not complicated with tuberculosis. Dunn, however, favors the Schede method of operation. He says that although tuberculosis is unfavorable it is by no means always so. Bernays claims that Hilton's method of dealing with abscess cavities in the lungs gives the best results. (*American Medicine*, June 22, 1901.)

Borchert operated in twenty-nine cases of lung disease, in twenty-one of which the lung itself was surgically treated. This writer claims that operation is necessary where there is danger of pyæmia, septicæmia, or hæmorrhage. He says surgical interference is contraindicated in tuberculosis, and also makes the interesting statement that no case of tumor of the lung has been diagnosticated early enough for operation. He divides his operation into two parts, going through the thorax and pleura, and opening the lung itself (pneumonotomy). He is a little inconsistent, in that he claims that the chest should be kept closed to prevent the entrance of air, and then states that drainage should be kept up for some time after the operation.

Trzebicki (September, 1892) reported twelve cases operated upon. Three were not complete cures, there were eight deaths, the result not known in three cases, and one case was not healed when the report was made.

Recovery is more certain in acute cases, the percentage being sixty-six. Quoting Trzebicki again, out of five operations, involving resection of lung tissue, there was one complete cure and four deaths. He reported forty-two cases of simple abscess operated upon. Of these "fourteen were reported completely cured, in three cases there were fistulæ, in one case the result was not known, and death resulted in twenty-four cases." He also gives the results of twenty-four operations on tuberculous cavities, reporting five complete cures, five not healed, nine deaths (one of these three years after operation), and in five cases, the results not known.

Quincke tabulated fifty-four cases of abscess of the lung, treated surgically. There are three groups in his classification, *i.e.*: 1st, acute, divided into simple and gangrenous; 2d, chronic; 3d, suppurating, by foreign body. Eighty-three per cent. of the fifty-four cases were in the lower lobe. He reports twenty deaths, twenty recoveries, and fourteen cases of total failure, or imperfect result.

The author has opened the chest in six cases. Three were tuberculous patients, in one of whom the right lung and three months later the left lung were drained; death ensued four months later. All died within six months. Of three traumatic cases, all recovered.

(See chapters on Gunshot, Lacerated and Incised Wounds, Foreign Bodies, and Abscess.)

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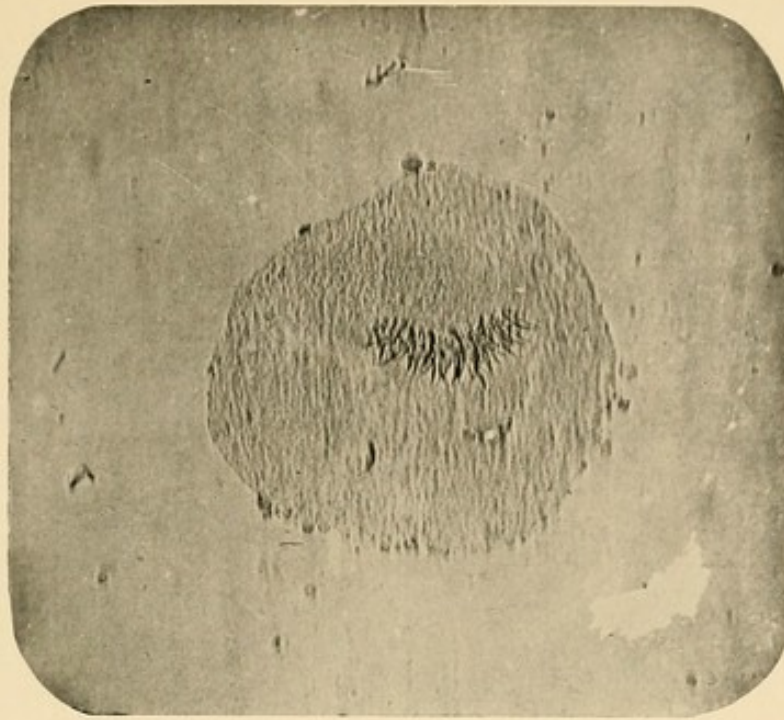
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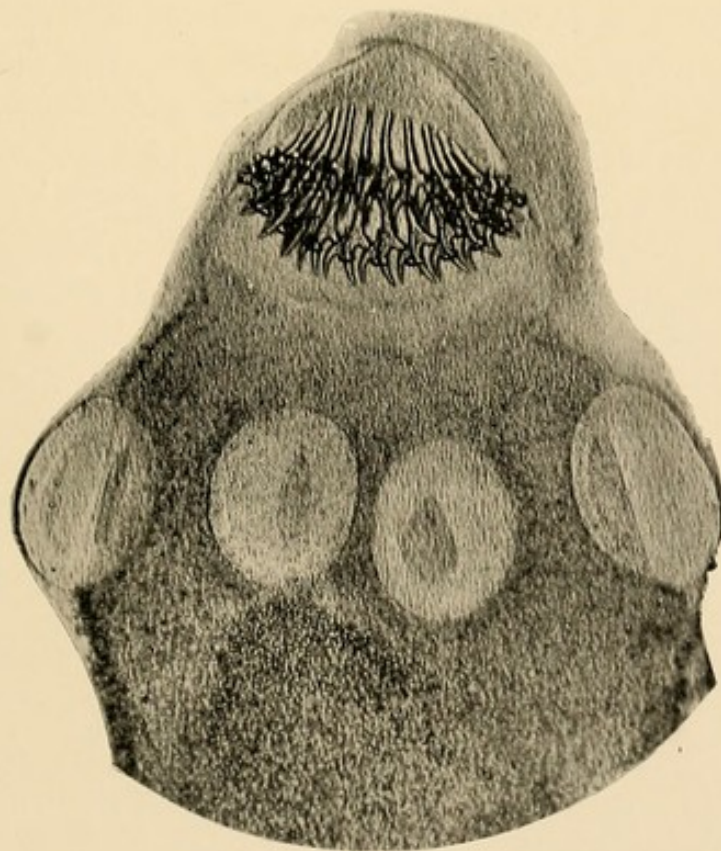
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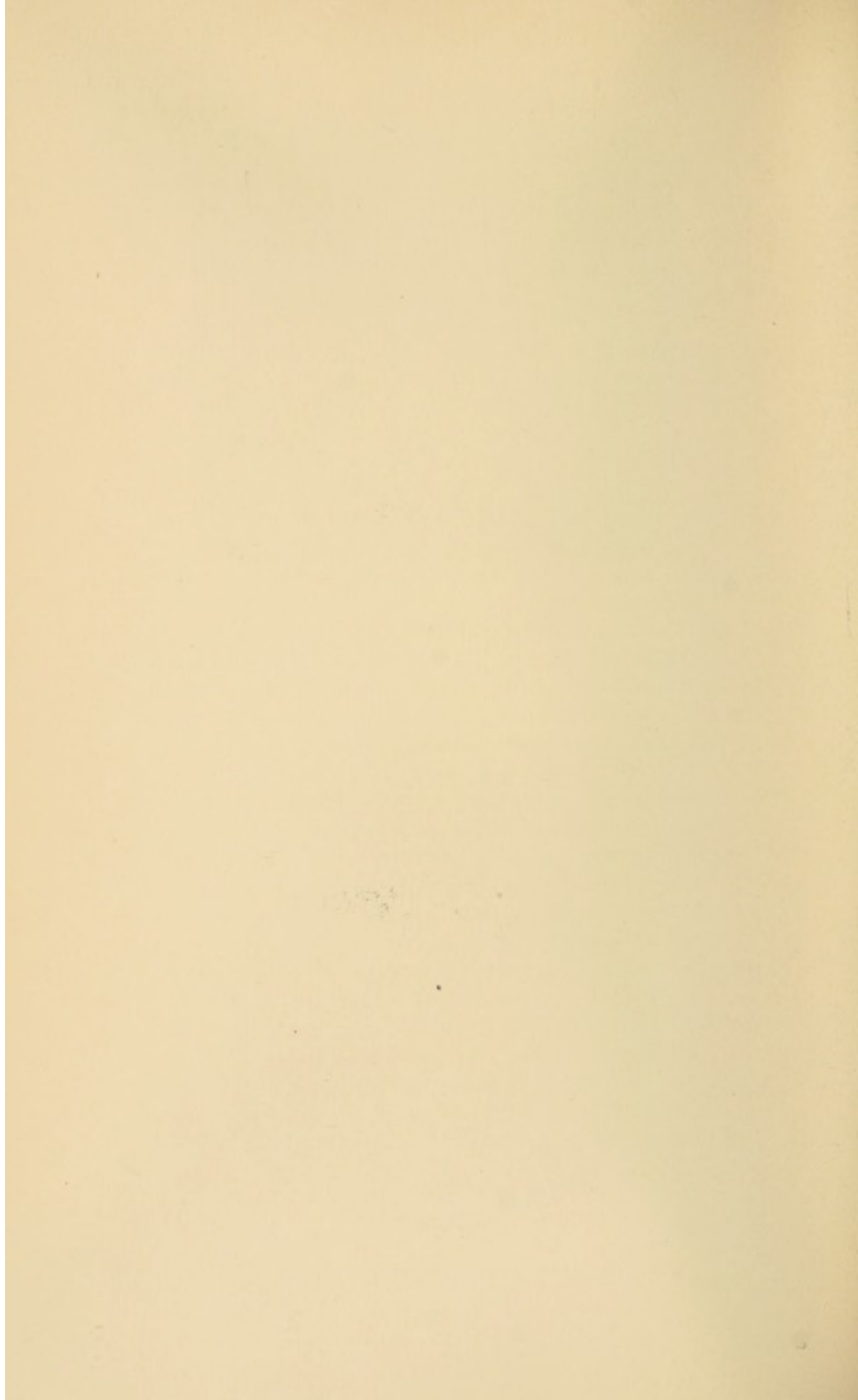
X 175.

ECHINOCOCCUS.



X 50.

ECHINOCOCCUS, (Advanced Stage).



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CHAPTER IX

GANGRENE

GANGRENE of the lung, while not infrequent, has been dealt with rather mildly. It is either circumscribed or diffuse, and has a downward course which can reasonably be ascribed to the course of the lymphatics of the lung as they terminate in the bronchial glands at its root. Perhaps this downward course is due to the lessening of the vitality of the pulmonary tissue as the extreme border of the apices is approached.

The site is most frequently the posterior aspect of the upper portion of the lower lobe. Learee says gangrene of the lung is more frequent in the lower than in the upper lobe. It has been shown that women have gangrene less frequently than men. Its bacillus resembles that of anthrax (Pasteur and Koch), and it will not grow unless oxygen (?) is excluded; hence its favorite location is within the chest. Experiments have shown that one attack gives immunity, and that the injection of toxines will also immunize.

Ætiology.—The causes of gangrene are numerous; such as syphilis, abscess from any cause, foreign body, and the acute inflammatory diseases of the respiratory system. It is occasionally the result of the pressure of aneurysmal, or other intrathoracic tumors, on the blood-vessels. Fountain enumerated among the causative factors traumatic injuries, embolism, and immersion of the body in cold water. Fountain's case as reported, was gangrene of the lung resulting from a foreign body lodged in the right bronchial tube, and terminating in emphysema, and perforation through the

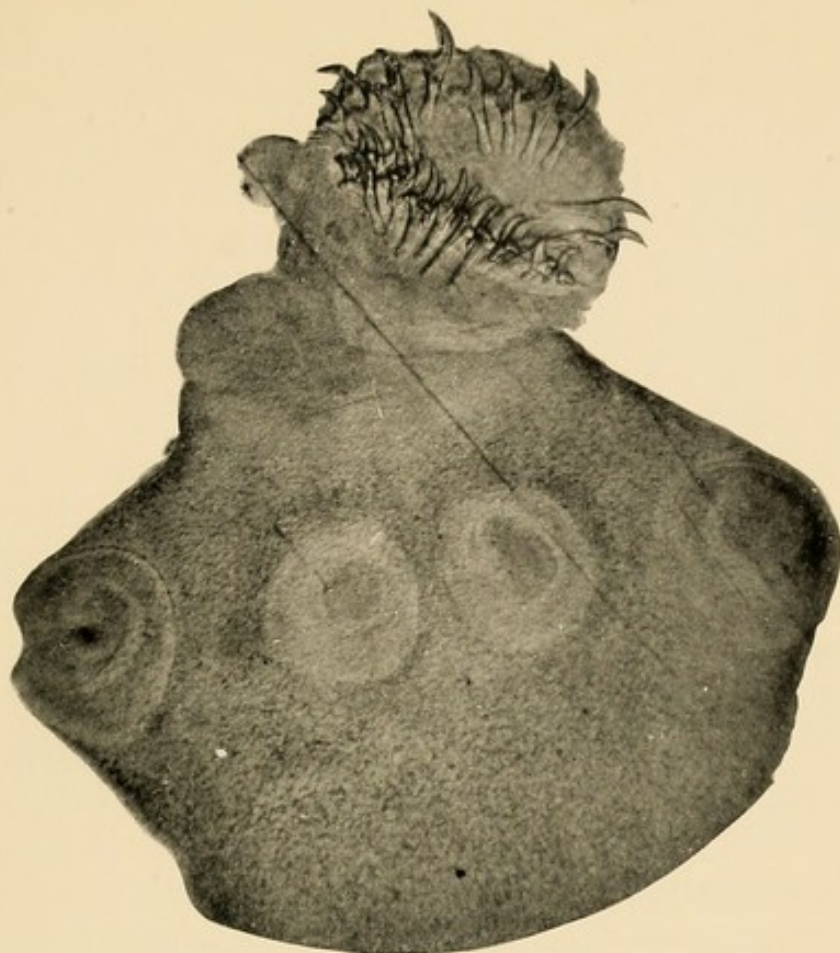
diaphragm into the colon. Trauma, infarct, diabetes, and, in cases of dementia and epilepsy, food in the trachea, are also some of the causes of gangrene of the lung. This may explain the fact that the statistics of Fischel and others show that gangrene of the lungs occurs more often among the insane.

Historical (1858-1903).—Martin (1840) reported an interesting case of abscess of the peritonæum opening into the bronchi, causing gangrene of the lung. Fuller (1859) reported a case where aneurysm of the thoracic aorta had produced gangrene of the upper lobe of the left lung, and had terminated by bursting through the pericardium. Baretz (1874) reports a case of gangrene of the lung from consecutive embolism. Magrath (1880) reported a case of gangrene of the right lung with caries of the spinal column, from the passage of a spear of grass into the bronchus. However, of all causes, pneumonia is the most frequent.

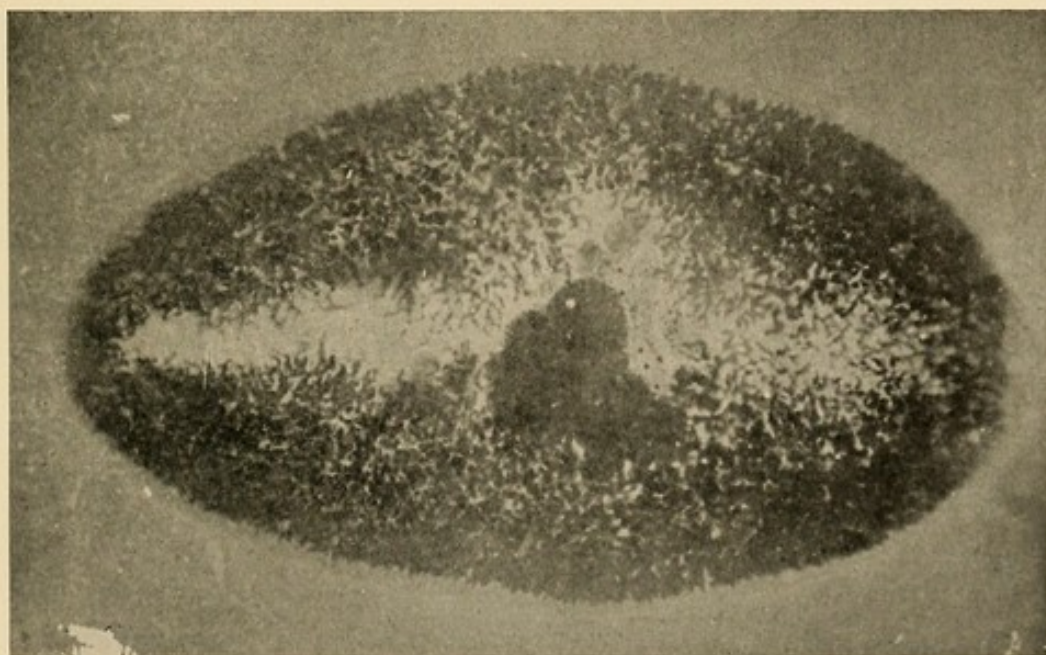
Holt (1885) had a case of a child three years old in which gangrene of the lung followed an attack of primary pleuropneumonia. Andree found in five hundred and eighty-three autopsies of pneumonic subjects that thirty-two per cent. had gangrene. Huss found but twelve per cent. in two thousand one hundred and sixty-six cases of pneumonia in men from thirty-five to fifty-five years of age.

No doubt the percentage of gangrenous cases in pneumonic conditions is greatly increased in childhood and old age. There is a certain percentage of lung gangrene, following pneumonia and other diseases, which, no doubt, recover by the formation of an abscess, and drainage in the various ways the abscess develops.

The mortality of gangrene of the lung from various causes, if let alone, is probably eighty-five or ninety per cent., while those that recover by operative measures are tabulated by Truc, Hufnaker, and Heydweiller (1879-92), to be in the proportion of thirty-six recoveries to thirty-one deaths.



X 30.
ECHINOCOCCUS.



X 9.
PARAGONIMUS WESTERMANI.



Many interesting facts may be deduced from the reports of surgeons in regard to gangrene of the lungs, and notably from operations. Guerin (1830) originated a percutaneous method which was revived by Vidal (1882). Breschet (1831), MacLeod (1836), Cleassens (1839), Hastings and Stork (1844), Herff (1844), and Collier (1855), operated evidently for empyema. Finny (1844) operated too late for gangrene and death resulted. Smith (1883) reports an operation for gangrene, while Rose (1884) was probably the first to institute extensive surgical measures for gangrene of the lung. Smith (1880) had previously treated pulmonary gangrene by incision. White and also Neisler (1872) opened a tuberculous cavity of the lung. Peterson reports a case of gangrene of the lung, with rupture of the eroded vessels, and sudden death from hæmorrhage into the pleural sac. Fenger (1884) wrote on the surgical treatment of gangrene of the lung, in a report which is of much value. Cayley and Gould's case of gangrene of the lung (1883) recovered. Runneberg (1887) operated for gangrene.

Trzebicki (September, 1892) collected twenty-four cases operated upon. There were seven complete cures, one case of fistula, one not healed; in two cases the results were not known; thirteen deaths resulted.

Truc has tabulated most of the cases to 1885, and Paget from 1885 to 1895. Simpson (1890) reported four cases of hæmorrhage into the lung tissue with œdema; he treated by aspiration, but the patient died. Anthony had a case requiring amputation of the lung; he does not state the cause, but it is probable that it was not for cancer. Lebert, Hutchinson, and Bonome have collected the cases where operations were performed for gangrene of the lung. Out of seventy-one cases operated upon, fifty-four died, or sixty-two and a half per cent.

Truc lost six out of thirteen; Richevalle, fourteen out of thirty-one; Pabrecauts, ten out of twenty-six, and Paget,

two out of thirteen, which brings the mortality down to thirty-nine per cent. Thus, it is shown that twenty-three per cent. more recover with operation than without it.

From reports of competent surgeons, it is probably only traumatic gangrene that offers anything to surgery, except drainage.

McFarland had a case of gangrene of the lung that resulted fatally. Hofmohl (1889) reported a case of lung gangrene. Kiemann reported a case of induration of the lung with bronchiectasis. Ross (1889) published a case of pneumomycosis with abscess of the lung, followed by gangrene. He made a demonstration of fungus and bacteria. Hirschler and Terray (1889) reported on the causes of gangrene of the lungs. Girode (1889) had a case of gangrene of the superior lobe of the left lung, complicated by tuberculosis and old heart troubles.

Soupoult (1889) reported a very interesting case of a large gangrenous cavity in the lung, which gave all the signs of pyopneumothorax caused by a suppurating hydatid cyst.

Martin (1890) offered suggestions on the treatment of pulmonary gangrene, and Jaccoud, Masci, Standthartner, and Ebstein (1890), have reports on this important subject. Schrotter's work on the ætiology of pulmonary gangrene, etc., contains valuable hints. Mader also has some ideas as to the treatment of this disease. Laporte had a case of pulmonary gangrene in a man who was a porter, in which the two valves of the pulmonary artery adhered.

Bastianelli (1889-90) employed pneumonotomy in treating pulmonary gangrene. Hewelke (1891) too, has some useful hints on lung therapy. O'Gorman (1891) reported his notes on cases of circumscribed pulmonary gangrene and fetid bronchitis, with pathology and treatment. Florschütz (1891) showed the connection between pulmonary gangrene and diphtheria. Bull (1891) reported two cases of gangrene of the lung, operated upon. Thue (1891) also reported a

case of gangrene of the lung operated upon with subsequent death, as a result of pericarditis. Monsd (1892) described pneumonotomy in connection with a case of gangrene. Dunn (1892) reported a case of softening of the sensory tract of the internal capsule with lesion, apparently trophic, on opposite side of the body; death ensued from gangrene of the lungs and pulmonary hæmorrhage.

De Ceronville (1892) published his observations on two cases, in which he resorted to pneumonotomy for gangrene of the lung. Delagenière employed partial pneumonotomy in similar cases, and Wells also reports cases. Streng published a paper on infusoria in the sputum, as a means of diagnosis. Lop writes on the ætiology of pulmonary gangrene, and Moussons on its surgical treatment. Fedotoff and Simonin each add to the number of cases reported.

Goelet had a case of gangrene of the lung following an attack of pleuro-pneumonia. Reimbach has something to say about ætiology of lung gangrene. Hofmokl (1895) reported a case in which he resorted to pneumonotomy, with death of patient. Mader and Parmerter follow with reports.

Babes (1895) published his "Pathogenesis of Pulmonary Gangrene," and Mery gave the results of his bacteriological studies. Alexsleyeff, who apparently finds so much fascination in the study of the lungs, has a valuable paper also on the same subject.

Roscins (Gould and Pyle's "Anomalies," et cætera, Philadelphia, 1897) is said to have removed successfully the protruding and gangrenous portion of a lung which extended through a penetrating wound of the chest wall.

Vekonet (1897) reported a case of lung gangrene surgically treated. Ewart (1897) has a paper on his methods of incision and drainage.

Within the last two or three years many surgeons have given their time and attention to the treatment of gangrene of the lungs.

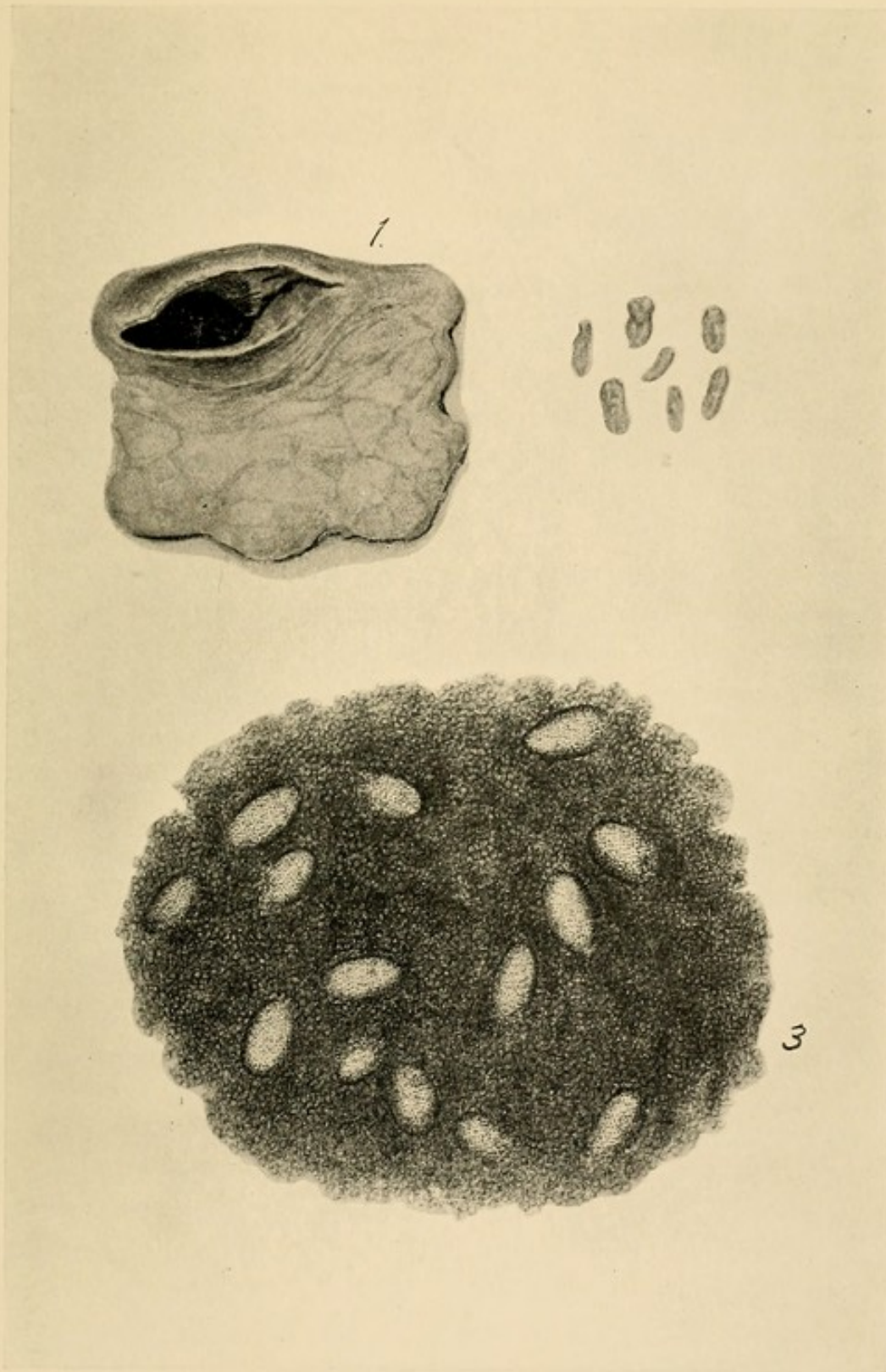
The greater number have devoted themselves to the surgery of the disease. In addition to those already referred to, readers interested in this subject might profitably consult Skeda, Patton, Rendu, Zalenski, Villiere (1898), who advocate surgical intervention in treating pulmonary gangrene.

Besson reports a death from hæmoptysis. Ferne, Swan, Bramwell, Fussell, and Robertson have reported cases. Dereaux (1899) describes his method of treatment with creosote. Warrack (1899) reported a case of a tooth impacted in the left bronchus, causing gangrene. Pique published a valuable paper on the curable forms of the disease.

H. Lenhartz reports twenty-three cases of gangrene of the lung, treated by resection of ribs and pneumonotomy. There has been complete and permanent recovery in eleven; three have died since from tuberculosis, three from sepsis, and one from general debility. Lenhartz operated in two sittings, as it is impossible to suture the pleura, and union has to be accomplished by vigorous compression. He warns against exploratory puncture, as it entailed empyema in at least one of his cases. (*Journal American Medical Association*, March 22, 1902, p. 799, Vol. 38, No. 12.)

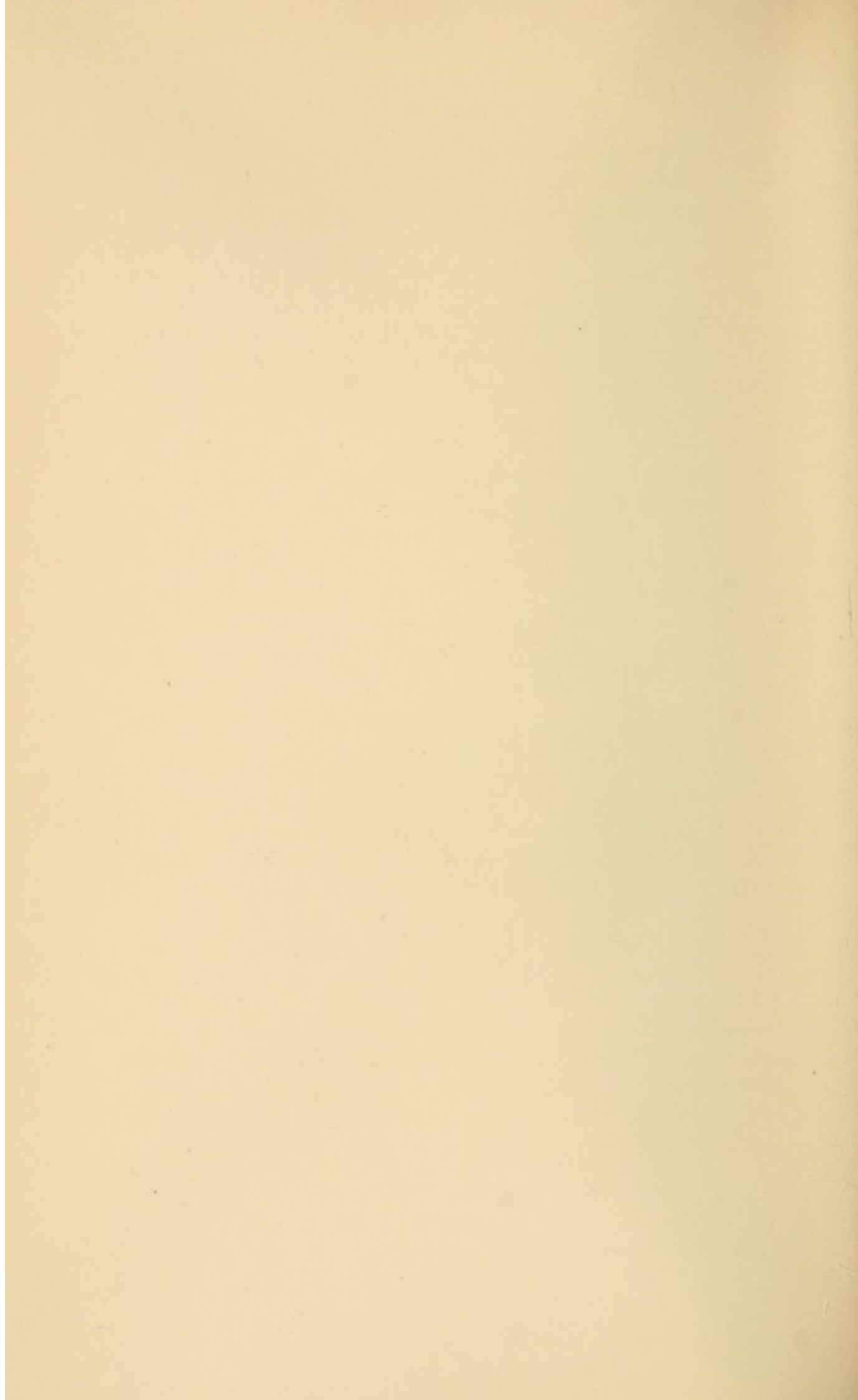
Pathology.—There are two forms of pulmonary gangrene, circumscribed and diffuse, or the two may be combined. In the circumscribed the area is first brown and dry, with hurrying congestion, and blood infiltration; there is also periodic or constant hæmorrhage from eroded vessels. Extension of the process is probably due to gravitation of fluid into the ends of the bronchi, combined with the low vascularity of the periphery of the lung.

Symptoms and Diagnosis.—The chief point in the diagnosis of pulmonary gangrene is the odor of the sputum. When placed in a glass, the sputum will separate into three layers. The upper layer will be found mucopurulent and frothy; the middle greasy and watery; and the bottom layer will con-



PARAGONIMUS WESTERMANI (FROM LUNGS OF A HOG).

1. Section Containing the Lung Fluke Cyst Cut Open. 2. Lung Flukes, Natural Size. 3. Contents of Cyst Containing Eggs of Lung Fluke, Greatly Magnified.



sist of pus and yellow shreds of tissue, which, with the peculiar fetid odor, is diagnostic.

Multiple cavities from lung abscess or gangrene are especially hazardous. The temperature may be above (105°) or below the normal (97°). The pulse is rapid and feeble, the skin dusky. There are prostration and an anxious expression; there is dulness upon percussion over the affected side, and râles can be heard in the otherwise consolidated lung. The respiratory murmur may be wanting, and, perhaps, exaggerated resonance. The symptoms in fact simulate those of pneumonia in the stage of consolidation. Fragments and pus may escape through the bronchi and mouth. In addition to the high fever, prostration, offensive breath, rusty sputum, there is a chill at onset, adynamia, dyspnœa, cough at first, more or less pain; the temperature is subnormal in the later stages. The expectoration may amount to twenty ounces in twenty-four hours, and its marked gangrenous odor is characteristic and never to be mistaken. Leyden says the patient reclines toward the affected side.

Treatment.—Open chest posteriorly by resecting two or more ribs, preferably the fifth or sixth, or both. If possible, operate rapidly with a local anæsthetic. Insert a finger for exploration and evacuation of pus, or débris, or both. Do not pack the cavity with gauze, unless for hæmorrhage, but keep the chest wall freely open for drainage and irrigation. All bleeding vessels in the thoracic wall must be occluded, as the severing of each tissue is accomplished.

It is necessary in all operations for gangrene in the upper portion of the lung to open the pleural cavity at its lowest point, that drainage may be accomplished by gravity. If possible, the gangrenous portion should be brought out of the chest opening. If the entire lobe be involved, three ligatures of silk or kangaroo tendon should be used to transfix its base, one to surround the vessels, one the bronchus, and one around the lung tissue proper. This once accomplished,

the lobe should be cut away, as in gangrene or any other tissue.

Complete excision and drainage are the two great principles involved in operating for gangrene of the lung. Stimulation and nourishment should receive careful attention. Much of the operative work will, no doubt, be done without general anæsthesia. The surgeon's finger should be used instead of the needle or knife. None of the important blood-vessels will be severed, and none of the bronchi injured, if the finger be thrust through the pleura and lung tissue. The sense of touch will enable the operator to locate the abscess with greater exactness. The finger can as easily detect pus by palpation in the lung as in any other soft structure of the body.

Garré reports one hundred and twenty-two cases of gangrene of the lung operated upon, with sixty-six per cent. cured.

August 3, 1903.

DEAR DOCTOR RICKETTS: In June I operated on a young lady suffering with gangrene of the lung. Opening was made over second and third ribs, anteriorly, on right side of chest. Patient died on the operating table after one rib had been removed. The gangrene followed extraction of teeth—chloroform and ether being used—very likely followed by an aspiration pneumonia. Autopsy showed gangrenous area with abscess directly under second, third, and fourth ribs.

O. A. BLUMENTHAL.

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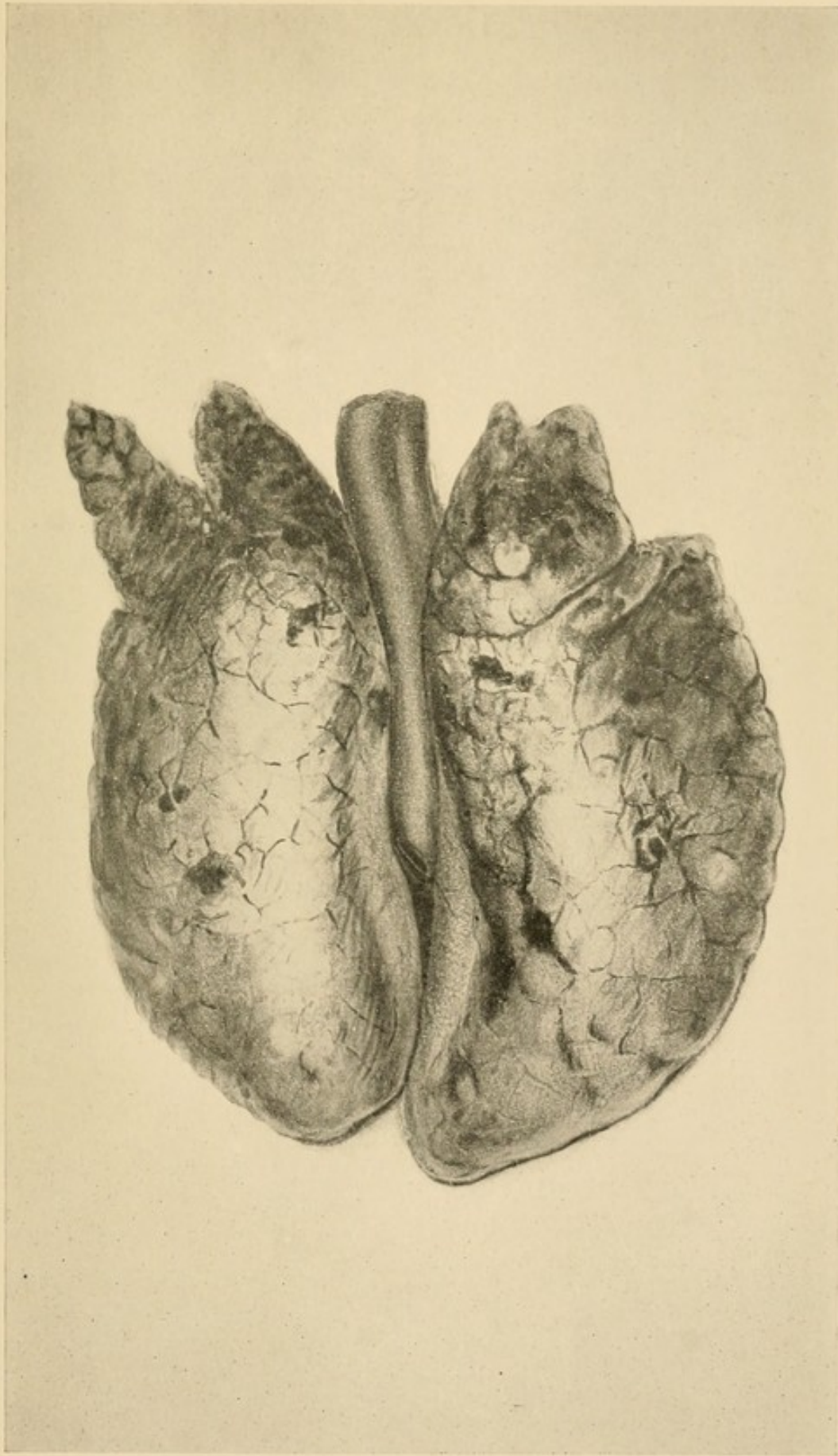
CHAPTER X

RUPTURE

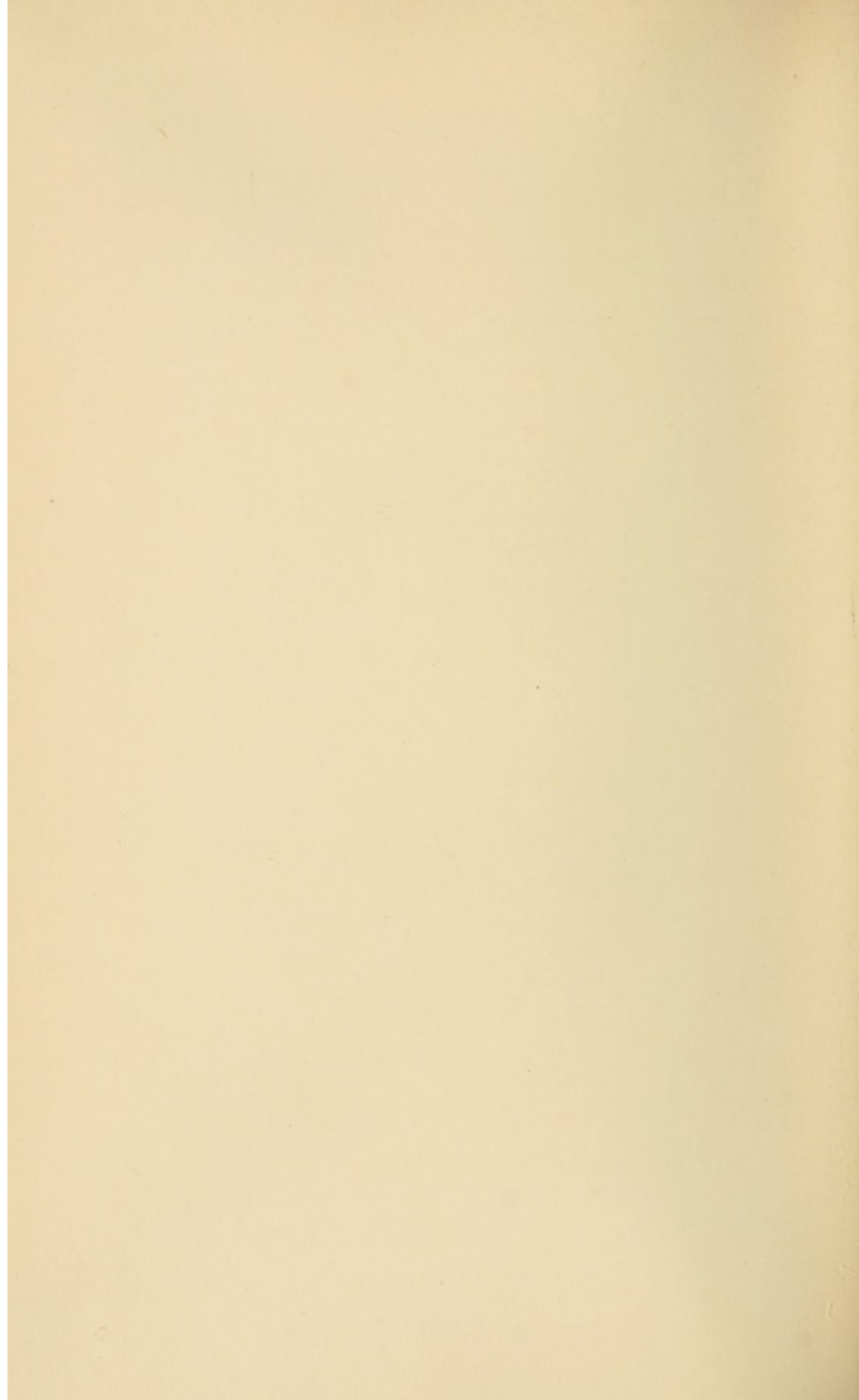
AUTHENTIC reports of this condition began with Hick's case of a child, suffering from a cough resembling pertussis, whose lung ruptured about two weeks after the cough began. Rupture, without injury to the chest wall, has been reported, especially by Ashhurst. This condition occurs oftener in children than in adults, and if death results, it is usually within five days. There may be laceration of the lung without blood-flow, as verified by a specimen in St. George's Hospital Museum. A four-inch laceration, two inches deep, resulted without hæmoptysis.

The mechanism of the rupture of a lung without fracture is the same as that which occurs when an inflated paper bag is struck by the hand. Gosselin's explanation is that it is due to a sudden pressure exerted on the thoracic wall, at the moment of full inspiration, concurrently with a spasm of the glottis or obstruction of the larynx. Consequently the lung bursts. Extravasation of air takes place, resulting in emphysema, pneumothorax, etc.

Others discard this theory because it does not also explain cardiac rupture from external violence on the thoracic walls. They claim that the rupture is due to direct pressure, as in the case of heart rupture without fracture of the ribs. But it is possible that the rupture of a small bronchial artery within the parenchyma of the lung may be the occasion of a rupture in some cases where there has been no external injury to the chest wall.



Lungs of a hog showing cysts caused by lung flukes
(reduced) from 16th Annual Report U. S.
Bureau of Animal Industry.



The alveolar tissue being so fragile, the bursting of a very small artery may do great damage. One such case has come under the author's observation, and many more may have occurred, the real cause being overlooked.

Ashhurst collected the histories of thirty-nine cases of rupture of the lung without fracture; of these twelve recovered. Otis has collected reports of twenty-five cases of this form of injury from military practice exclusively. These were generally caused by a blow upon the chest by a piece of shell, or other like missile. Among the twenty-five cases there were eleven recoveries.

Historical (1840-1903).—Tait, of Edinburgh (1844), was among the first to report a case of rupture of the lung. Barlow (1844) reported a case of hydropneumothorax with tuberculous perforation. Strong (1850) also reported a case.

Ferrari (1855) speaks of rupture of the lung by deep inspiration; Dunlin (1855) reported a lesion of the lung caused by compression. Coulon (1860) reported a case of rupture of the lung caused by the passage of a wagon-shaft through the chest. Skay had a case without external injury. Galvez (1864) reported a case from violent contusion without fracture of the ribs, resulting in instant death.

Bermutz (1865) reported a case of rupture following suppuration. This case was cured. Ashhurst (1871) mentions a case of rupture, without injury of the thoracic parietes. Watson (1881) reported a case of laceration of the lower lobe of the right lung caused by violence without fracture of the ribs, which terminated in death. Gould (1882) reported rupture of the lung, with pneumothorax; paracentesis was performed, followed by recovery.

Gross (1882, Vol. II, p. 368) says that rupture of the lung, without injury to the thoracic wall, is not so frequent as at one time supposed. Laurent (1883) reported a rupture of both lungs, with external injury, followed by death. Uckmar (1889-90, and 1890-91) published his contributions on

rupture of the lung. Buttell (1892) published a work on the general treatment of lung wounds. Kerr (1894) reported a case of rupture of the lung, associated with fracture of the ribs, with early subsequent recovery.

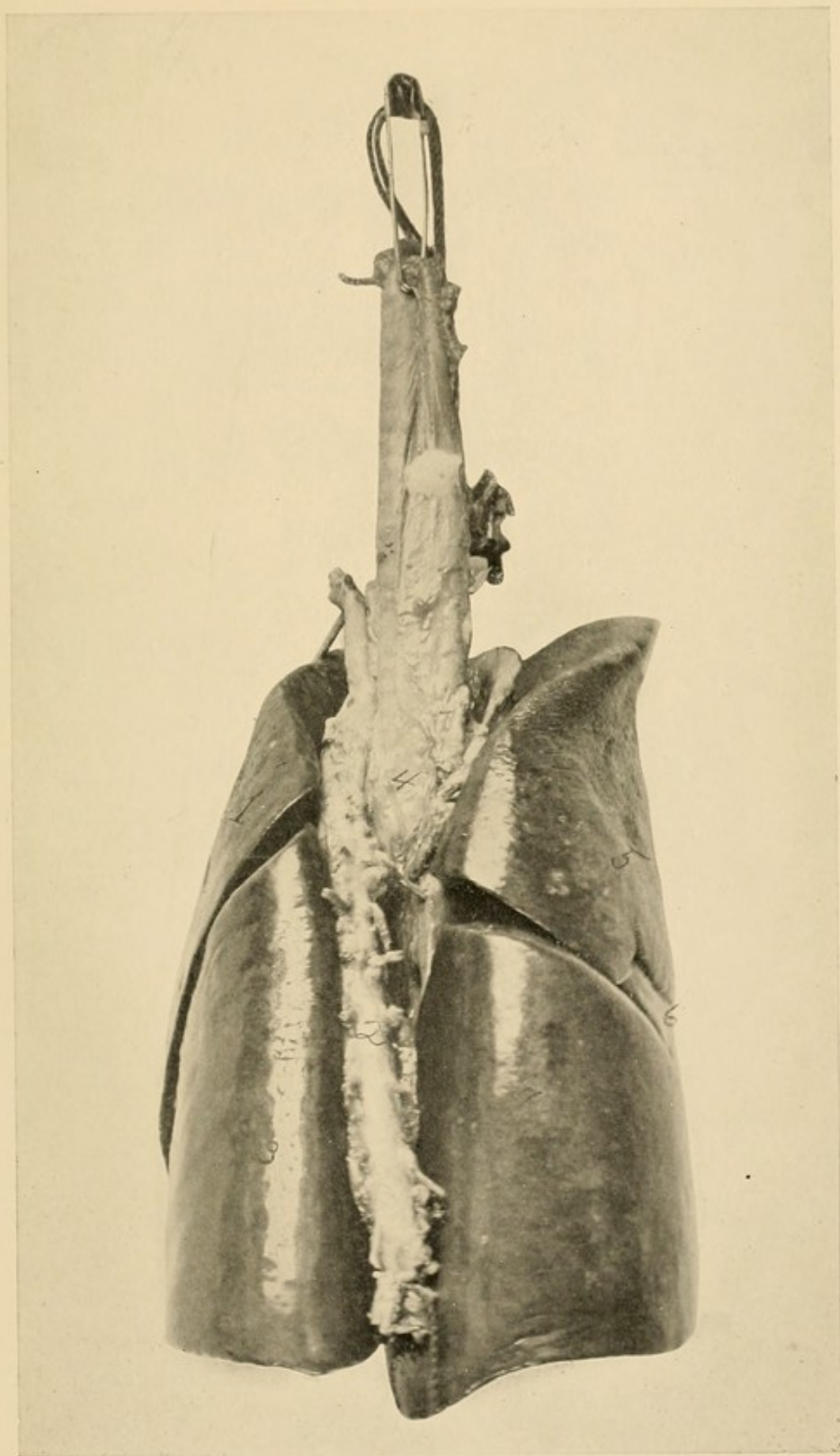
De Sanctis (1894) reported his method of suturing in lung rupture. Comte (1894) published his notes upon a case of rupture of the lung, and Hermanid (1898) reported a case of rupture from whooping cough.

Wallingford and Roberts, of Paris, Ky., were called to see a negro who had died suddenly. He was a stout, robust fellow with a good history. The autopsy revealed nothing to account for the rupture of the lung except that one of the bronchial arteries had ruptured. The rupture of the artery was doubtless due to erosion by a deposit of coal dust, which had become infected. The negro was a coal-heaver.

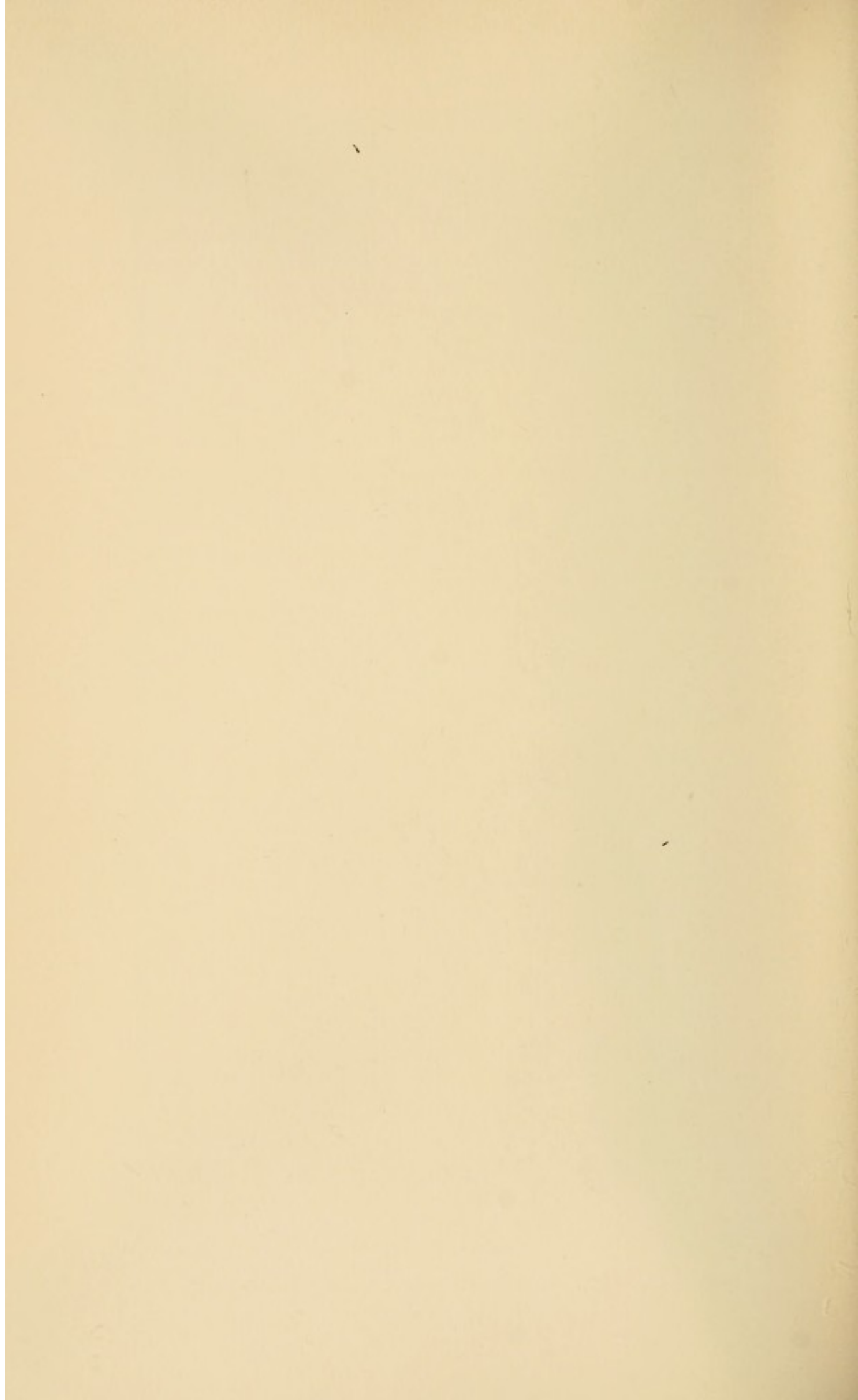
(For Treatment and Symptoms, see Chapter on Lacerated and Incised Wounds.)

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POSTERIOR VIEW OF HEART AND LUNGS OF DOG, IN-
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CHAPTER XI

HERNIA

HERNIA, or pneumocele, is where a portion of the lung protrudes through the chest wall, or below the clavicle, or through the diaphragm. In most definitions of hernia of the lung it is stated that the protrusion of the lung may be through the chest wall or through the diaphragm. However, although many cases of diaphragmatic hernia of the abdominal viscera are recorded, there is but one instance where the lung has protruded through the diaphragm. When it does so occur, it is likely to be on the left side. Out of two hundred and seventy-six cases of hernia of the abdominal viscera through the diaphragm reported by Lacher, two hundred and twenty-five were on the left side. The support afforded by the liver on the right side prevents the escape of the abdominal viscera into the thoracic cavity.

Hernia of the lung may be primary or secondary, and is usually traumatic. It is not often subcutaneous. As a rule, a slender apex enters a small opening in the chest wall or diaphragm. The protrusion is increased by inspiration and decreased by expiration; and, if not immediately returned to the pleural cavity, will sooner or later become hard and dry.

If not immediately reduced, the adhesion to the adjacent soft tissues will be so firm that operative measures will be necessary to release it.

Hernia of the lung is to be differentiated from chronic abscess, from hernia of omentum, intestines, or liver upon the right, and of the stomach or pericardium upon the left.

Hernia is generally sudden, but may be gradual, or appear subsequently. If late, it may be free from adhesions, and therefore reducible. It is more frequently in the right lung, owing to the latter having one more lobe and fissure. It is not necessarily fatal, nor does it shorten life. It is very rare, and may vary in size from that of a hazel-nut to that of the human head.

Operative measures should not be resorted to, unless gangrene should ensue. It is indicated if the tumefaction be troublesome by giving pain or by undue prominence. The subcutaneous form of hernia of the lung is said to be always reducible. Some teach that if the hernia protrudes externally through the cutaneous structures, reduction must be attempted. If this fails, or if gangrene appears, the protruded part must be removed, or allowed to slough away.

The other variety of hernia of the lung may be reduced and held in place by pad or belt.

Historical (1499-1903).—Rolandus (1499) published one of the first reports of a surgical operation for hernia. It is worthy of reproduction.

“Called to a citizen of Bologna on the sixth day after wound, I found portions of the lung issued between two ribs. The afflux of the spirits and humors had determined such a swelling of the part that it was not possible to reduce it. The compression exercised by the ribs retained its nutriment from it, and it was so mortified that worms had developed in it.

“They had brought together the most skilled Chirurgeons of Bologna, who, judging the death of the patient to be inevitable, had abandoned him, but I yielded to his prayers and those of his parents and friends, and, having obtained leave from the Bishop, the Master, and the man himself, I yielded to the solicitations of about thirty of my pupils, making an incision through the skin, the breadth of my little fingernail, away from the wound, all round it, then with a cutting

instrument I removed all the portion of the lung level with my incision.

"The wound resulting from the resection was closed by the issuing from my incision. By the grace of God it cicatrized and recovery took place.

"It is true that one had to wait long for it.

"The patient, with his master, Rolandini, has since made a voyage to Jerusalem, returning in good health.

"If you ask me what I should have done in this case, I answer: I should have dilated the wound with a small piece of wood, keeping the lung warm with a cock or fowl, split down the back, or should then have reduced it and kept the wound open until the portion of the lung was wholly mortified.

"If you still question me to know how this man can live without his lung, I answer: That the part remaining in the chest profits by the nutriment destined for the whole lung, and so is developed. Nature has been able to create supplementary parts in it, which is an easy thing, that is so soft and near the warmth of the heart."

Tulpius (1674) ligated and cut off three ounces of a herniated lung; the patient recovered. Chassier also mentions a herniated lung, and was the first to give it special consideration. Erichson reports a case in a cornet player. Boerhave's case (1814) was due to child-birth, and occurred in the mother. Cloquet (1819) reports a case in a man thirty-two years of age, who was crushed under a gun-carriage, but recovered.

Morell-Lavallée collected thirty-two cases of hernia of the lung. Forde (1837) reports a case in which a protruding portion of the lung was removed. Lake (1852) reported a case of hernia of the lung, caused by the handle of a wheelbarrow penetrating the side of the chest. Dufour (1855) reported a case of traumatic hernia cured without an operation, after having caused much loss of blood. Hale (1856) details a case which required removal of a part of the left lung.

In twenty thousand wounds during the War of the Rebellion there were only seven herniæ of the lung. Cockle (1873) published a case of double pulmonary hernia. Lewtas, of India (1876), reported a case of congenital hernia. From the same country another native physician (1878) reported a case of wound in the chest with protrusion of lung, and death.

H. Hirschprung (1879) reported a case of congenital hernia of the lung, and Beale reported an equally interesting case of hernia through the diaphragm. Hagentorn (1892) speaks of a case of pneumonotomy in pneumocele. Malpeli (1892) mentions "pneumonotomies." Muller (1893) resected the lung with gratifying results. Pitt's lecture (*Lancet*, October 14, 1893, and Transactions Ninth French Surgical Association) states that the protrusion occurs at once, or at any time later. Lopez (1894) reported a resection of the lung for hernia, with recovery.

The year 1894 marks an epoch in Japanese surgery, and Karotta, a rising young surgeon of that country, excised a herniated lung with success.

Omar (1894), of Lyons, made a total extirpation of a lung. Llobet, Reclus, and Tuffier (1895) all mention resections of the lung, and Knox reported two cases of hernia of the lung into the neck.

From 1895 to the present there have been several cases of hernia of the lung and its treatment reported by Nagy, Roussell, Martiny, von Nagy, Wightman, Gaillard, Vogeler, Rotenpeiler, and Potain.

Reymeî, of Paris (1895), reported a successful operation for traumatic hernia of the lung. Couvey collected fourteen cases of removal of portion of lung, with twelve recoveries. Heydweiller says: "It is safe to remove it," referring to the protruding part of the lung. Vulpius, of Berlin (1900), reported a case of hernia of the lung resulting from injury. Five weeks after a plastic operation the patient was discharged, cured.

Symptoms and Diagnosis.—These are very definite. The front and side of chest and the lower costal spaces are more frequently the site. Old adhesions prevent hernia.

Morell-Lavellée and Otis maintain that the hernia is not increased on inspiration and decreased on expiration. Slow, natural expiration should not increase the tumefaction, but it is far different when expiration is violent.

Paget says a sudden puncture of the chest is followed by immediate expiration, with closed or half-closed glottis, raising the pressure in both lungs, or causing overflow of air from the sound into the injured lung, and thus the hernia is brought about; without cough or violent expiration it could not occur.

A gradual hernia may have a true sac lined with pleura, free from adhesions, and reducible. Protrusion is always accompanied by vesicular murmur and a crackling sound.

There are many successful reductions reported. The only certain relief is to remove the ribs and return the protruding parts.

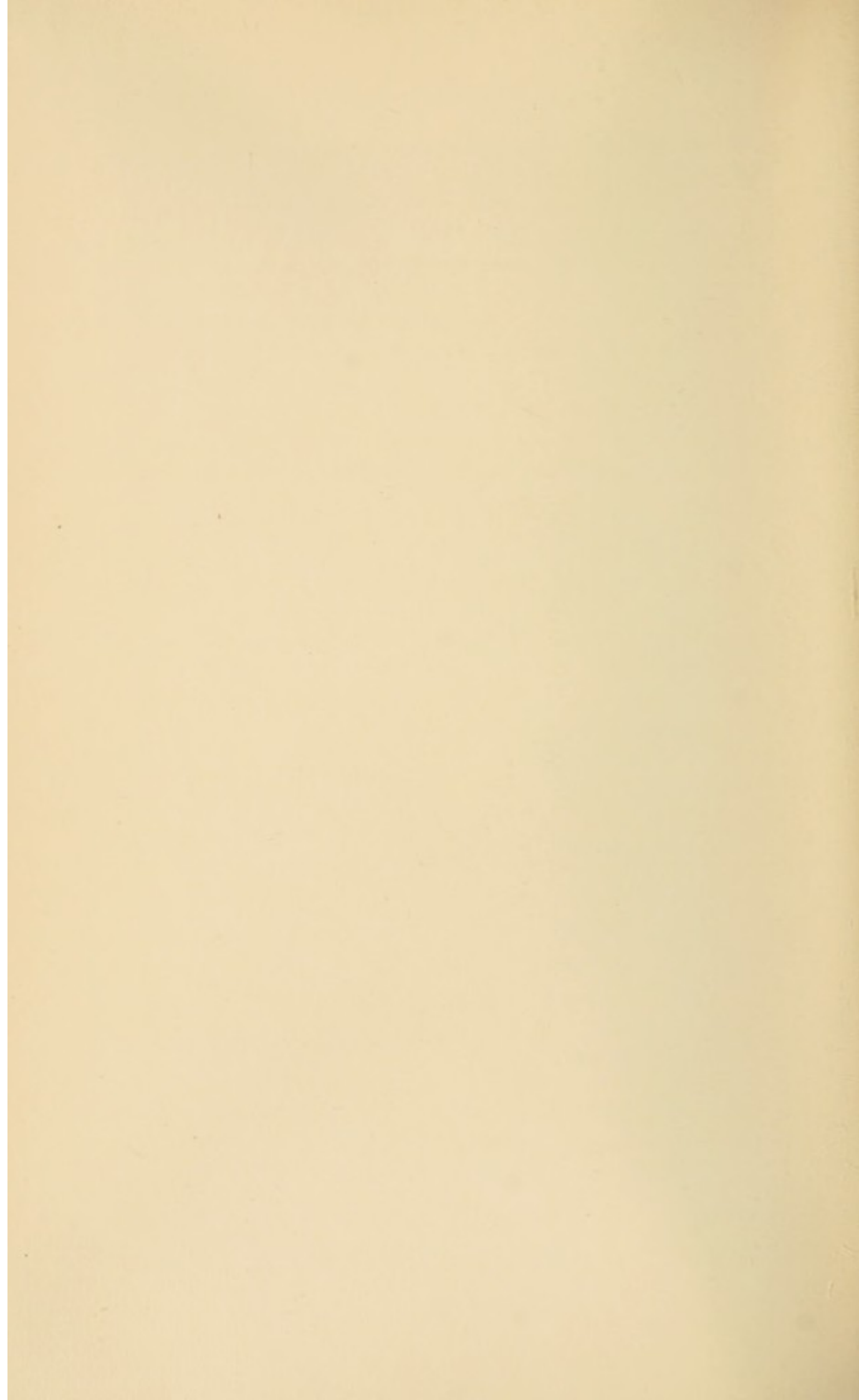
Treatment.—The removal of a section of one or more ribs should be avoided if possible. The protrusion of the lung, as a rule, is through the intercostal space, but occasionally it will protrude through an opening in the chest-wall, as a result of displaced fracture of the rib.

If the herniated sac is lined with pleura, reduction is usually very easily accomplished. If not, great difficulty is encountered. In either event, reduction may be impossible. If reduction can be accomplished by manipulation, the opening can easily be closed perfectly and permanently by incorporating in the sutures periosteum, or ribs, or fragments therefrom.

If the sac is lined with pleura, and reduction cannot be done by manipulation, sections of ribs should be made. After the lung has been returned to the pleural cavity the opening should be closed in a similar manner. That is, by suturing



TRANSVERSE SECTION OF THE LOWER LOBES. (Description, page 484.)



the periosteum, or ribs, firmly together, dividing them if necessary (osteoplasty).

If there is no pleural membrane incorporated within the hernial tissue, and the hernia can be returned to the pleural cavity, the opening in the chest is to be closed as directed above; but if it cannot be returned to the pleural cavity by manipulation, and the protrusion is through the intercostal space, amputation of the projecting mass is the only resource left.

This should be done only after transfixing it with a ligature, to prevent hæmorrhage, and the integumentary tissue, together with the periosteum, if possible, should be subsequently sutured over it.

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CHAPTER XII

ŒDEMA

ŒDEMA is the effusion of serum, from many causes, into the submucous connective tissue. Flint says the transudation is primarily within the air-cells, the serum also infiltrating the interlobular structure. It may be slow or rapid, and is produced by several conditions, principally by acute and infectious diseases. The malignant form is due to a specific germ.

Valvular disease of the heart is a prominent factor in its causation. Compression of the lung by a tumor of any character, inhalation of hot or cold air, or gases, suppurative hepatitis, Hodgkin's disease, eclampsia, leucæmia, anæmia, or chlorosis, may cause it. It may be local or general, and is usually found in persons under fifteen years of age. It is indicated by dyspnœa, varying in intensity.

Historical (1891-1903).—Muller (1891) describes this condition in a most interesting manner, while von Basch reports a series of experiments to show its pathology. Anthony (1891) speaks of a case of pulmonary œdema, secondary to nephritis, complicating pregnancy. Smith (1891) reports a case, while Grossmann (1891) verified the work of Basch by his experimental research. Ferri (1893) reports a case of pulmonary œdema after the publication of one by von Ziesell (1893). Lowith (1893) also mentions an interesting case. Corin (1897) mentions a case of pulmonary œdema, while Milian (1897) speaks of pulmonary sclerosis, and Flava (1897) mentions kaolinosi.

Freyberger (1897) speaks of an anæmic infarct in the lung. Furinami (1898) also speaks of a hæmorrhagic infarct into the lung, which caused pulmonary œdema. Paulain, Natale, and Fouineau (1898) each make mention of cases. Fouineau (1898), in a most interesting article, mentions the rarity of pulmonary œdema.

Momburi reported a case of pulmonary apoplexy and thrombosis. Muller showed by his experiments that if the vagi be divided in the neck, death will result from the infiltration of the lungs and air-passages with serum. Hasse remarked a peculiar fact in cases of general dropsy which prove fatal, *viz.*, that one lung is always found adherent to the pleura, and the other is not. The adherent lung is œdematous, and the other is compressed by hydrothorax.

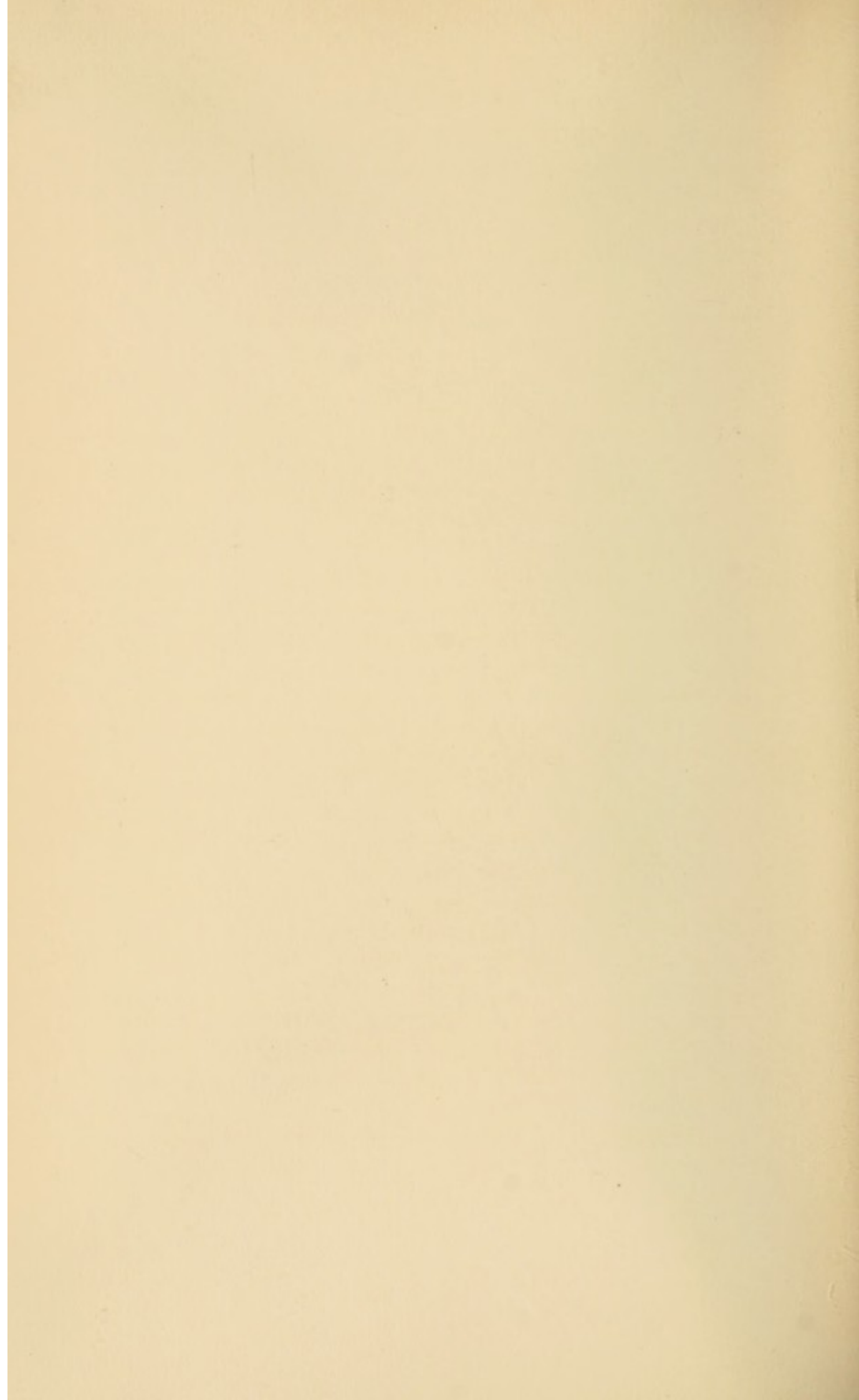
Symptoms and Diagnosis.—There is increased frequency of respiration with dyspnœa, and dulness on percussion. The respiratory murmur is lost, or very feeble. The vocal resonance may be increased. The presence of liquid is denoted by fine mucous or subcrepitant râles. The pulse is rapid and feeble. When the effusion involves the interstitial tissue, cyanosis appears, and there is often intense suffering.

The sputum increases with the increase of serum in the alveoli. It is often thin and watery, and sometimes viscid. In this case it increases the dyspnœa by obstructing the larynx. It is at times tinged by the presence of red blood-corpuscles. Urea may also be found in the sputum.

There is no fever unless there are complications. In extreme cases the patient dies from heart failure and carbonic-acid poisoning. Bianci's phonendoscope is claimed to be a useful instrument in tracing the progress of the œdema. Œdema may be differentiated from bronchopneumonia by the physical signs, which in the latter disease show no marked difference between the affected and the non-affected areas. The mucous râles occur late in the bronchopneumonia, while they are present from the beginning in œdema.



TRANSVERSE SECTION OF THE HEART AND LUNGS. (Description, page 485.)



Hydrothorax, too, possesses some things in common with œdema, but in hydrothorax change of position of patient will alter the area of dulness.

Treatment.—Measures are to be directed to the causative diseases. At the same time, use every means to sustain the heart's action. Phlebotomy has been advocated, and Huchard says that the best treatment for the acute form is venesection from the arm.

(See also Treatment, in the Chapter on Gangrene and Abscess.)

Apply the same surgical measures as used in abscess and gangrene of the lung, and in addition, employ the syphilitic remedies. Abscess and gangrene of the lung caused by syphilis cannot be differentiated from pulmonary abscess and gangrene from other causes. Not all cases of abscess or gangrene of the lung in a syphilitic patient are due to syphilis, for these diseases may exist as complications of syphilis. Whether the cause of the abscess or gangrene is syphilis or not, it should be treated as if it were.

Abscess, gangrene, and syphilis of the lung present nearly the same physical signs. Often it is only by the closest study and a full knowledge of the patient's history that anything like a satisfactory diagnosis can be made. Fœtor of the breath is common to all three. In gangrene the fœtor is intensely foul and persistent. In abscess there is fœtor, but it is not excessive, nor does it have the peculiar gangrenous odor. Pulmonary abscess must not only be differentiated from gangrene, but also from putrid bronchitis. In the latter disease, the odor of the breath resembles acacia blossoms.

Gangrene is also to be distinguished from putrid bronchitis. In this last disease the sputum does not contain shreds of lung tissue, nor is there the fatal marasmus that accompanies gangrene.

It should also be remembered that œdema may result

from either of these diseases, or from the maladies which gave rise to them. In œdema the sputum is of diagnostic importance. At times it is thin and watery, and again viscid. It may at times be colored, and in this case the color is due to the presence of red blood-corpuscles. It may also contain urea. But when the sputum splits up in the three characteristic layers, as described in the chapter on Gangrene, there can be no mistake, and whatever else may be found on thorough examination, you may rest assured that you have a case of pulmonary gangrene.

Œdema is to be carefully differentiated from bronchopneumonia. Râles are present from the beginning in œdema, but not until rather late do they appear in bronchopneumonia.

Hydrothorax is easily distinguished from œdema, because change of position produces an alteration in the area of dulness.

In all the diseases considered here, temperature is not a positive diagnostic factor. It may be present or it may be absent. It is, usually, a sign of infection when it does exist.

Surgical treatment is essentially the same for all three diseases. Nothing should be done rashly. Make sure of your diagnosis, and then operate boldly.

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CHAPTER XIII

POLYPI IN THE BRONCHIA

ONLY a few cases of polypi of the bronchia have been reported. Many cases have been overlooked or else have not been clearly diagnosticated. Polypi may degenerate, or slough, and be coughed up and expectorated, and thus escape detection. No doubt, many obscure cases of pulmonary disease are due to polypi in the bronchia. There are several reports of fibrous growths in the bronchia. Cases of this character are, perhaps, many times due to polypi which have degenerated. The same is also true of hyperplasiæ. So, too, many cases of hæmoptysis that have appeared inexplicable may have been caused by polypi. The titles of many papers indicate that their authors were not sure of their diagnosis.

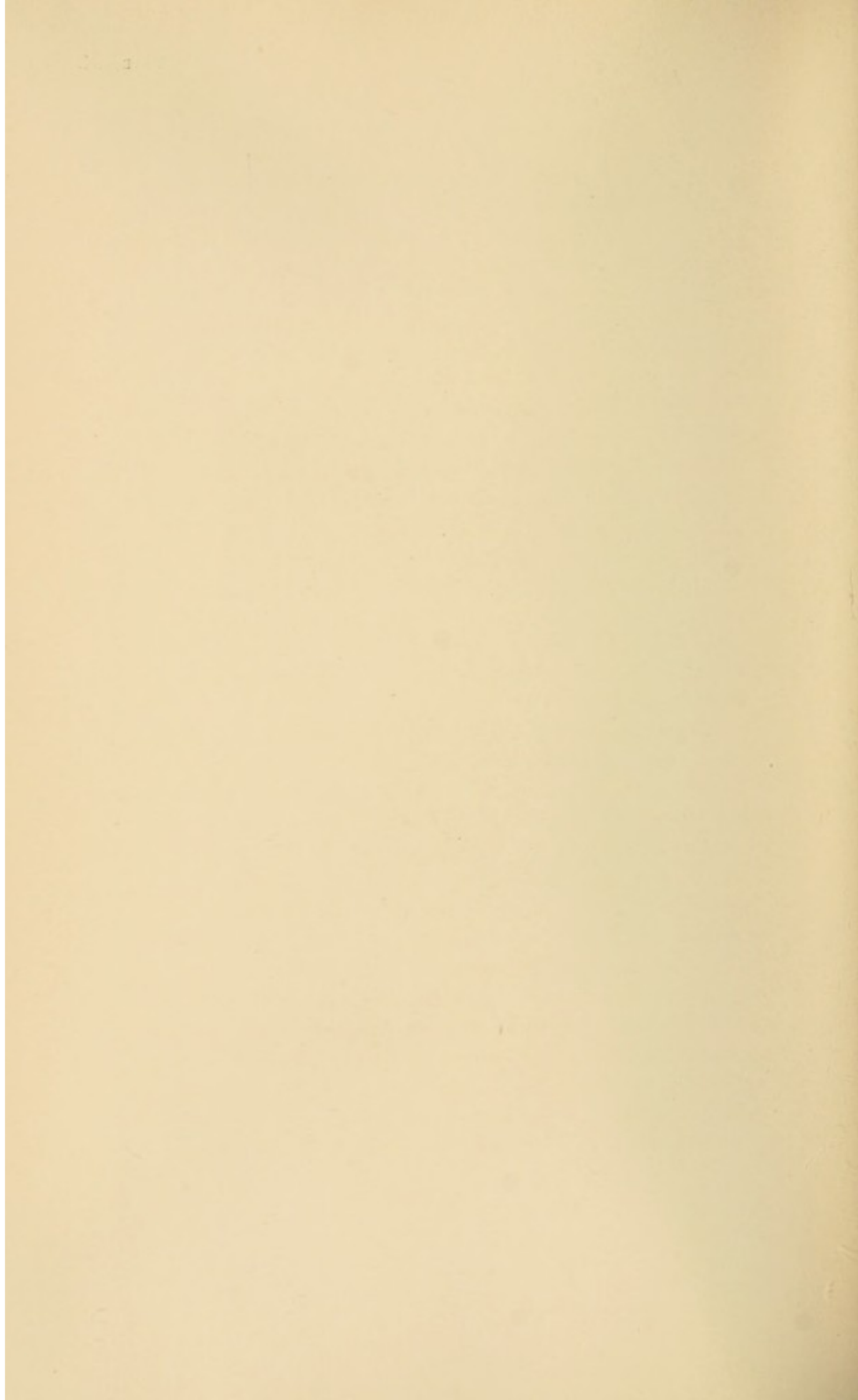
It is very probable that polypi of the bronchia are not so exceedingly rare as some writers assume. Just what effect polypi in the bronchia have on the lungs is unknown. Polypi in the lungs themselves have been reported by some observers.

In case of a very large polypus in the bronchia there is danger of the bronchia being occluded. If it be one of the ultimate bronchia, the result may not be very serious, but in case of the larger many grave complications may arise; not only from the occlusion of the bronchia, but the increase in growth of the polypi, will cause a dilatation.

The excessive dilatation of the larger bronchia exerts great pressure on the neighboring tissue of the lung. There results from this, not only a loss of lung capacity, but the



POSTERIOR VIEW OF TRANSVERSE SECTION OF THE HEART AND LUNGS. (Description, page 485.)



blood supply is shut off, and this portion of the lung may become gangrenous or atrophied. Abscesses may also result from polypi in the bronchia.

If a polypus becomes degenerated, or is torn loose by the movements of the lungs in efforts to expel it, the lungs may become infected.

The mere presence of polypi in the bronchia does no harm, but the increase in size of the polypi may cause gangrene, by constriction of the blood-vessels.

Historical (1700-1903).—Clark (1700) reported a case of polypus of the lungs, and Bussière reported a similar case.

Samber (1719) reported a case of polypus which was coughed up from the windpipe. Nichols had a somewhat similar case in which the expectorated polypus resembled a branch of the pulmonary vein. Strack (1799) published a work on "Polypi as a Causative Factor in Pulmonary Diseases." Acharius (1802) wrote a paper on a case of pulmonary polypus. Cheyne (1808) had a case of bronchial polypus. Hankel reported several cases of chronic tracheitis and bronchitis due to polypi.

Middendorff (1837) published a dissertation on polypi of the bronchia. North (1838) gave an account of two cases of bronchial polypus. Berliner (1848) published a work on polypi of the bronchia. Oppolzer (1858) had a case of chronic tracheitis and bronchitis due to polypi. Morris (1862) reported several cases of bronchial polypus. Commandre (1872) observed polypiform masses in the bronchia. Warren (1876) published a paper on the nature, etc., of bronchial polypi.

Symptoms.—The symptoms of polypi in the bronchia are very similar to those caused by the benign tumors. If the polypus has a pedicle, there will be a noticeable change in the bronchial sounds. This will be caused by the polypus swinging back and forth, but when the growth of the polypus produces occlusion of the bronchia, the sounds will cease.

Hearn and Roe (*American Magazine*, July 1901) reported

a case of pneumonotomy for abscess of the lung, due to a polypus. Two operations were performed; on making an examination of the abscess cavity, after the second operation, a polypus was found extending into the abscess cavity. These writers believe that localized gangrene was responsible for the trouble. They claim that the abscess cavity was not a saccular bronchiectatic cavity; but it is very probable that the polypus observed after the second operation, was the prime cause of the abscess. It is not likely that a polypus, several centimeters in length would have developed in the interval, between the two operations. Nothing is said to indicate that the polypus had been seen before the examination of the cavity.

This case illustrates the importance of a thorough knowledge of the condition of the lesion in all pulmonary troubles. This is necessary, not only for diagnostic purposes, but that the proper surgical procedure may be selected.

CHAPTER XIV

ATELECTASIS APNEUMOTOSIS

ATELECTASIS PULMONUM (imperfect expansion of the lungs) is a condition more often spoken of in literature than found in actual practice. Atelectasis, collapse, or carnification is rare and always congenital. When caused by continued compression of the lung by fluid, new growth, gauze packing, or compression from any cause after birth, it is termed apneumotosis.

“Congenital atelectasis is of great medico-legal import. This much has been demonstrated, notwithstanding the controversies which have arisen among pathologists: 1. That atelectasis may continue indefinitely as a foetal condition, and occur in infants who have lived, breathed and even cried. 2. The presence of much pigment shows that the affection has not developed before the fifth year. 3. The absence of pigment does not necessarily show a foetal condition, because the pigment may have been absorbed in the process of time. 4. Complete absence of air from the alveoli is an evidence of death before birth. 5. Aspirated products found in the air passages is absolute evidence of respiration” (Abrams).

Mechanism of Collapse.—Lichtheim demonstrated that in bronchial obstruction, the air is absorbed by the vessels of the alveolar walls, aided by the inherent lung elasticity. The oxygen is most, and the nitrogen least rapidly absorbed. Obstruction collapse may occur in any part of the lung, but the site of predilection is the lower lobes. Here, many factors are involved in explanation of this fact. Insomuch as bronchitis is

a common cause of obstruction, the secretions gravitate to the most dependent parts. Again, the lower chest is more pliant and mobile, and is, therefore, very susceptible to external atmospheric pressure.

Complications.—" 1. The atelectatic areas may pass into a condition of fibroid induration. 2. Dilatation and hypertrophy of the right heart are present, due to causes which will be discussed in the next chapter, on emphysema. 3. Thrombosis is present in the brain sinuses, due in part to the imperfect circulation, and in part to the debilitated condition of the system. 4. There is compensatory emphysema, the healthy lung assuming the functions of the collapsed areas. 5. There is persistence of the foramen ovale and ductus arteriosus. These channels are closed normally within two weeks after birth, but they may remain patent, owing to the enfeebled respiration which causes the blood to linger in the right heart, and to utilize the foetal channels for voiding its contents " (Abrams).

Historical (1832-1903).—Joerg (1832) reported a case of morbid pulmonary organ, and imperfect respiration from birth. G. H. Barlow (1841) published his observations on certain diseases originating in early youth, illustrating his position by three cases of defective expansion of the lungs. Spangenburg (1844) had a case of atelectasis with uterine respiration. Fischer (1851) reported a case of infantile atelectasis pulmonis.

In 1852, appeared Meig's paper on atelectasis pulmonum and collapse of the lung in children, with cases. Cockle (1856) reported a case of acquired atelectasis (carnification) of the entire upper lobe of the right lung, from direct mechanical pressure. Ward (1856) reported a case of enlarged thymus, and atelectasis, in an infant which survived its birth four hours.

Kunkler's work throws some light on this questionable condition. His work prepared the way for Hewitt's discoveries concerning apneumotosis or pulmonary collapse, and observations on the diagnosis and treatment of such cases. Clark (1859) reported a case of carnification of the lungs in an in-

fant. Thomas (1864) had a case of complete atelectasis of the lungs. Houston (1867) reported a case of congenital atelectasis, with death after the establishment of respiration.

Stevens gave an account of two cases of collapse of an entire lobe of the lung, without displacement of the thoracic viscera. Long reported a case of pulmonary collapse caused by hæmoptysis. T. Barlow (1879-80) reported an interesting case of atelecstasis of the lungs, emphysematous cysts, and congenital heart disease. Meigs (1879) reported a case of collapse of the lung, and cyanosis in a young infant, produced by violent crying. Francke (1883) also reported cases of atelectasis. Owen (1886) tells of a case of complete collapse of both lungs, without organic disease or mechanical injury.

Adams published in 1898 an article on postnatal atelectasis. The Italians have been especially interested in this subject. At Kiel (1891) appeared an article on a case of atelectasis complicated by bronchiectasis. Werner also published an account of a somewhat similar case. Abrams (1894) published his observations on the pathology of pulmonary atelectasis. Desplats (1894) had a case of gastrointestinal apneumotosis, which caused atelectasis of the two lower lobes of the lung, and death by asphyxiation.

Patton's work on bronchiectasis (1898-99) with those of Whitney, Starr, and Case, and their reports of one-sided chronic pulmonary atelectasis, brings the published knowledge up to date.

Symptoms and Diagnosis.—It is only when the atelectasis is extensive that the condition in the infant is recognized, small foci giving rise to no demonstrable manifestations. Cough and fever are absent as a rule. Cyanosis is usually marked and progressive, and corresponds to the impaired respiratory movements and imperfect chest expansion. The cyanosis is specially prominent in the face and fingers. The pulse is feeble, rapid, and irregular.

Physical examination of the chest shows recession of the

lower thorax with each inspiration. If the child cries during the examination, it does so with difficulty, and the cry is no more than a moan.

Percussion shows dulness, usually marked in the infero-posterior portions of the lungs. The percussion below must be light, otherwise one only obtains impaired resonance. If the hand of an assistant is made firmly to compress the thorax above the area percussed, any dulness, if present, is accentuated; the compressing hand confines, as it were, the thoracic vibration, and prevents its transmission to the percussional area.

Auscultation is by no means conclusive. The respiratory murmur, although usually absent or enfeebled over the atelectatic area, may be intensified to bronchial breathing.

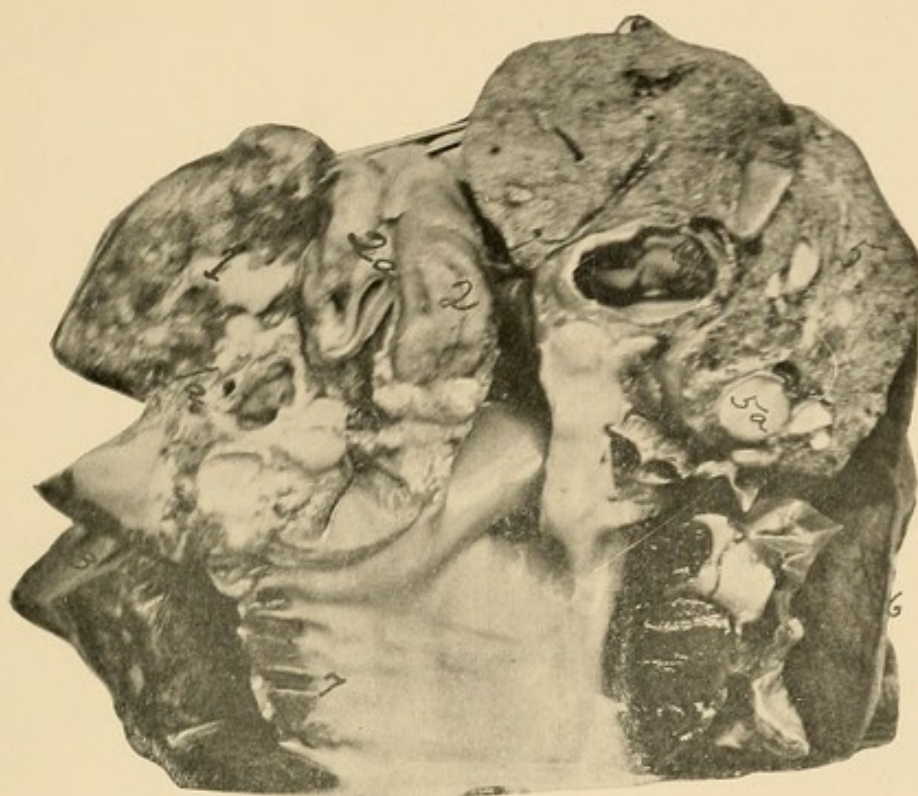
Pathology.—A part or all of the lung may be involved in either atelectasis or apneumotosis.

The tissue is non-crepitant, smooth, dark blue, or purple in color; becoming hard and dense with age of the child, if not aerated soon after birth. Bronchitis is the most common cause.

Paralysis of the pneumogastric nerve as the result of pressure from tumor, injuries, or otherwise, is also a causative factor. "The dyspnoea is of the inspiratory type" (Abrams).

Treatment.—"Place in fresh air, induce vomiting, and try artificial respiration, remove mucus from mouth and throat, with gauze or finger. Induce cutaneous stimulation by alternating hot and cold water; try rectal divulsion with finger and rhythmical contraction of the tongue" (Laborde).

Mouth to mouth inflation of the lungs, with tongue of patient drawn forward and his nostrils closed, is a useful procedure. Emetics should not be given, as they are useless.

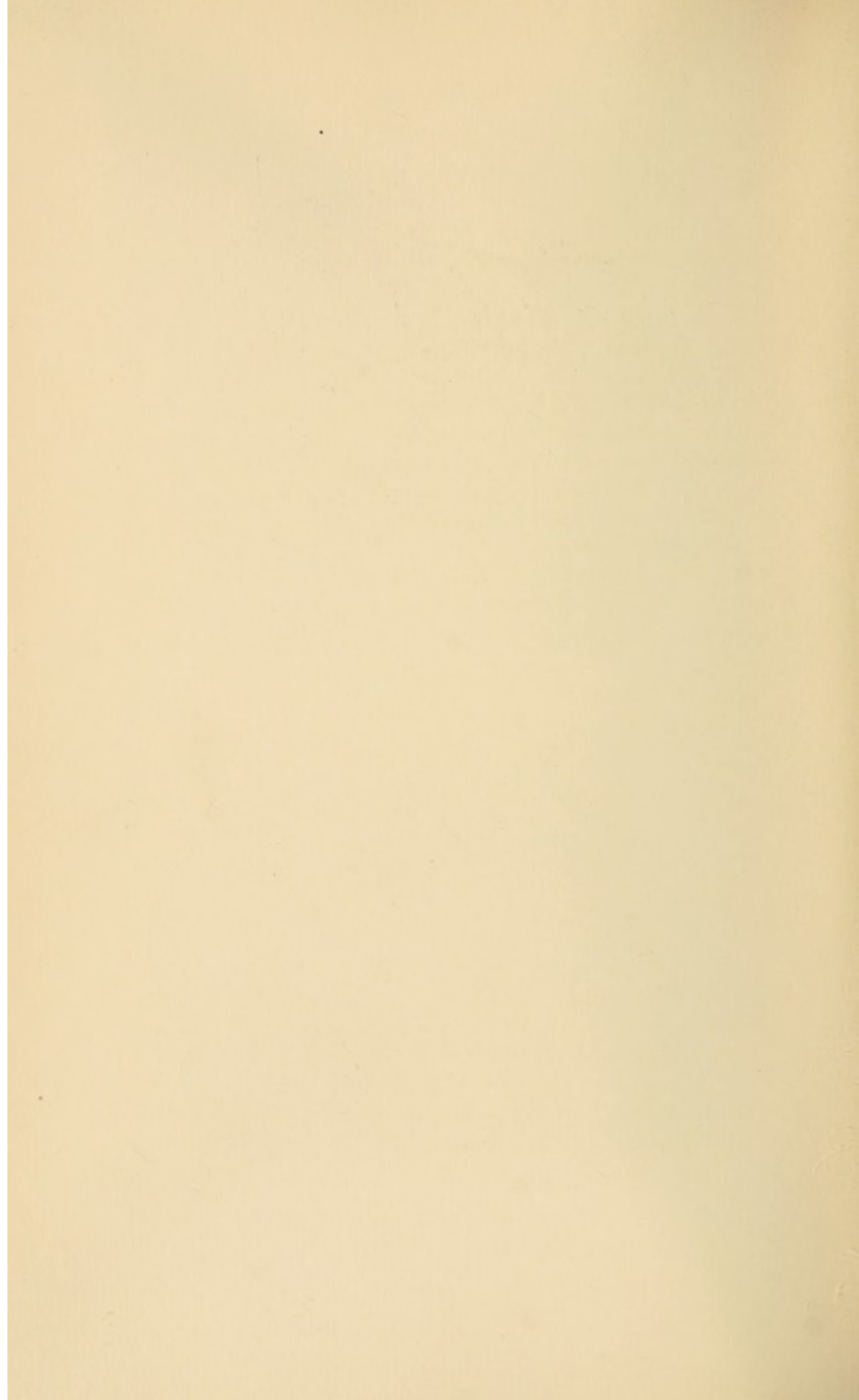


A.



B.

TRANSVERSE SECTIONS OF THE HEART AND LUNGS.
(Description, page 485.)



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CHAPTER XV

SYPHILIS

SYPHILIS being next to tuberculosis in importance as a causative factor in lung abscess and gangrene, should be considered. Unlike their action in tuberculosis, remedial agents for syphilis will prevent, at least to a very great degree, the formation of lung abscess and gangrene, if they will not at all times cure them. There are, perhaps, no pathologic lesions more easily influenced or completely overcome by medicaments than those caused by syphilis. It is, therefore, proper to use the remedies for syphilis to the maximum degree, not only before abscess, or gangrene, or both, manifest themselves, but during their existence, and after any operative measure that may have been employed.

Not all cases of lung syphilis terminate in abscess or gangrene. Such conditions are indeed few, in comparison with those of syphilitic tubercle, that are not arrested in their course, and overcome by proper medication before such a destructive stage is reached.

Historical (1797-1903).—The literature of this subject begins with the publication by Zadig in 1797, of a paper on diseases of the lungs from venereal sources. Then nothing appeared until 1841. That year Munk published his paper on syphilitic diseases of the lungs. Ten years elapsed before anything else on this subject was published.

Lagnean (1853) published his work on the diseases of the lungs, caused, and influenced by syphilis. Stevenart (1853) announced the fact, that constitutional syphilis often revealed

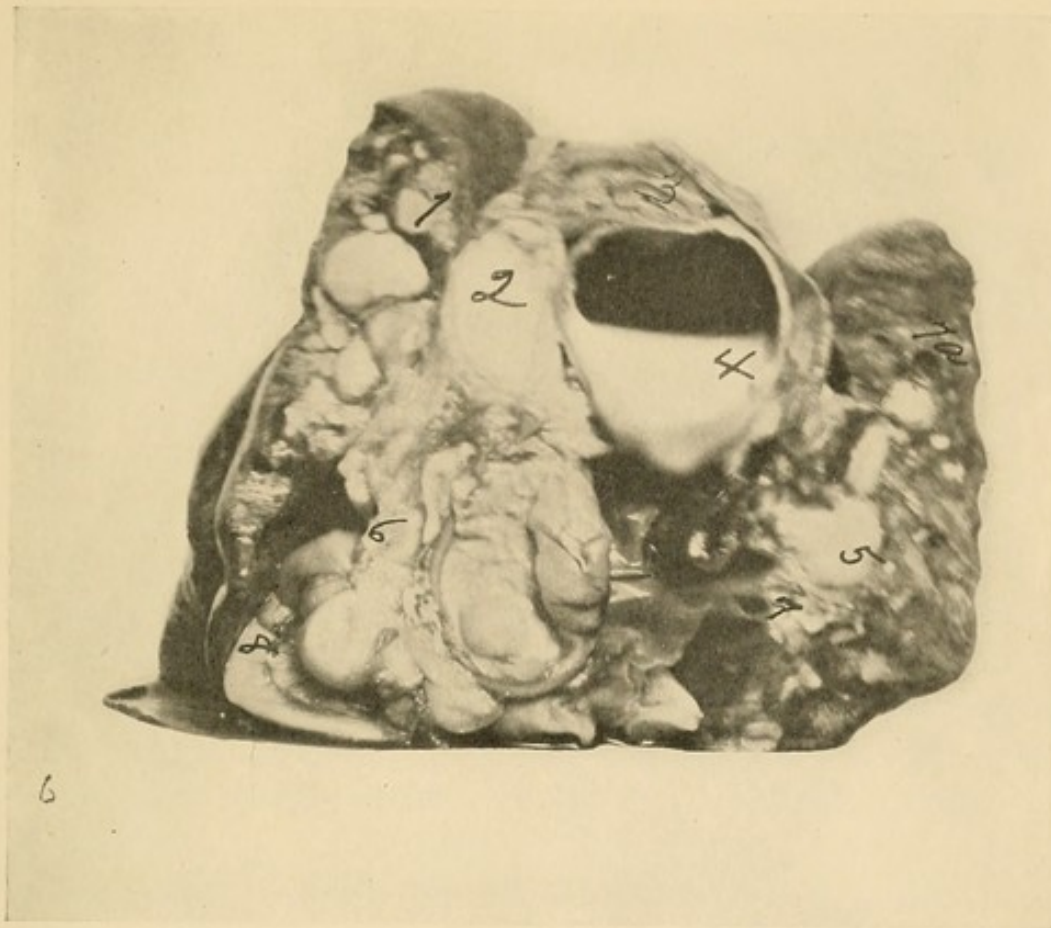
itself by grave changes in the lungs, etc. Aitken (1863) published his notice of pulmonary lesion, associated with syphilis. Fontain (1865) observed a case of syphilis of the lung, in an eight months foetus. Mescrede (1866) published a paper on the subject. Gintrac (1867) had a case of syphilitic phthisis. Negri (1868) published his paper on Some Practical Considerations concerning Syphilitic Diseases of the Lungs.

Dr. Lindseth (1870) appeared with his work on syphilitic phthisis, laryngitis, etc. He boldly advocated certain ideas, which, at the time, caused considerable criticism. Ouvre was the most important of his critics. Depaul (1870) reported a case of syphilitic alterations of the lung at birth. We are also indebted to Fox for additional knowledge of syphilitic affection of the lung.

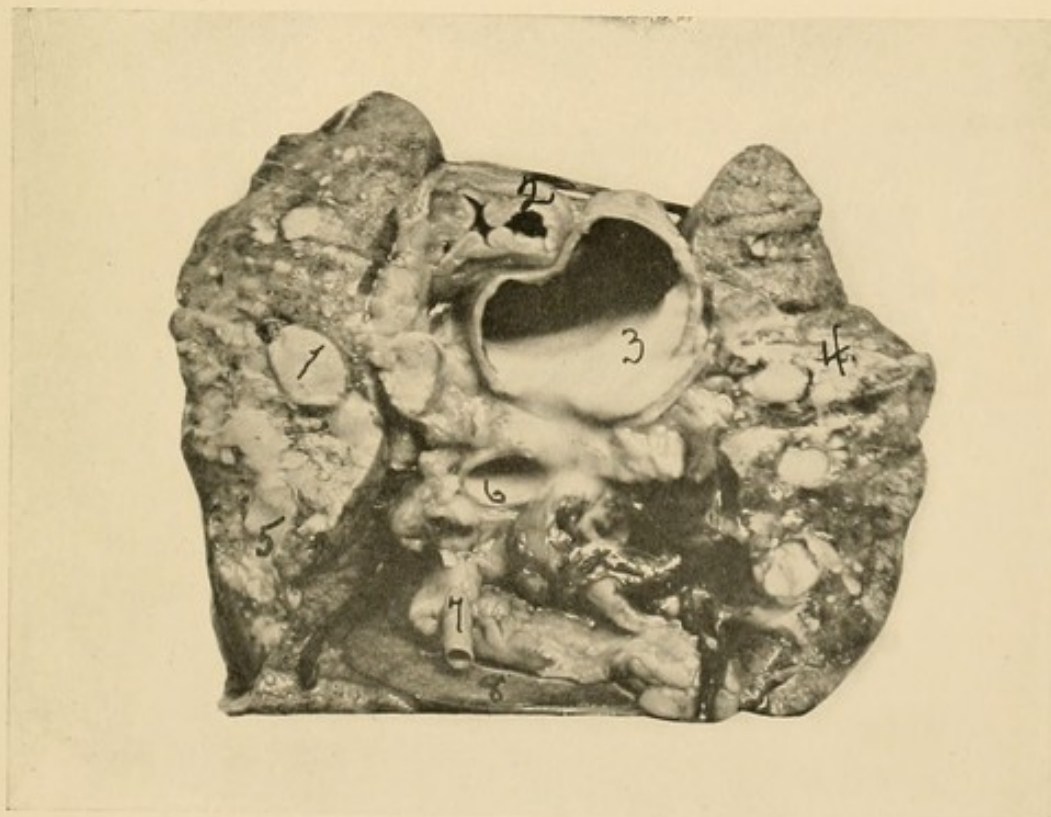
Zelinski (1871-72) issued a paper on inflammation of the pleura in a syphilitic patient. Hand (1872) reported an interesting case of syphilis, accompanied by capillary bronchitis, and lobular solidification of the lung tissue. Huchard (1873) published his work on syphilitic tumors of the lungs. Goodhart (1873) also reported cases of syphilis of the lungs. Grandier (1875) published a valuable paper on the same subject. Rollitt (1875) made a contribution to the literature of this subject. Fournier (1875) also published a report. His, however, was more of a treatise on syphilitic phthisis.

Pentinalli (1877) published a valuable paper on congenital and acquired syphilitic diseases of the lungs. Frey (1876) reported a case of infiltration of the lung from syphilis. Mahomed (1876-77) published two cases of syphilitic disease and early fibroid of the lung. Gowers reported cases that came under his observation.

De Bomilla (1876-77) reported a case of tracheobronchial adenoid, due to syphilis. Porter also reported a case of syphilitic phthisis, and Poggio the same year reported a case somewhat similar. Tiffany has a valuable paper on syphilitic diseases of the lungs. We are under obligations again to

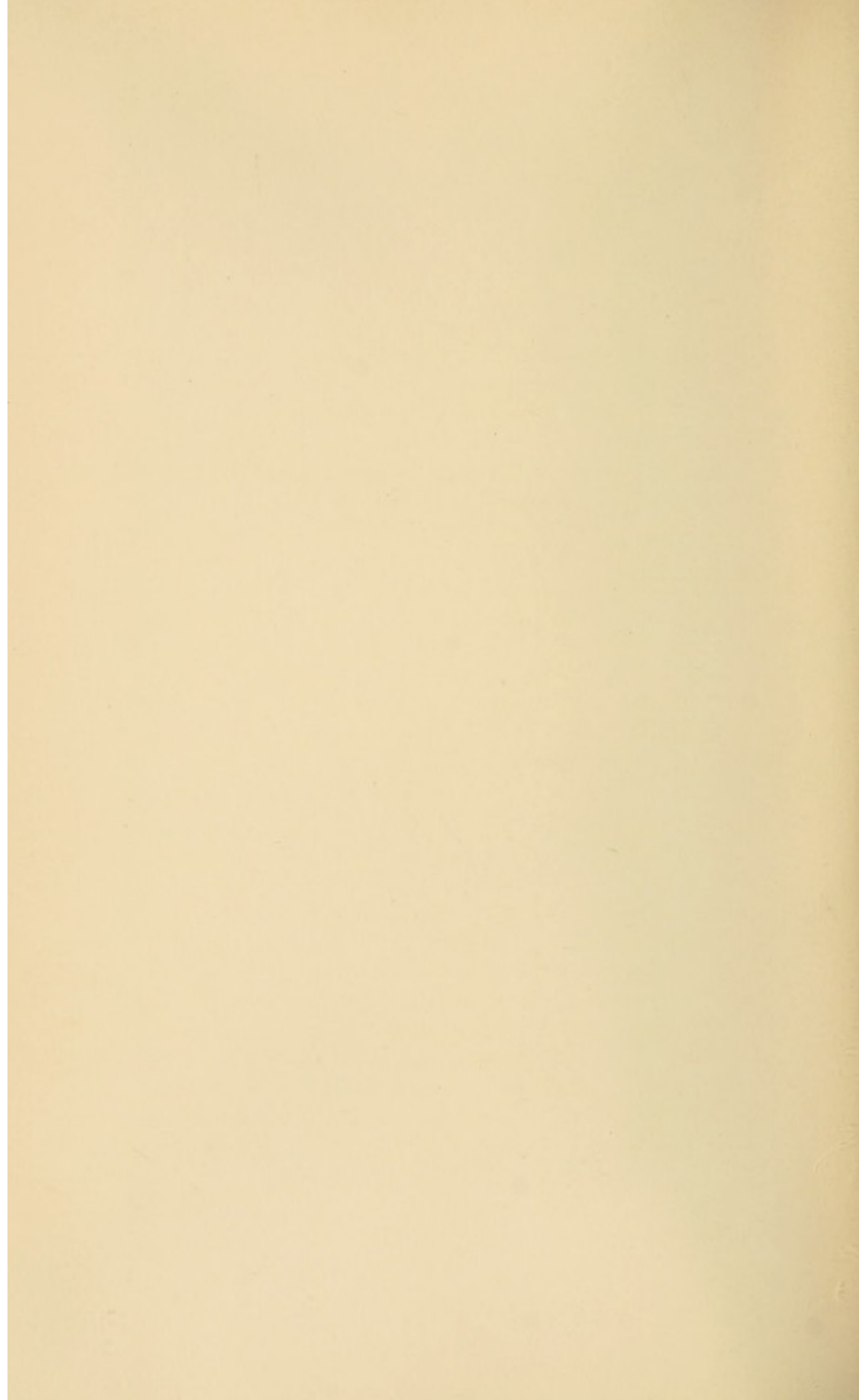


A.



B.

TRANSVERSE SECTIONS OF THE LUNGS.
(Description, page 486.)



an Italian, for Jaunuzzi's paper on hereditary and acquired syphilitic diseases of the lungs.

Landrieux (1878) published a useful work covering all the syphilitic diseases of the lungs. Raindohr (1878) added much in the way of caring for these diseases by his work on methods of treatment. Vierling (1878) had a case of syphilis of the trachea and bronchia. Kortmann (1878) published an extensive treatise on syphilitic diseases of the lungs. Bresse (1879) published his study on a case of syphilitic phthisis in an adult. Proksch (1879) published his history of syphilis of the lungs; Warder reported a case of syphilitic disease of the pleura. Langehaus also reported a case; Eve and Schnitzler (1879) had several valuable reports on syphilitic diseases of the lungs.

Sacharjiss (1879) contributed valuable lessons in his work on the diagnosis of syphilitic pneumonia. Henop (1879) also published a report on syphilis of the lungs.

Cantarano (1880) furnished contributions to the clinical history of these diseases. Frank (1880) had a valuable paper on syphilis of the lungs, and discussed the relation of such diseases to hereditary syphilis. Gamberini (1880) made some excellent clinical studies in syphilitic diseases of the lungs. Von Cube's report contains a great deal of new matter.

Lehmann (1881) had an interesting paper on the same subject. Seiler (1881) reported two cases of pulmonary syphilis. Rutgers von den Loef reported several interesting cases. Schech (1881) made the literature interesting by his reports. Pancritius (1881) published his work on the practical treatment of syphilitic diseases of the lungs. Engstrom, too, has practical and useful hints on the treatment of syphilis of the lung. Schech (1882) published a paper on syphilis of the lung and trachea. Rodriguez Gongora (1882) reported on methods of treatment. The year 1882 was prolific in papers and reports on this subject. Carlier's study upon pulmonary syphilis; Concetti's case; and Hiller's two cases, are all important contributions. Engel (1882) was the first to differentiate pulmonary

syphilis from tuberculous phthisis, or rather, to give a method of differential diagnosis in cases of syphilitic diseases of the lung. He also has some valuable remarks upon the pathology of the lungs in this disease. Guntz (1882) published a valuable paper on diagnosis by examination of the sputum.

The next year, 1883, is also prolific in reports, papers, etc., on this subject. Raphael, Senger, Blondeau, De Renzi, and Nogueire each have published cases that came under their observation.

Rethi (1884) reported methods of treatment. Koeniger, Kopp, De Renzi, Hiller, and Juarez with his paper on lung troubles in children, caused by syphilis, made lasting contributions to medical literature upon this subject.

The year 1885 was not the least prolific in papers and reports on lung syphilis, as witness: Porter, Signorini, Ferguson, and the valuable article in the *Boston Medical and Surgical Journal*. We are again placed under obligation to Schnitzler for his paper on the pathology of pulmonary syphilis, etc. Both Bruen's remarks and Augier's and Laveran's papers are valuable.

Szohner's paper (1886) on syphilitic cirrhosis of the lung and mode of treatment was valuable. Heler (1886-87) published papers on this subject.

Karnbach (1887) appeared with a valuable work on the pathology of syphilis of the lung.

Mauriac (1888) reported a case of tertiary syphilis of the lung, and Ruhemann added to our knowledge of the treatment of this class of disease. Beissel's paper (1886) also proved of value because he details his experience in diagnosing cases of syphilis of the lung. Potain's work on the history, cause, pathological anatomy, symptoms, and diagnosis of pulmonary syphilis is of great value.

De Blois (1889) published an interesting paper on the manifestations of syphilis of the upper air passages. Haslund (1890) reported cases of a similar character. Raymond (1890)

wrote a most interesting work on the results of experiments on animals, regarding tertiary syphilis, and its effects on the lungs, larynx, trachea, and bronchus; also bronchopneumonia, and adenopathic pleurisy; the peritracheal compression of the right recurrent nerve, and miliary aneurysm, due to syphilis.

Bokenko (1890) reported a case in which the left lung was affected, and at the same time the patient had an attack of catarrhal pneumonia of the right lung. Kurn (1890) reported a case of pulmonary syphilis.

Forget (1890) reported a case, complicated with adenopathic tracheobronchitis. Lancereaux (1891) published a work on the various pathological changes produced in the lung by syphilis. Councilman (1891) and De Renzi reported cases of pulmonary syphilis. Perry (1890-91) reported a case of diffuse syphilitic fibroma of the lung. Neeman reported a case of multiple gummata, and Rolleston (1890-91) reported a similar case.

Satterthwaite (1891) published a treatise on pulmonary syphilis in the adult. Sevestre (1891) had a case of pneumothorax in an infant, twenty-two months old, due, probably, to syphilis, and Roubleff added his contribution to the study of syphilitic affections of the lungs.

Manfan (1892) reported cases and De Renzi (1892) published a most interesting case of pulmonary syphilis. Seibert (1892) brought out a paper on syphilitic bronchiostenosis in children.

Hodenpyl's article on the differential diagnosis of miliary tuberculosis and gummata in the same lung, is of great value, and Juleos's work on the diagnosis and treatment of pulmonary syphilis is also timely and valuable. Abrams (1893) reported the results of an autopsy, held in a case of death from syphilis of the lung. Feulard had a case of syphilis, and gummata of the right lung simulating gangrene and tuberculosis. His treatment is of great interest. Peterson and Thompson (1893) reported cases which they had treated. Bryson published a

paper on some of the manifestations of syphilis of the upper air passages.

Schirren and Gerber's reports (1894) were on cases of hereditary syphilis of the lungs. Gemmell had a very interesting case of syphilitic ulceration of the trachea and bronchia, with fibroid induration of caseous tuberculous nodules in the basal parts of the lungs, with enlargement of the lymphatic glands and gummata in the liver. Those interested in this subject will find many useful hints in Le Fèvre's work on the value of early diagnosis in syphilitic lesions of the upper respiratory tract.

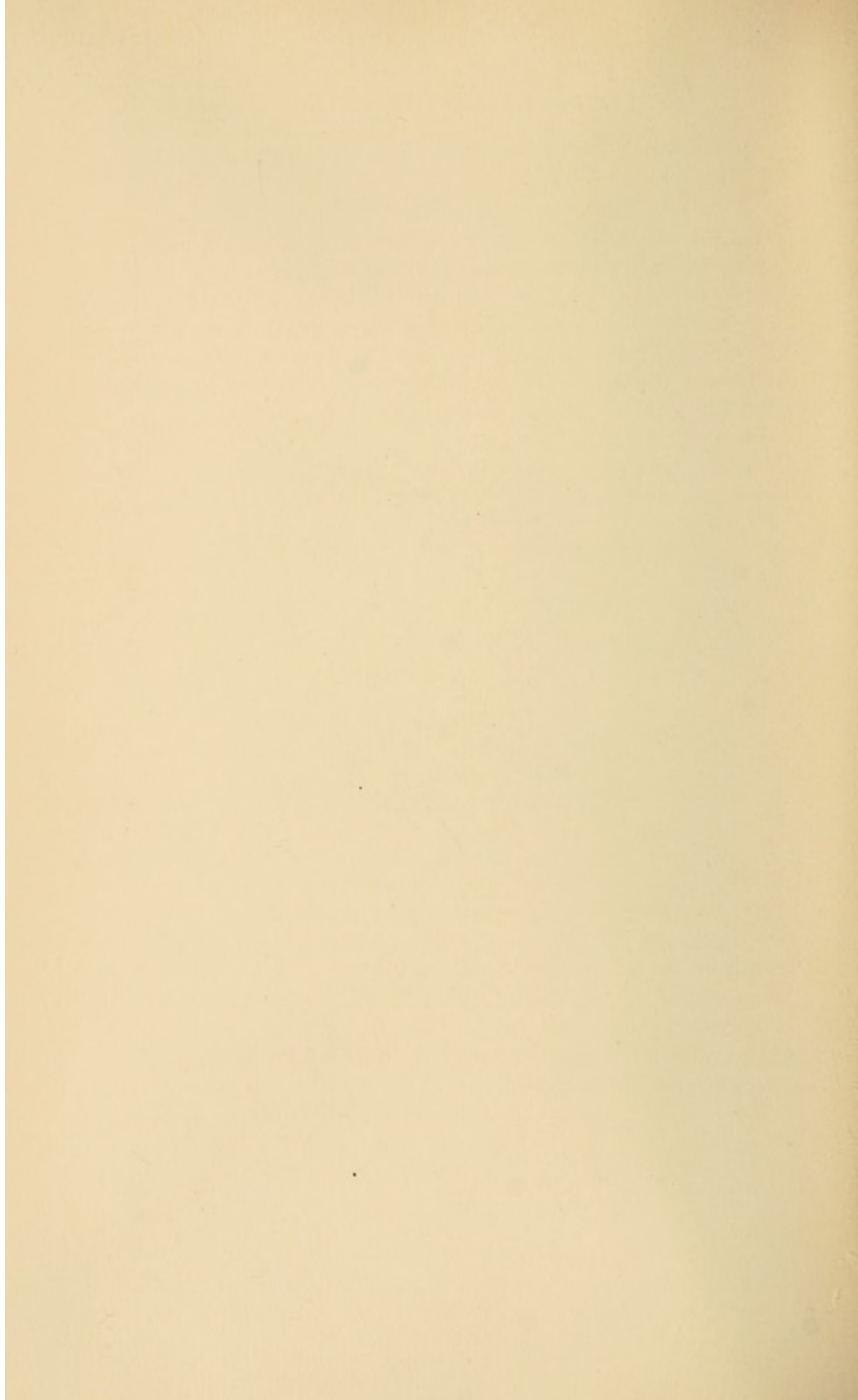
Straight (1894) had a case of pulmonary syphilis, complicated with catarrh of the apex. Pispoli (1895) reported a very interesting case. Merigot de Treigny (1896) published a valuable paper on pulmonary syphilis, and Tandoff's paper on the same subject is of some value. The same may be said of Vires's paper. Schwyzer has some useful and valuable data on the treatment, especially the surgical treatment, of cases of syphilis of the lungs. Lucidi has made a contribution to the literature on this subject.

Potain's paper on the connection of alcoholism and pulmonary syphilis is of great value, while Mongour's case has some points worth considering. Taube (1897) writes on the treatment and Carruccio (1897) reported cases of pulmonary syphilis. Dinkler (1898) published a paper on the manifestation of syphilis in the upper respiratory tract, with a report of a case of chancre of the nasal sæptum. Dieulafoy (1898) published a paper on syphilis of the pleura, lungs and bronchia. Fowler (1898) published an interesting work on syphilitic diseases of the lungs.

At the Ninth German Medical Congress, April, 1901, Hausemann exhibited three cases of syphilis of the lungs. He spoke of the difficulty of differentiating syphilis of the lungs from tuberculosis.



POSTERIOR VIEW OF TRANSVERSE SECTION OF THE LUNGS.
(Description, page 486.)



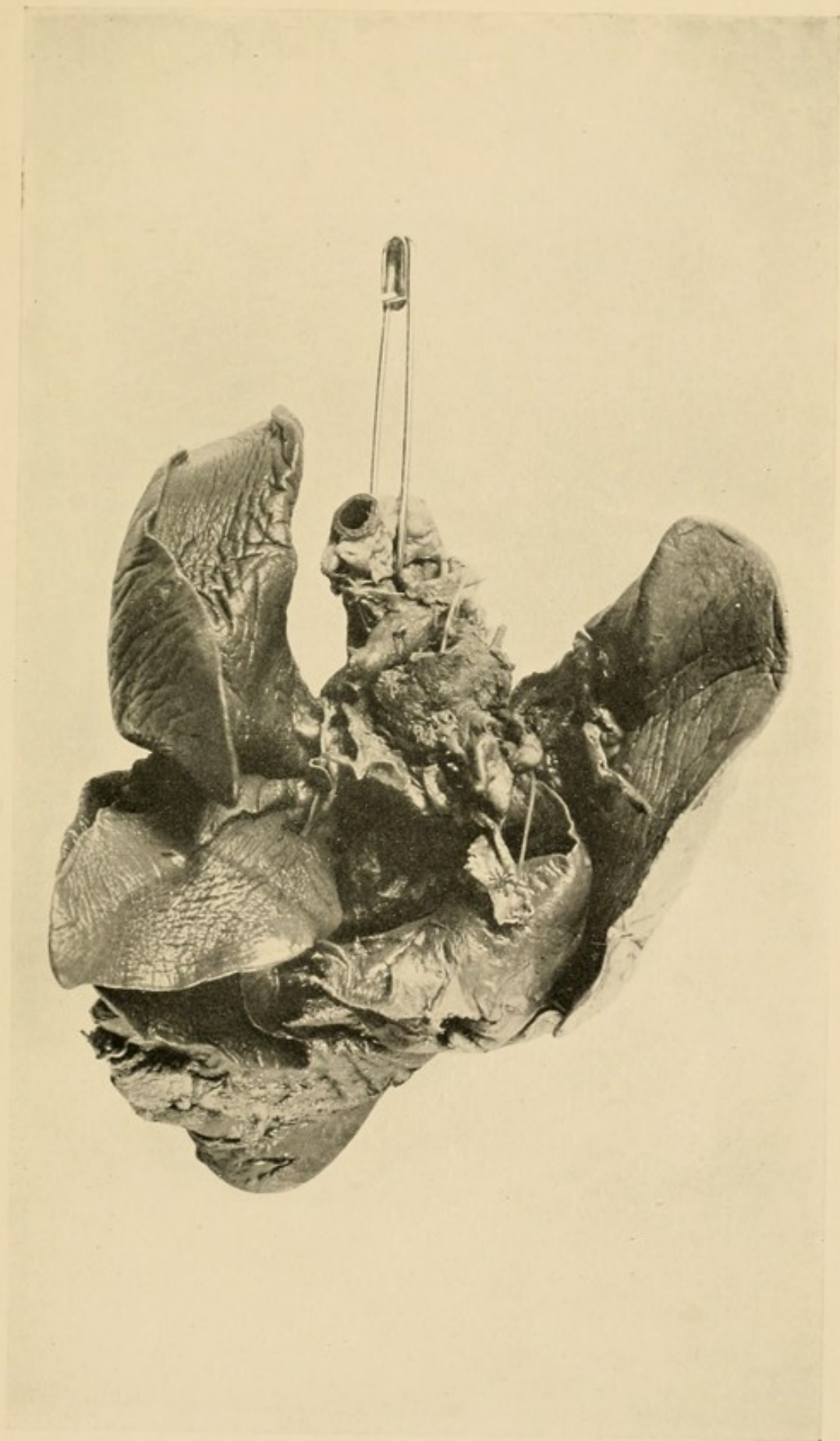
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CHAPTER XVI

BENIGN TUMORS—LYMPHOMA, CHONDROMA, OSTEOMA, DERMOID TUMORS

It has been thought best to make but three divisions in the classification of tumors, *i.e.*, Benign Tumors, Malignant Tumors, and Parasitic Tumors.

Historical.—Virchow (1863) was the first to make a satisfactory classification of tumors, in recognizing a homology and a heterology in new growths, even though a homologous growth may become heterologous.

It has been only in the last decade that certain forms of benign tumors have been observed. Schultz (*Russk. Med.*, St. Petersburg, 1890, xvi., 518-524) reports a case of primary fibroma in the lung of a child two years of age. Moskowitz (*Gynogyszat*, Budapest, 1891, xxxi, 317-329) had a case of scleroma of the air passages. Poor (*Lond. Lancet*, 1895, i, 873) reported a case of tumor of the lung; while Zakieff (*Roussky Vrach*, St. Peters., 1897, xviii., 340-342) reported four cases of tumor of the lung. West. (*St. Barth. Hosp. Reports*, 1897, Lond., 1898, xxxiii., 109-137) reported cases of new growths of lung and pleura.

LYMPHOMA.—Lymphoma, pseudoleucæmia, or Hodgkin's disease, is a rare malignant growth, resembling sarcoma, that sometimes attacks the lungs. It is generally secondary to primary involvement in the cervical glands, that is, other than bronchial glands are involved. It usually follows the glands of the bronchia, and fills the lungs from their base by involving the interlobular sæpta. It is a formation of lymph tissue as a

diffused infiltration of lung tissue, and should, therefore, be classed with sarcoma.

The lymphoid cells are supported in a delicate reticulum of a hard and soft variety. More or less fluid may be present, and it may be gray or white in color, with no distinction between the cortical and medullary portions. The cells are greatly increased in number. The harder growths are yellowish white and dry, rarely spreading beyond the capsule, and never undergoing cheesy degeneration. Suppuration is rare. The capsule is thickened with fibrous bands which pass through the mass. It is found oftener in men than in women, the ratio being three to four. The lungs of the cobalt miners of Schneeberg are said to be invariably affected with lymphosarcoma.

CHONDROMA.—Chondromata usually appear in cartilage (enchondromata), but may originate in the absence of cartilage (ecchondromata). In the lung, however, its origin appears to be in the bronchia.

Ecchondromata are rare, but enchondromata are not so rare. The latter may be composed of hyaline cartilage, fibrocartilage, or osteoid tissue. They may be soft, or, partially or completely ossified. Chondromata are often the result of trauma, and may be combined with sarcoma. The case of primary enchondroma reported by Courment gives such a history. (*Lyon Med.*, 1895, lxxviii., pp. 259-261).

OSTEOMA.—There are three varieties of tumors formed of osseous tissue, *i.e.*, Osteoma durum or eburneum; Osteoma spongiosum; Osteoma medullosum. The first is formed of exceedingly hard tissue which resembles the cement substance of the teeth. The second is formed of spongy bone-tissue, with narrow trabeculæ, and wide medullary spaces. The third has medullary spaces filled with marrow. All the osteomata agree, structurally, with normal bone-tissue in the main points, but differ in not having the regular architecture of the bone trabeculæ, and in not having the typical arrangement of the vascular and medullary canals and bone-corpuscles.

The osseous and cartilaginous tumors are said to be more frequent in youth, but do not appear in young children. They are also more frequent in men than in women. Osteomata are frequently found in the lung in the form of thin plates. They are of very slow growth. Some writers think there is a hereditary disposition to these growths, especially for the multiple variety.

Osteomata in the lungs are supposed to be due to syphilis, or gout. They do not often reveal their presence during life; they are usually found on autopsy.

The removal of osteomata is to be considered only when they become troublesome; doubt always prevailing as to their character before exposure of the lung, prior to, or, after death. When surgical intervention is employed, they should be removed in the same manner as other foreign bodies, or benign tumors.

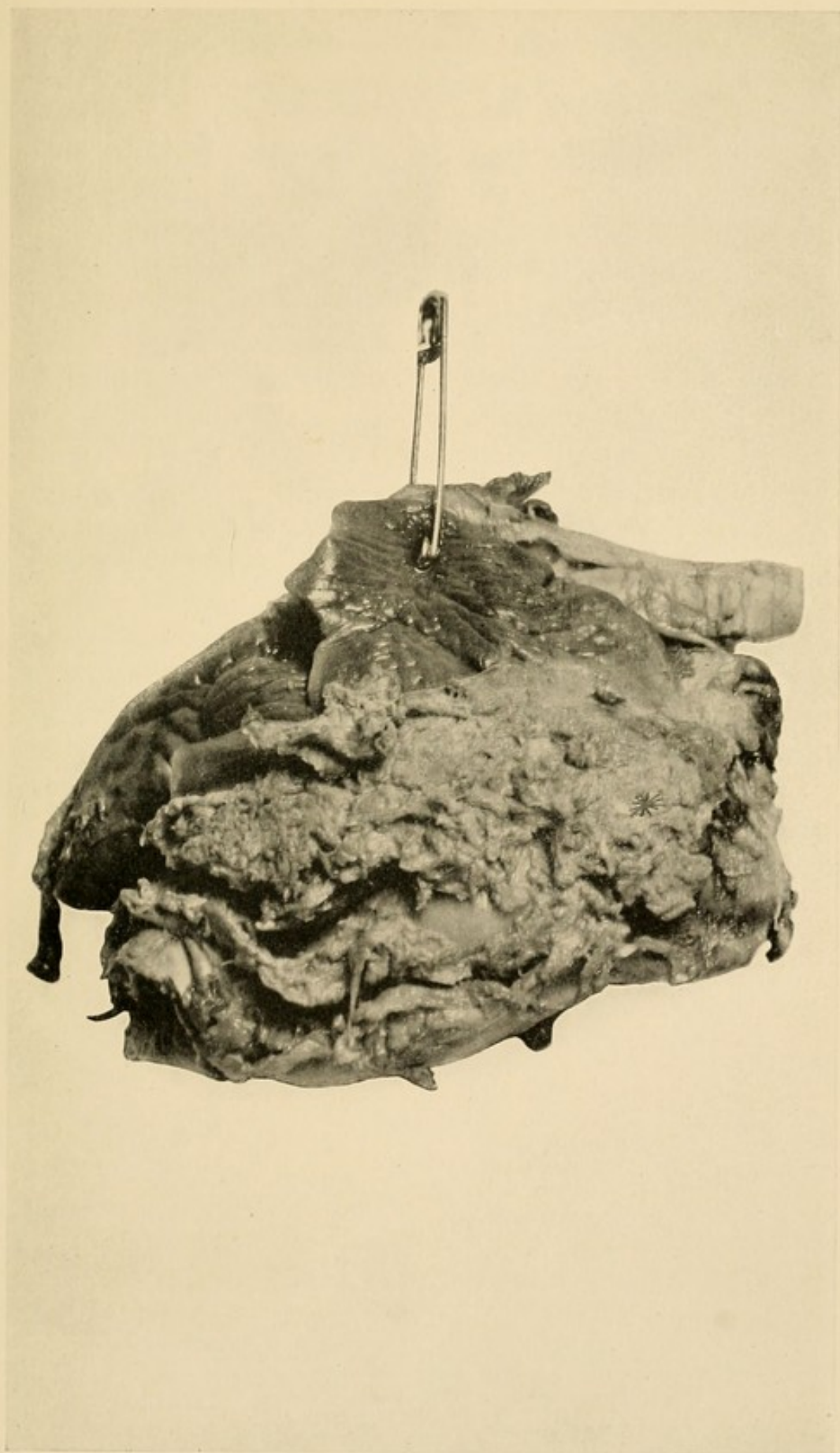
Brambella (*Gazz. Med. Lomb.*, Milan, 1895, liv., 128-130) reported a case of multiple osteoma of the lung which was, perhaps, due to gout or syphilis, the history of injury being absent.

DERMOIDS may be found in one or both lungs, but usually, in one only. They are rare, however, and are found, as a rule, on autopsy. Their variety is shown by the few cases reported.

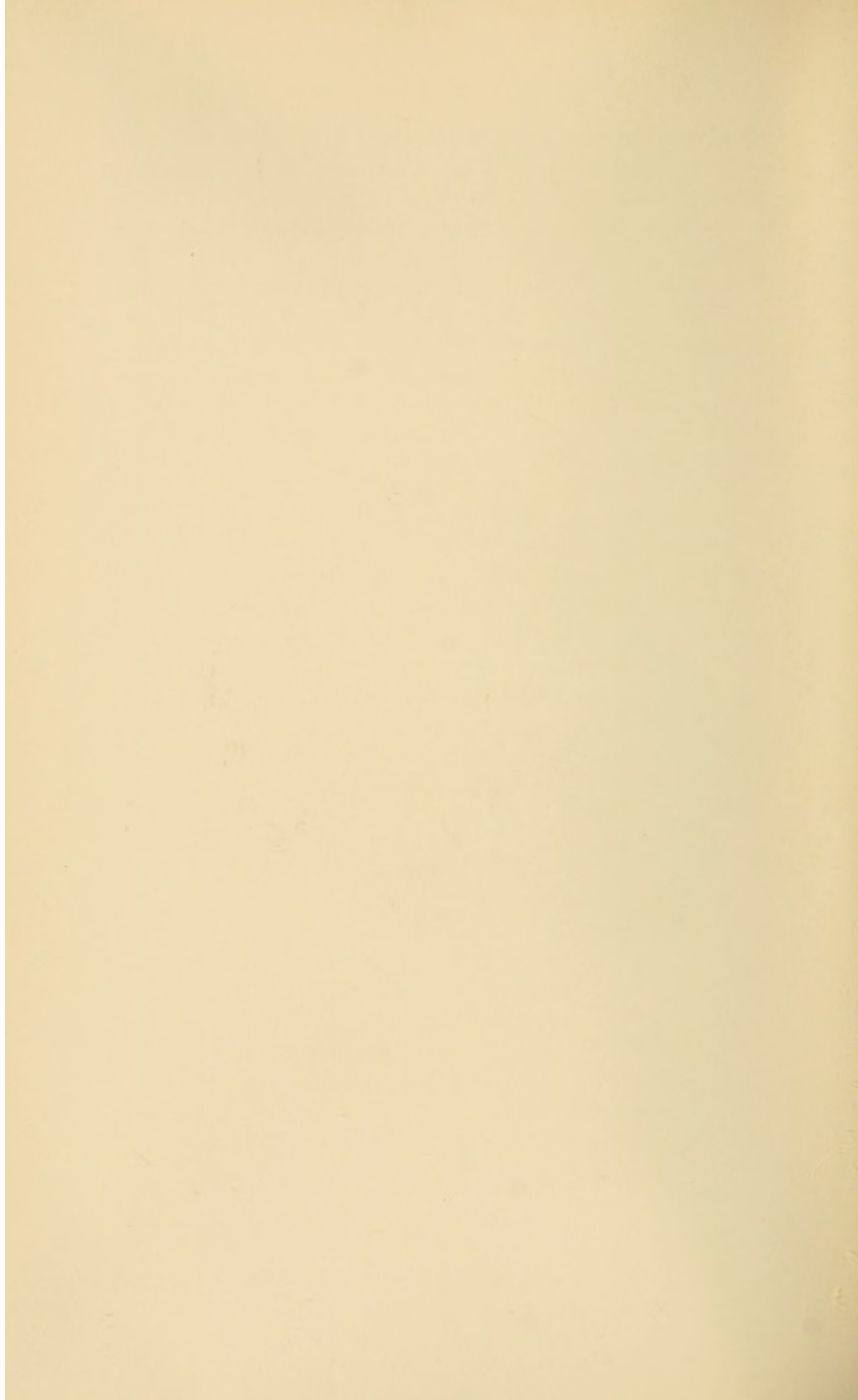
Goodlee opened a dermoid cyst of the lung, removed the processes and drained with recovery (*Trans. Med.-Chir. Soc.*, 1889). Sormain of Milan mentions a case of dermoid cyst (*Gazz. d'Osp.*, Milan, 1890, xi., 314-332). Ogle also described in detail a dermoid growth in the lung (*Trans. Path. Soc.*, Lond., 1896-97, xlviii., 37-39). The amount and character of dermoid tissue in the lung varies, as it does in other organs of the body.

Included in this group are the following four rare growths: Lymphoma, Chondroma, Osteoma, and Dermoids.

Lymphomata are the most treacherous of this class owing to their sarcomatous characteristics. The remaining three are harmless, unless their growth should be continuous, when the



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danger would be due to increased size. They would then act mechanically. But this is a rare occurrence, especially in the lungs.

All benign neoplasms, as a rule, seem to be limited in growth in the lungs.

Treatment.—*Lymphomata* should be dealt with in as radical a way as *sarcomata* and in the same manner.

Chondromata, because of their position at or near the base of the lung, almost preclude the possibility of attack. Not so, however, with the *osteomata*. These are usually numerous small bodies located here and there in the parenchyma. Their removal offers little hope of success, as the bodies are too small to justify search for them. If, however, an *osteoma* should be large enough to be detected with the finger, or otherwise, its removal should be accomplished.

The detection of *dermoid* cysts is also very difficult. Generally, they are small, but when detected they should be incised and their contents removed through the chest wall. Dissection of the tumor capsule is not necessary, as the cavity can be treated much in the same manner as in the removal of other growths.

In conclusion it may be said that a benign tumor requires no interference, except when troublesome on account of size. A malignant tumor cannot be entirely removed.

CHAPTER XVII

MALIGNANT TUMORS—SARCOMA, CARCINOMA

THERE having been numerous reports of malignant growths of the lung before a classification of malignant tumors had been made, it is necessary to consider "cancer" as then used to be a general term covering all malignant growths.

Historical (1833-1903).—Bricheteau's work published in 1833 has some suggestive things bearing on this subject. It reported a doubtful case of the lungs, with irreducible omental hernia. Begbie (1860) had a case of mediastinal and pulmonary cancer, attended by great local dropsy. Russell (1869) reported a case of primary cancer of the lung, simulating pleuritic effusion. Experimental paracentesis was done. Moore (1890) reported a new growth in the mediastinal gland and left lung, in a boy aged ten years. Schwable (1891) published his hand-book on cancer of the lung. Spillman and Haushalter (1891) published a paper on the diagnosis of malignant tumors in the lungs.

Satterwaithe (1891-92) reported rare pulmonary growths. Leprevost (1892) reported a case of cancer of the left lung in a peasant. The lung weighed eight kilogrammes, and the cancer finally invaded the abdominal cavity. Powell (1892) reported a case of malignant disease invading the right lung, complicated with gastric ulcer. Drysdale (1892) also reported a case of cancer of the left lung. Jappa reported an exactly similar case. Leech (1892) had a case of cancer of the lung, terminating in softening and cavity, and complicated with paren-

chymatous nephritis. Inurrigarre (1892) had a case of malignant tumor complicated with pleuropneumonia. Jepha (1892) reported a case of primary lung cancer. Anderson (1893) had a case of cancer of the lung complicated with secondary cancer of the liver. Siegert (1893) published a paper on the histogenesis of primary lung cancer.

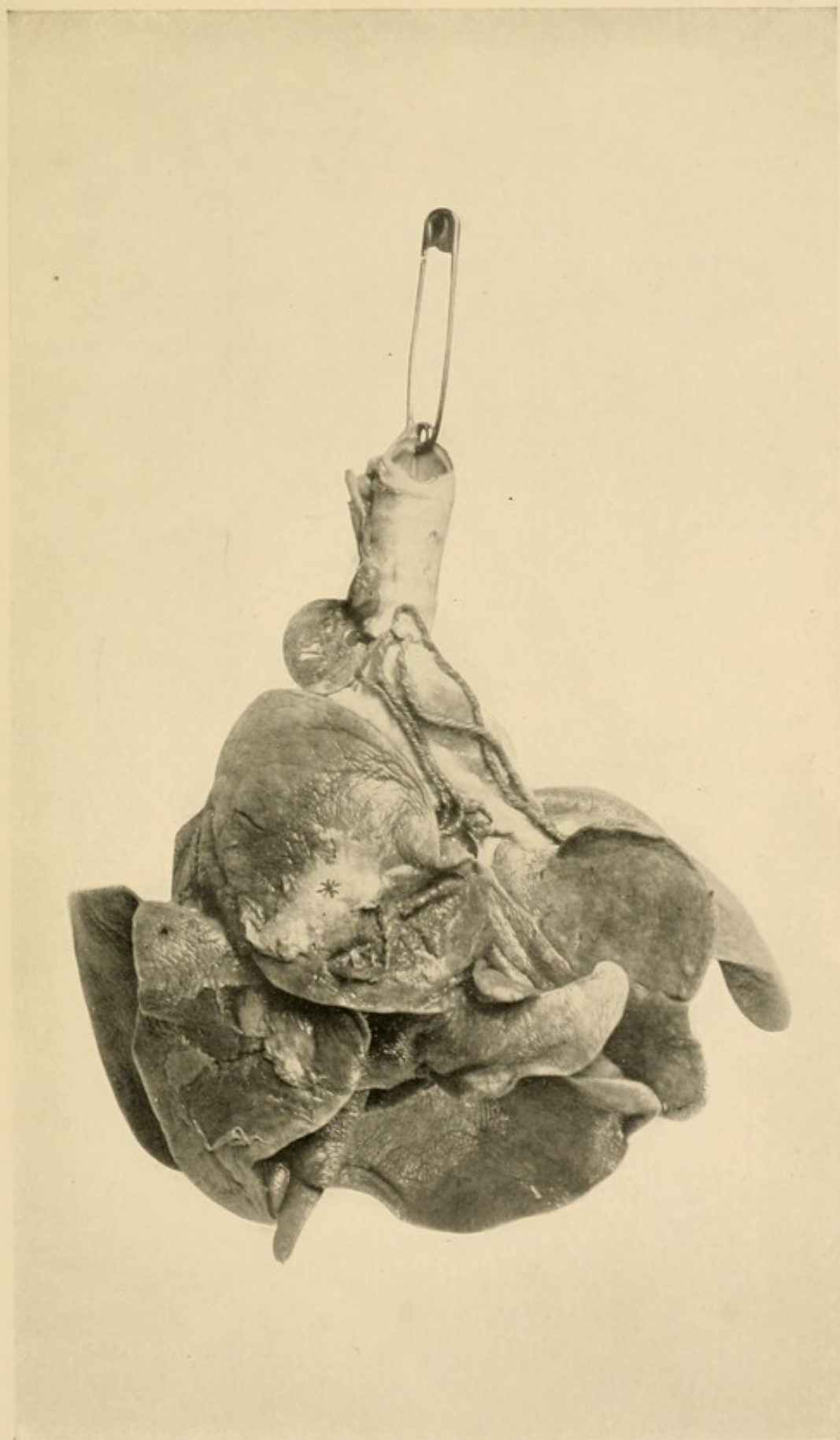
Passow (1893) published a treatise on the differential diagnosis of tumors of the lungs, and Steel (1894) gave a clinical lecture on a case. Foa (1894) also reported a case of hæmothorax, and cancer of the lung. Betschart (1895) published his work on the diagnosis of malignant lung tumors by means of the sputum. About this time appeared several reports on primary cancer of the lungs, the reports of Loomis, and De Renzi on primary cancer of pleuritic form, and Meuner's case of cancer of the bronchus.

Wolf (1895) also reported a case of primary cancer. Alder (1896) published a paper on the diagnosis of malignant tumors of the lung. Kazem-Beck (1897) added much to this subject by his report of two cases of primary cancer of the lung, and one of cancer of the mediastinum. Lenhartz (1897) had a case of primary lung and pleural cancer. Simmonds (1898) produced a work on the histology of primary lung cancer and Lazarus (1898) also reported malignant tumors of the anterior mediastinum and lung.

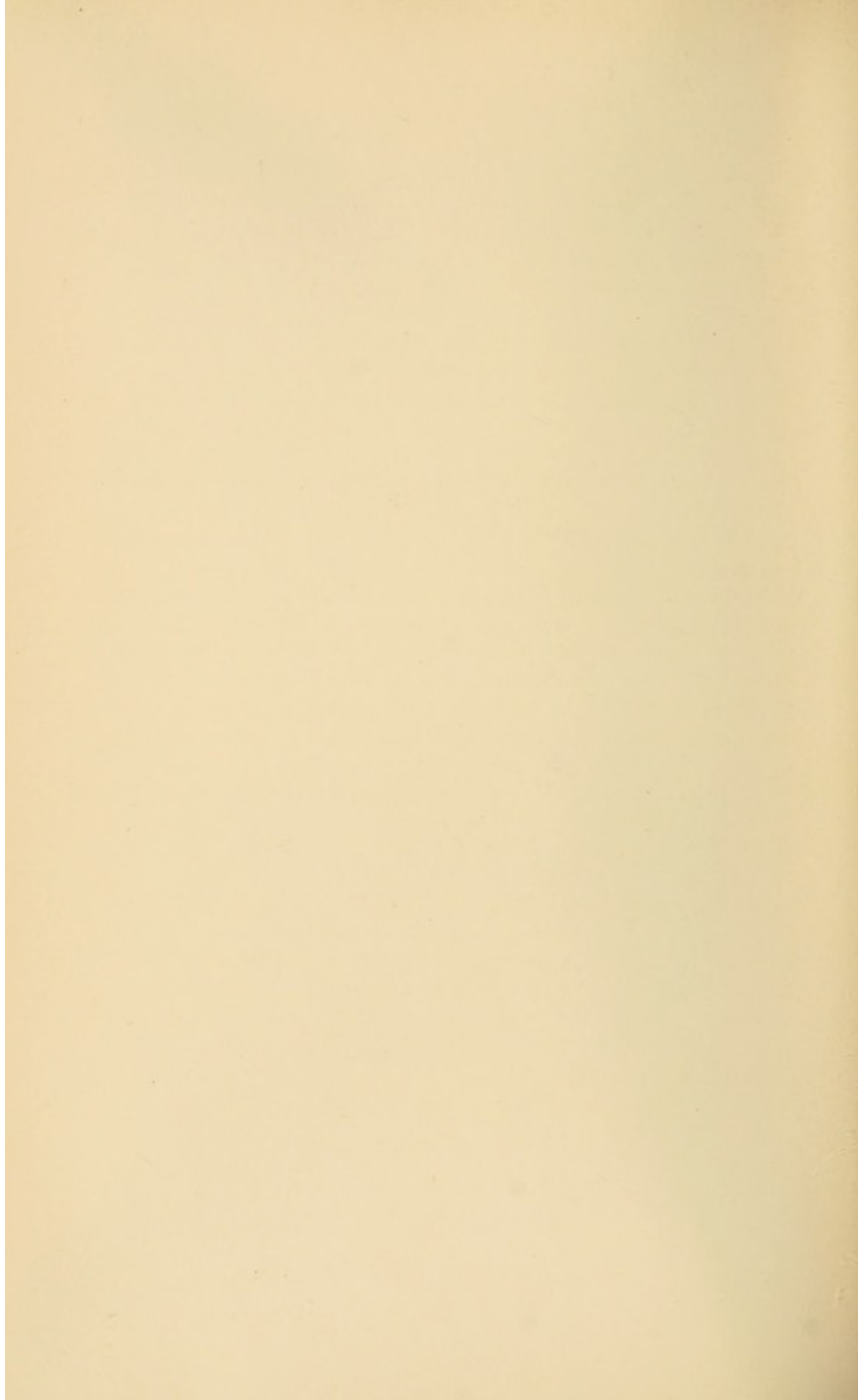
Kazem-Beck (1898) again reported two cases of primary lung cancer. Tubenthel (1898) published a paper on operations for cancer of the lung. Guralanos (1898) contributed to the literature on this subject, his study of the operations for pneumothorax, and resection for cancer of the lung. Yappa and Pensuti (1898) also had papers on primary cancer of the lung, while Claisse (1899) placed the profession under obligations by his paper on diagnosis.

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SARCOMA.—While rare, sarcoma is said to be the most common of the malignant growths of the lung. It may be of primary or secondary origin. When primary, it develops

from the larger bronchia, usually at, or near their base. The development is rapid, gradually involving the bronchial tract, and, subsequently, the lung tissue proper. Hæmorrhage is rare, and when it does occur, is likely to be fatal.

Historical (1833-1903).—The year 1890 saw the first published account of these tumors. Although the year previous Davies had reported a case of lymphosarcoma of the left lung, yet in 1890, Kozlowski and Marini reported cases in addition to that reported the same year in Berlin.

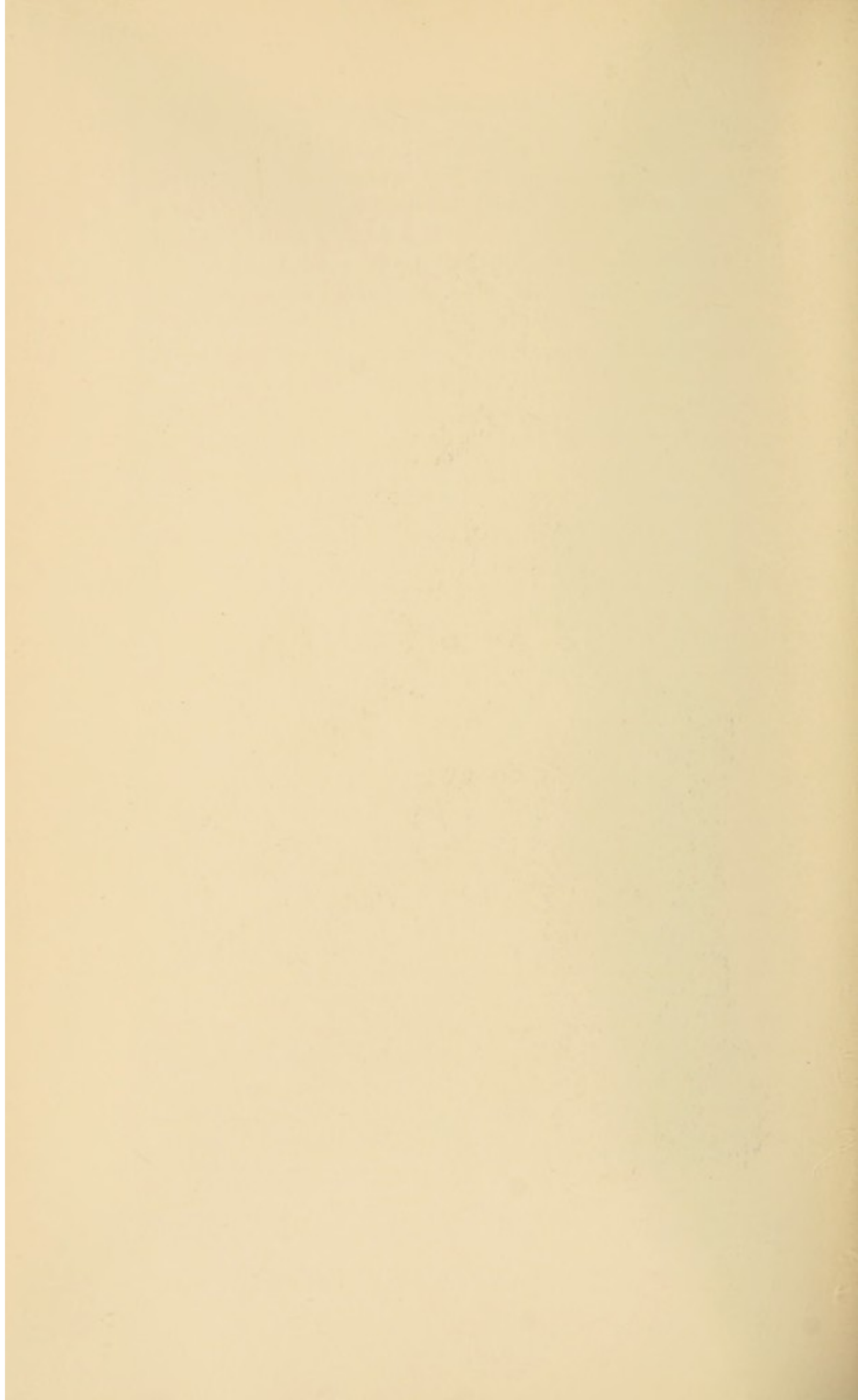
Sangelli (1888) reported a case, but he seems to have been a little doubtful as to the diagnosis. Jackson (1890) also reported a case of secondary adenosarcoma of the lung, and Schech was another who appeared in print on the same subject.

Vandervelde (1892) produced a paper on a case of primitive encephaloid sarcoma of the lung. Rolleston (1890) reported a case of myxosarcoma of the lung. Barclay (1892), Ferrand, and Mirinescu (1893), reported cases of sarcoma. West (1894) had a case of primary sarcoma of the lung in a boy aged eleven. Before this Ehrlich had reported a case of primary bronchial and lung sarcoma. Dolgopol discusses in a very interesting way the question of sarcomatosis of the internal organs, and also reports a case of sarcoma of the lung. Packard reported a case and Sangalli's observations on sarcoma of the pleura and lungs are of great value. Greenwood reported a case of pulmonary sarcoma. Besson (1898) wrote a report of alveolar sarcoma, secondary to that of the pleura and lung, and Hooper, Milan, Habershon, have reports of cases of lymphosarcoma. (For an interesting account of osteosarcoma of the lung see *Berl. Klin. Woch.*, 1898, p 349.)

Pathology.—Sarcomata are characterized by possessing a large number of cells on a typical connective tissue. The cell structure of the sarcomata is similar to that of the granulation tissue of an old ulcer. At times large protoplasmic masses, containing many nuclei, may be found. The blood-vessels, which ramify through these tumors, appear to be nothing but



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channels, surrounded by a net-work of connective tissue. The small vessels are in direct contact with the tumor cells. They are more voluminous than blood-vessels in normal tissues. Their cell walls are often similar to the tumor cells. The sarcomata are classified according to the shape of their cells, and also according to the other kinds of tissue that may be found incorporated in the tumor.

Shaw reports a case of stenosis of the bronchus and vessel, associated with pneumonia, produced by a sarcoma at the root of the left lung. There was great resemblance to tuberculosis, microscopically, but a more minute examination revealed the true state of affairs.

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CARCINOMA.—It is said that carcinoma is less common in the tropics than in the colder regions. Billings showed that it is more frequent in New England, New York, Ohio, Michigan, and the south Pacific; that it is less frequent in the Mississippi valley and southern coast, than in the interior.

Carcinoma in the lung is less frequent than sarcoma, and slower in its development; both, however, develop more rapidly in the lung than in any other tissue of the body.

Carcinoma may be primary or secondary in the lung. It is a malignant endothelial and epithelial growth, springing from the same embryonic tissue, which may be found in the sputum.

Historical (1833-1903).—Among the earliest reports is that

of the surgeon general of the Marine Hospital (1889). Wieber (1889) also reported a case of primary carcinoma of the lung with metastasis. Fuchs (1890) published an article on the treatment of carcinoma. In Berlin observations were made on a horse. Hardford (1889-90) reported a case of carcinoma of the root of the lung, with comparative absence of symptoms; it was complicated with simple gastric ulcer, and death resulted from enteritis.

Rickards (1891) had a case of carcinoma, at the root of the left lung, with extension through the outer vertebral foramen, and compression and softening of the spinal cord. Satterwaithe, Belcher, and Kidd (1891) reported cases. Kidd's case was very interesting, one of mediastinal and pulmonary carcinoma, associated with retraction of the chest wall. Simon (1893) published a case of primary carcinoma of the lung with secondary deposits in the liver, brain, and scapula. Perinato also reports a case.

Wolfe reported thirty-one cases of primary carcinoma of the lung in seven thousand necropsies; there were twenty-seven men and four women, of whom the youngest was thirty-six and the oldest seventy. In five cases, the right lung was affected, in three cases, the left. The right bronchus was the seat of disease in thirteen cases, and the left bronchus in eight cases. In two cases, both bronchi were affected. In thirteen cases, there were tuberculous complications, and, more likely, metastasis in cases of bronchial origin.

Hampeln (1897) gave an extended account of carcinoma, and Pfarmenstill (1897) published his observations on primary carcinoma. Scotti (1898) reported on diffuse pulmonary carcinoma. Le Count reported a case of diffuse secondary carcinoma, confined to the lymph channels of both lungs. The necropsy discovered many metastatic tumor nodules in various organs. The primary tumor was located near the pylorus.

As the edge of the right pleura lies between the œsophagus and aorta, it is very probable that a carcinoma of the œsophagus

may extend to the right pleura, and thence to the right lung, and vice versa.

Pathology.—Carcinomata are formed of true epithelial cells; but they grow in an irregular, atypical manner. This is due, some claim, to the difference in pressure exerted by the various kinds of tissue in which they grow. They are arranged in alveoli, the latter round, elongated, club-shaped, etc., and are formed of single cells in close contact, with no connective tissue between the alveoli.

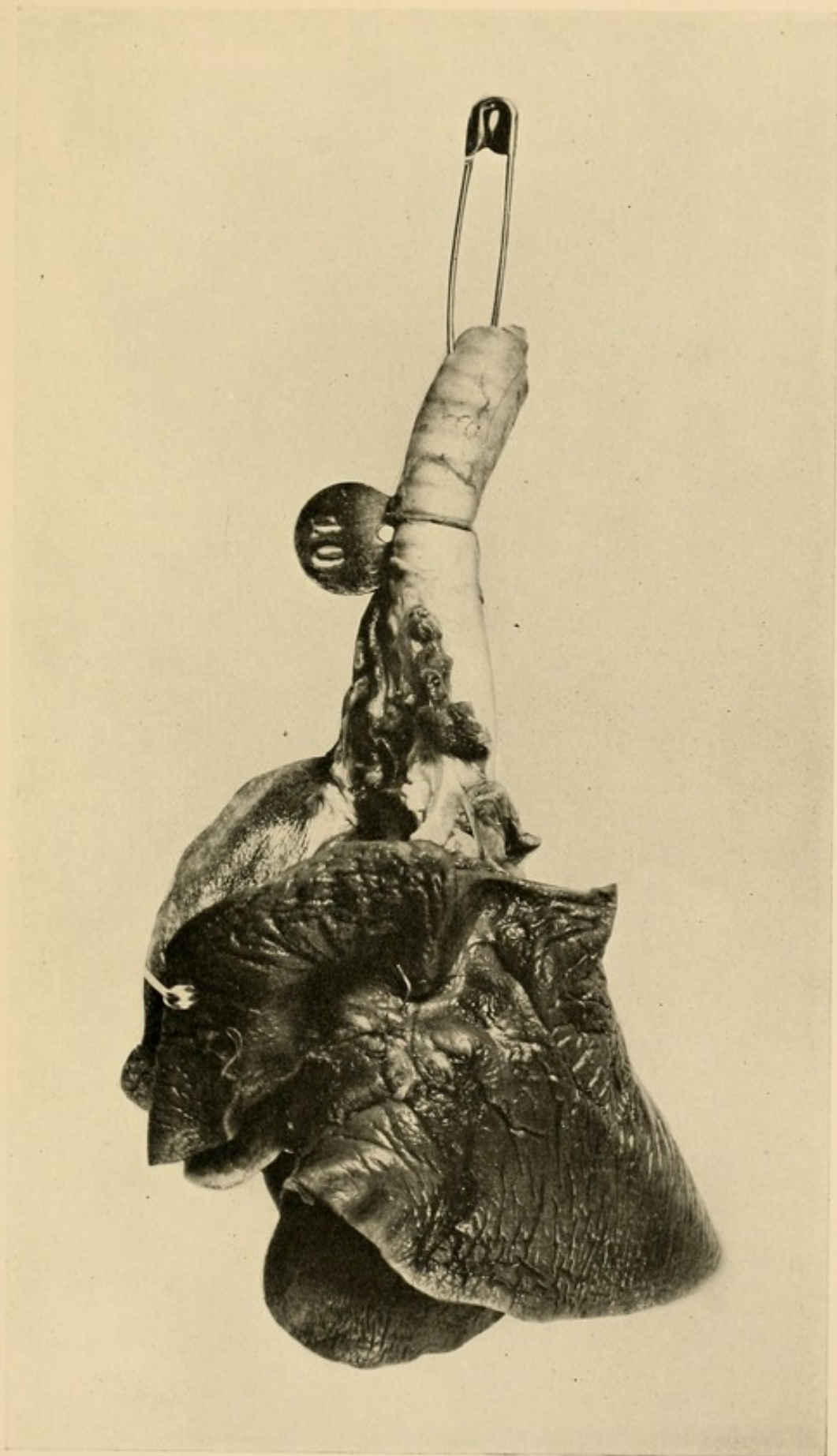
There is no essential difference in structure of the various kinds of carcinomata which originate in the surface epithelium; the same may be said of those which have a glandular origin; but between those of glandular origin and those formed in the surface epithelium there is sufficient difference to enable them to be classified. Still the difference is only in their microscopical appearance.

Weinburger reported two cases of primary bronchial carcinoma. One resembled tuberculosis. A third case, in a young woman, was a lymphosarcoma of the mediastinum, which invaded the lung. (*Zeitschrift für Heilkunde*, volume xxii, part 2, February, 1901.) Heidenhain of Worms (Ninth German Congress, April, 1901) reported a resection of a lung for the removal of a carcinoma; later, because of bronchiectasis, he had to make longitudinal incisions in the bronchial tubes, to evacuate pus.

The most usual intrathoracic cancer is the medullary or encephaloid. Infrequently, a scirrhus cancer may be thus situated, and there are a few reports of colloid.

Many malignant growths are metastatic in origin, especially those found in the lungs. Walshe claims that cancerous diseases of the testicle may be followed by pulmonary cancer. Lebert says that duration of life is from one to two years, and in some cases several years.

Symptoms.—Pain, cough, and expectoration, the latter becoming mucopurulent, and sometimes presenting the appear-



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ance of currant jelly. This peculiar appearance of the sputum is somewhat diagnostic. There is dulness on percussion and the respiratory murmur is either suppressed or modified.

Treatment.—Unfortunately the removal of such growths offers but little encouragement. Prognosis would, however, become more favorable if the neoplasms could be removed earlier in their development. This is hardly possible, owing to the lung being inaccessible without opening the chest wall, which is not justifiable until the destruction of the lung has become too far advanced for safety.

Operative measures are especially undesirable if the origin of the growth is in a bronchial gland or the base of the lung. However, if the growth involves the apex of the lung, and its removal be made early, much encouragement may ensue.

As in all other operations upon the lung, resection of one or more ribs is necessary at a point most convenient for attack. It is also desirable in this, as in the majority of lung operations, to have adhesions of the visceral to the parietal pleura. The removal of the diseased tissue with the knife, ligature, cautery, or otherwise should be followed by securing the bleeding vessels and smaller bronchia with ligature, or clamp, or both, with sufficient pressure with gauze packing to prevent bleeding and the escape of air. Drainage is more easily and perfectly accomplished in all pathologic conditions involving the lower portion of the lung. If only one lobe be involved, complete removal of that lobe should be practised with thorough drainage by gauze.

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CHAPTER XVIII

BACILLI—BACILLUS ANTHRACIS, BACILLUS ŒDEMATIS
MALIGNI, BACILLUS AEROGENES CAPSULATUS,
BACILLUS PNEUMONIÆ, BACILLUS TUBER-
CULOSIS, BACILLUS TYPHOIDES

ANTHRAX.—This disease is very frequent in Russia, Hungary, France, and Saxony, and it occurs as an epidemic in Siberia, and India. It is only occasionally found in man or beast, in the United States.

Historical (1850-1903).—Bacillus anthracis was discovered by Davaine and Rayer, who reported to the Académie des Sciences (1850) the finding of small filiform bodies in blood in length about twice the diameter of a red blood corpuscle. Grouin states that fifty-six thousand cattle died of this disease in Novgorod, Russia, between the years 1867 and 1870.

Among the domesticated animals, cows, sheep, and horses are more susceptible than asses, goats, and hogs. Mice, rabbits, and guinea-pigs are especially susceptible to infection. It is difficult to infect dogs and poultry.

Bacillus anthracis was the first to be discovered and is, therefore, of great interest, because it was the foundation upon which the science of bacteriology has been built. Pasteur succeeded Davaine in the study of this bacillus, but the discovery of spores was not made until Koch reproduced the disease by inoculating animals. It was he who maintained that an infection could take place through the organs of respiration; he had placed a mouse under a bell-jar containing the bacilli, with fatal results.

The period of incubation is from a few hours to three or four days.

Schottmuller (1898) reported two cases of anthrax in the lung. One of the patients was a maker of baskets from strips of hide; in the other case the cause could not be ascertained.

All those who work among cattle, sheep, wool, hides, etc., are exposed to infection. The domesticated animals, indigenous to Algeria, seem to possess immunity from this dreaded disease. Salines in the soil, combined with warmth and moisture, are supposed to favor the development of the bacillus, hence the disease is prevalent along rivers and low lands.

Symptoms.—Onset sudden; dyspnoea; headache; chill; fever; nausea; gastralgia; coryza; lacrymation; exhaustion; consolidation of lung; temperature, later on, sub-normal; sputum, although often like prune juice, is not characteristic. The outcome of the disease is very uncertain.

BACILLUS ŒDEMATIS MALIGNI.—Previous to Lister's great discovery, this organism caused many deaths from progressive gangrenous œdema and emphysema.

Its habitat is decaying matter, dust of dwellings, old rags, hay, etc. It is often associated with the bacillus tetanus in earth which has been fertilized with foul fæcal matter. Rich garden earth has been used to inoculate animals by being injected, subcutaneously.

The internal organs are only slightly affected by this bacillus. But the bacilli are found on all serous surfaces. It makes its appearance in the blood only after death.

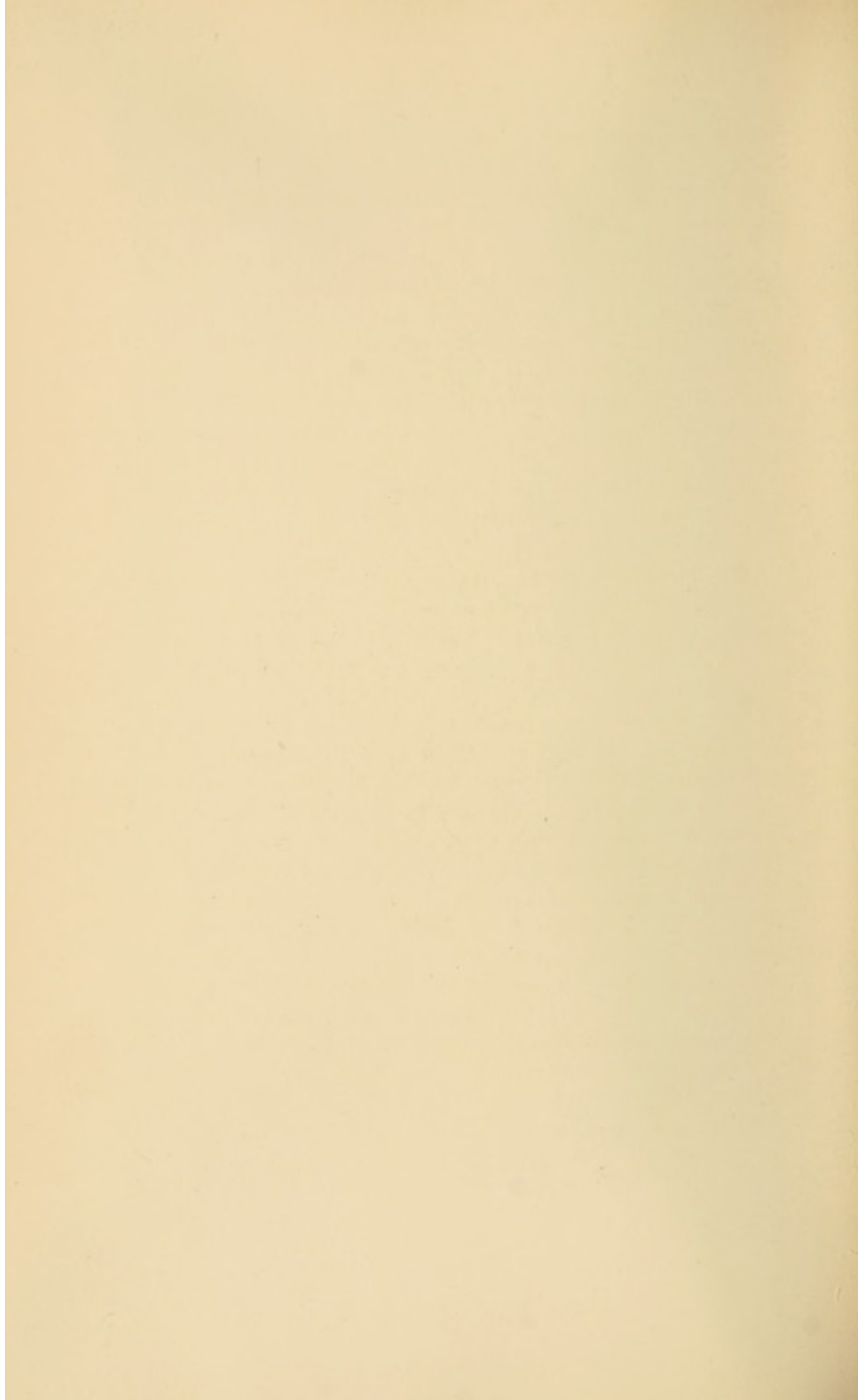
This bacillus resembles the bacillus anthracis. The colonies have a granular appearance. They form long chains which are often twisted. They have no independent motion. Spores are found in individual bacilli, but not in threads. It is anaerobic.

(See chapter on Œdema, for a fuller description of this disease, etc.)

BACILLUS AEROGENES CAPSULATUS (Gas Bacillus).—The bacillus aerogenes capsulatus, described by several investigators



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(see bibliography), is probably the cause of emphysematous gangrene in the lung as elsewhere. Although found most frequently in cases of trauma, it also has been observed in non-traumatic cases.

Ohlmacher says that this bacillus "was not found in smears or cultures of the heart's blood, but it was found after inoculation of heart's blood into rabbits, which were killed and in twenty-four hours presented the characteristic lesions. An organism corresponding morphologically and tinctorially with the gas bacillus was found in the heart muscle, lung, kidney, and liver. In all of these, gas bubbles were also found on microscopic examination. Cultures from the heart's blood showed *Staphylococcus aureus*, *Streptococcus pyogenes* and the colon bacillus." (*Amer. Medicine*, July 27th, 1901, vol. ii, p. 137.)

Loeb, in the same article, states that "the bacillus of malignant œdema rarely, if ever, produces those lesions which were always attributed to it." "The bacillus aerogenes capsulatus, or *Bacillus Welchii*, practically dominates the whole field of pneumatopathology."

This organism is extremely virulent, but there is great variation in its action. One-half of the sixty reported cases of emphysematous gangrene, caused by the gas bacillus, have been fatal. The majority of the other half have either been mild, or recovery quickly ensued upon an operation. Even in severe cases, if the patient lives, the bacillus will die in ten days or two weeks. Mild cases have been known to recover spontaneously. This bacillus gains a foothold in healthy tissue only with the greatest difficulty.

The intestine is also one of the habitats of the gas bacillus, but thus it usually does little harm except in case of typhoid perforation, appendicitis, or strangulation. In some cases gas is not found in the tissues until after death; again, there are cases in which the tissues do not produce gas.

The bacillus aerogenes capsulatus is large and thick, and is

one of the encapsulated bacilli. It is not very active, but it has not been decided whether it is motile or not. It is supposed to be anaerobic.

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BACILLUS PNEUMONIÆ.—*Pneumonococcus* (Friedländer) is found in the alveolar exudate, and in the exudates from the pleura, and pericardium, in cases of croupous pneumonia. It has been found in the rusty sputum and blood. It is not a reliable diagnostic test, as there are other bacilli which resemble it, and because other varieties of bacilli also cause pneumonia.

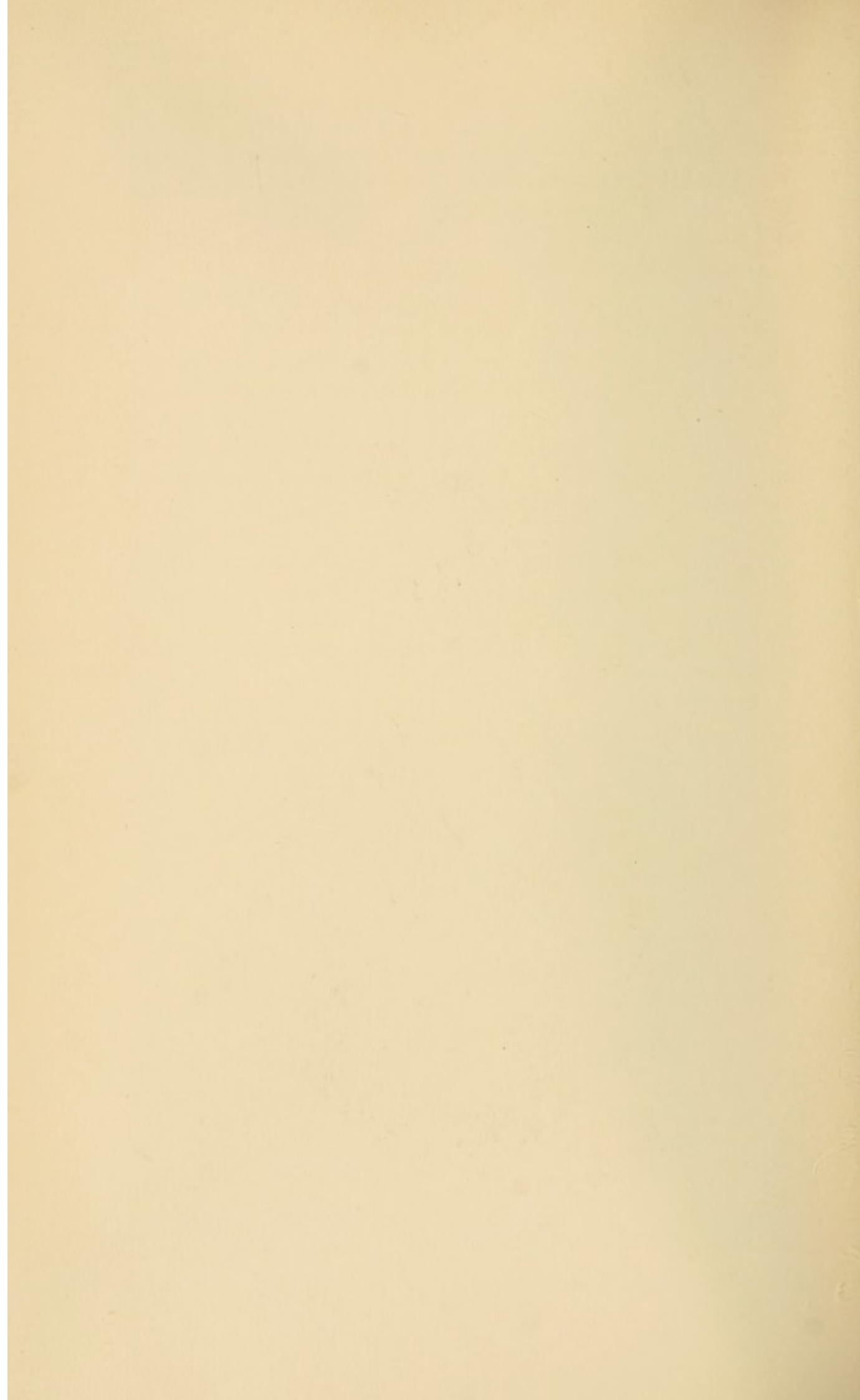
This bacillus is short and thick, somewhat resembling cocci. It is enveloped in a gelatinous capsule, sometimes a single capsule containing two or more bacilli. It has no independent motion. The colonies are white, with knob-like projections above the surface.

BACILLUS TUBERCULOSIS is the active cause of tuberculosis, lupus, and scrofula. No animal seems to have absolute immunity from the ravages caused by this organism. All the diseases attributable to this bacillus can only be caused by infection with the bacilli, or their spores. Infection is by inhalation, by swallowing the virus, and by inoculation.

The bacilli are found where the disease is just beginning to attack a new place. In the early stages of the disease, the bacilli are isolated, and will be found in the cells close to the nuclei; where the disease has existed longer, the bacilli will be



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found in clumps. They are not readily found in old cheesy masses, unless the latter have been exposed to the air. They may always be found in the giant cells.

The bacilli are often curved, or bent at an angle. The spores are larger in diameter than the individual bacilli. When found, from two to six will be seen together.

BACILLUS TYPHOIDES (Eberth) was found in an abscess of the lung by Ramsey (1890, *Annals of Surgery*, January, p. 39). He also found it in a case of gangrene of the lung and spleen.

It is probably of secondary and not primary origin, and when found, is associated with tissue necrosis, arising after the third week from the onset of the fever.

CHAPTER XIX

PARASITIC FUNGI—ACTINOMYCES, ASPERGILLUS, PNEUMONOMYCES, OIDIUM

ACTINOMYCOSIS.—Actinomyces is a vegetable parasite found in animal and human life, and is supposed to be inhaled after having colonized in the mouth, probably in decayed teeth. Direct infection of the lung is very much questioned. The left lung is more often affected than the right, and resembles a lung with fibroid phthisis, though the pearly gray or yellow nodules or granules (threadlike in appearance) are diagnostic, as is the contracted thorax, later on.

The granule is a star-shaped body, composed of numerous threads with club-shaped ends which, together with the branching segmented mycelium, is characteristic. The pus with which it is associated is epiphenomenal, and the disease may be confounded with abscess or phlegmon.

Eighty-five to ninety per cent. of cases of involvement of the lung terminate fatally. However, the mortality is very much reduced if the superficial portion of the lung be involved, or if surgical principles are employed.

The fungus of actinomyces is from one-half to two millimeters in diameter, and the nodules which it forms soon begin to decay, but the process of growth keeps pace with that of decay. The disease spreads by the adjoining parts becoming infected, and sometimes metastasis occurs. It has been found in the crypts of the tonsils, lacrymal duct, and in carious teeth, from which places it is easy for the fungus to be aspirated into the lungs.

When the lung is involved there is first pain, followed by

pleurisy and expectoration, pneumonia or bronchitis, or both. There is at this time great proliferation of round cells, which soon undergo fatty degeneration, and an abscess is formed which ruptures into the bronchia. The expectoration is of some aid in making a diagnosis, but although peculiar, it is not definite.

Clinically, this disease can be diagnosticated by the presence of the yellow, seed-like bodies in the pus, which are visible to the naked eye, and, when rubbed between the fingers, have a greasy feel.

The carnivorous animals appear to enjoy immunity from this disease. This, apparently bears out the theory that the disease is due to a fungus or parasite growing on plants, which cattle may eat, thus becoming infected themselves, and in turn infecting those who may eat their flesh.

Historical (1877-1903).—Ponfick was the first to recognize this disease in man. He had a case in which there was a metastatic growth in the right auricle, and numerous metastases in the lungs. (*Die Actinomykose des Menschen, eine neue Infektionskrankheit auf vergleichend-pathologischer und experimenteller Grundlage geschildert*, Berlin, 1882.)

The name of the parasite is *Actinomyces bovis* when found in cattle, but some writers term it *actinomyces hominis* when found in man. But whether found in man or in animals, it is evidently the same thing. The disease caused by this fungus is termed actinomycosis. Some writers do not seem to make a careful distinction between the name of the plant and the name of the disease; they use the terms as if they were synonymous.

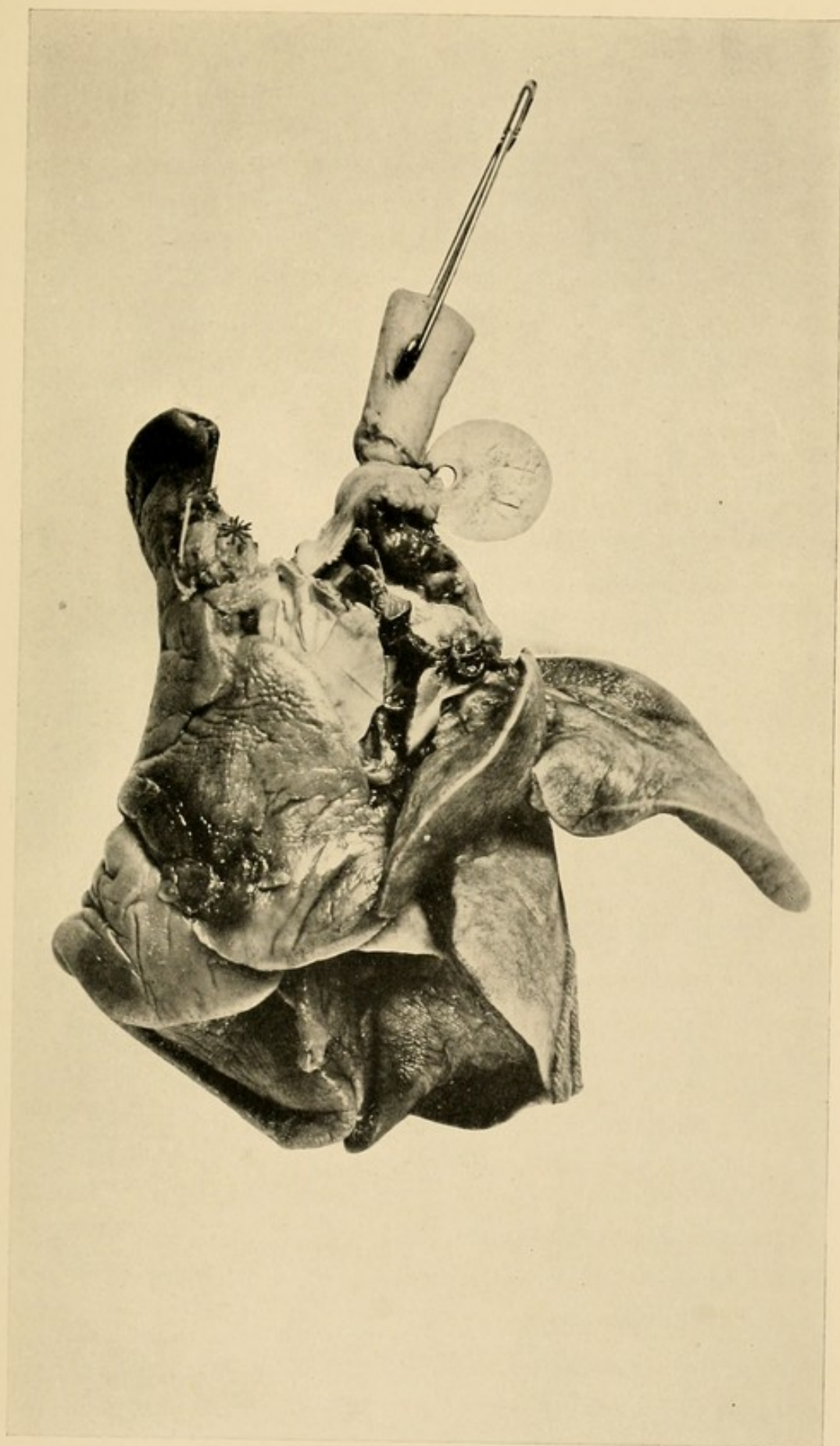
Belfield (1879) was the first to discover this disease in America. Sebert, however (1848), was the first to publish anything on this subject, and, like others, did not know just what he had found. Bollinger (1877) found it in animals and was the first fully to describe the disease; Dr. J. B. Murphy (1884) has the credit of being the first in the United States to discover it in man.

Israel published the results in thirty-eight cases. In seventeen cases, the patient was infected in the mouth, or pharynx. In nine patients, the infection was in the air passages of the lungs. In seven, the infection was at some point of the alimentary canal, and in five, the point of infection was uncertain. Israel demonstrated that pure cultures could be made and that animals could be inoculated from them. He also proved that rabbits could be inoculated from man. (Klin. Beitrage zur kenntniss der Aktinomykose des Menschen, Berlin, 1885.)

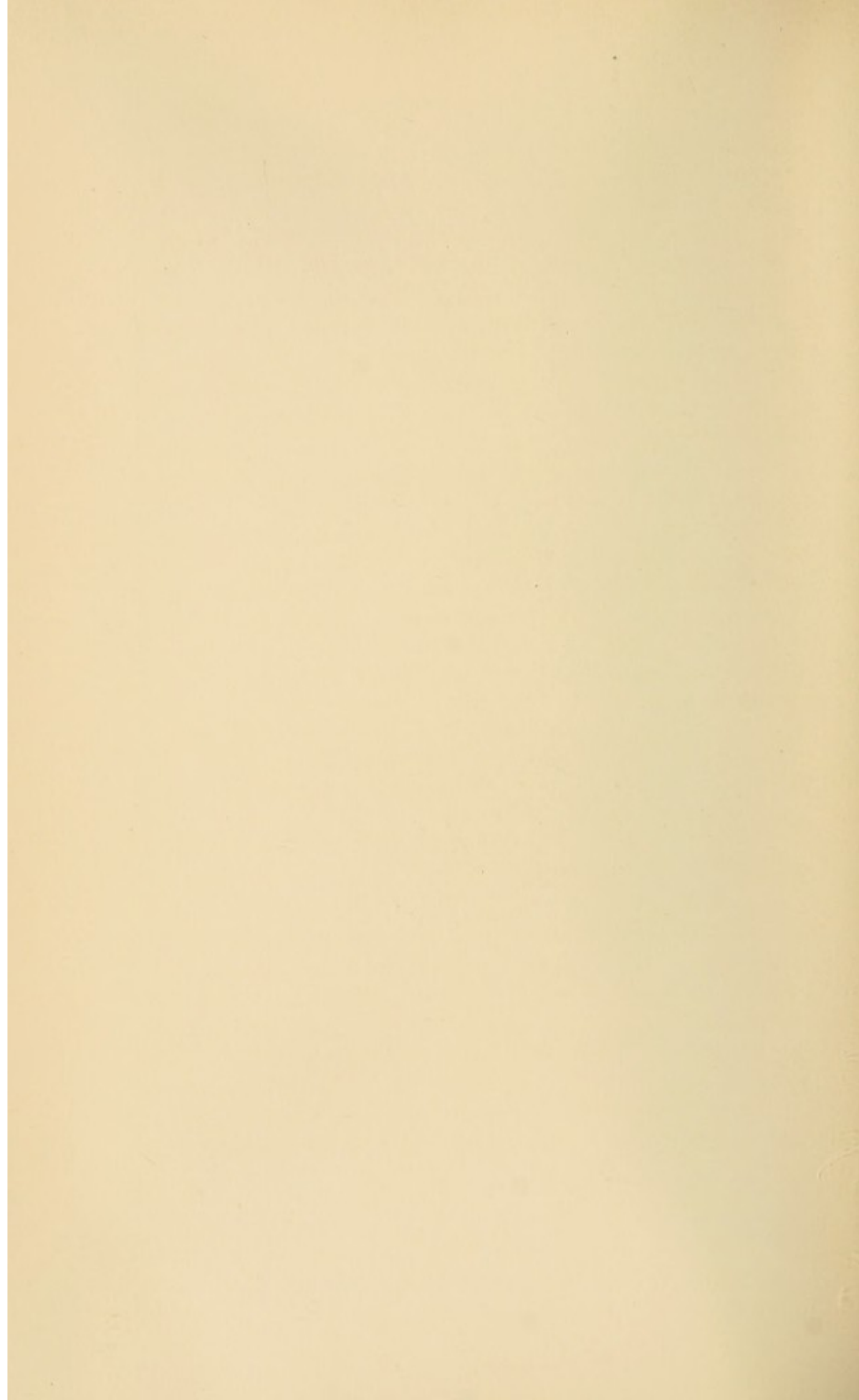
It is stated that the first case diagnosticated in man during life, was reported February 12th, 1889, by Powell and Goodlee to the Medico-Chirurgical Society. Richerale (1892) reported five cases of simulating tuberculosis. (*Münch. Med. Woch.*, 1895, p. 49.) Partsch (1892) mentions a case of infection at the root of a bicuspid tooth. (Die eingang des Aktinomyces. *Wien. Woch.*, 1897, p. 97.) Heuser (1895) reported a case of primary actinomycosis of the lung. Aschoff and Butler each reported a case which recovered. Karewski, Caglieri, Babrazes, and Visconti have also contributed to this subject.

Treatment.—Ruhraeh of Baltimore (*Annals of Surg.*, vol. xxx) gave an analysis of sixty-five cases that had been reported as occurring in America. He says: "The thoracic cases do badly as a rule, no matter what treatment is followed." J. L. Sawyer (*Jour. Am. Med. Assn.*, p. 1314, vol. xxxvi, 1901) is one of the latest writers on this disease. He reports several cases, but only one case was of the lung. He recommends the administration of iodide of potassium, combined with hypodermic injections of a one per cent. solution of the same. The injections are to be given in one-half drachm doses, every third day. There will be a temporary increase in the symptoms, and swelling for about six hours after an injection. Dr. Sawyer found threadlike mycelia with clubbed ends in the urine, and also found traces of indican in nearly all cases.

Five per cent. solutions of potassium permanganate, one per



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cent. solutions of methyl violet, and five per cent. solutions of carbolic acid in doses of fifteen to forty-five minims, have all been used for parenchymatous injections.

The head and neck are most frequently the seat of the disease. Fifty-five per cent. of all cases have been found in these parts of the body, while twenty per cent. were in the thorax or lungs, twenty per cent. in the abdominal organs, and five per cent. in all other parts of the body.

Garre reports ninety-six cases of the lung operated upon, with eighty-seven cases cured.

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ASPERGILLUS.—Virchow first mentioned it in 1856. It is a vegetable parasite, and has been described by Freyhau (*Wien. Med. Presse*, 1882, p. 185). With the aspergilli, as with all other of the mould fungi which attack the human body, there is a tendency to lodge in some one of the internal organs. After lodgement, the mycelia grow out and form distinct foci.

Three species of aspergilli are known to be pathogenic, i. e., *Aspergillus fumigatus*, *Aspergillus niger*, *Aspergillus flavus* or

flavescens. These species of fungi are widely distributed; they are found at times on mouldy bread, etc. Persons should be very cautious of all mouldy foods. Some of the moulds are harmless, but all should be handled carefully. Birds are often observed with mycosis of the lungs caused by inhalation of the spores of the aspergilli. Other animals have also been found suffering from accidental infection.

The most dangerous species is *Aspergillus fumigatus*. This mould is greenish in color. The conidia-bearers are short and hemispherical, very thickly set with sterigmata. The latter are, in shape, awl-like. The conidia are generally colorless, round and smooth, and show no membrane. This species is not known to have sclerotia. A temperature of thirty-seven to forty degrees Centigrade is best for its growth.

Aspergillus flavus or *flavescens* ranks next to *Aspergillus fumigatus* in pathogenic power. This species is greenish-brown in color, with yellow or brown conidia, having a finely nodular surface. The sclerotia are very small and black. It grows best at about twenty-eight degrees Centigrade.

Aspergillus niger is said not to be very malignant. It is brownish-black in color. The fruit-bearers are globular, and the sterigmata long and branching; the conidia, round and black, or nearly so, and the sclerotia, brownish-red and about the size of a rape-seed. The best temperature for its growth is about thirty-five degrees Centigrade.

Among reports of pulmonary trouble, caused by these moulds, is that of Wheaton, who mentions a case in a child two and one-half years old. Bland Sutton (*Trans. Path. Soc.*, 1885) gave a full account of these moulds in the air-passages of birds. Kidd (1886) showed by experiment that the injection of the spores of aspergilli into the auricular veins of rabbits produced them in abundance in various organs, especially in the kidneys. (*Path. Soc. Trans.*) Boyce (1892) remarks upon a case of aspergillus pneumonocosis (*Jour. Bacter.*, Oct. 1892). He found them in small irregular cavities in the

apex of the lung, forming white bodies about the size of a pin head, and resembling calcified bodies. Furbrüger (1876) collected eleven cases (Beobach. über Lungenmycose beim Menschen. *Virchow's Arch.*, 1876, p. 330). There is no general infection; and examination of the sputum reveals nothing. It is said to be always secondary.

PNEUMONOMYCES.—For over half a century this fungus has been known as a causative factor in lung disease. The lesions are similar to those produced by the other fungi. The symptoms and diagnosis are similar to those of aspergillus. It is this reason, perhaps, that has caused pneumonomyces to be mistaken for aspergillus. It is only by a microscopical examination of the plant that positive knowledge of its identity can be obtained.

Some writers consider pneumonomycosis to be caused by aspergilli, or have confounded the two. Von Dusch and Pagensteher call it *Aspergillus Pulmonum Hominis*. Stieda, Weichselbaum, and Rother also consider it to be an aspergillus, or care has not been taken to differentiate the two.

Historical (1853-1903).—Bristowe (1853-1854) reported a vegetable fungus growing in the cavity of the lung. Cohnheim (1865) reported two cases of fungoid growths in the lungs. Von Buhl (1878) reported on *pneumonomycosis sarcinica* as a causative factor in diseases of the lung. Furbinger (1876) reported cases of pulmonary disease in man caused by a fungus. Von Ziemssen (1876) published an article on pneumonomycosis. Manwerk (1881) reported cases of pneumonomycosis in the lung, and Roeckl (1884) also reported cases.

(For symptoms, diagnosis, and treatment, see under these headings in the last chapter.)

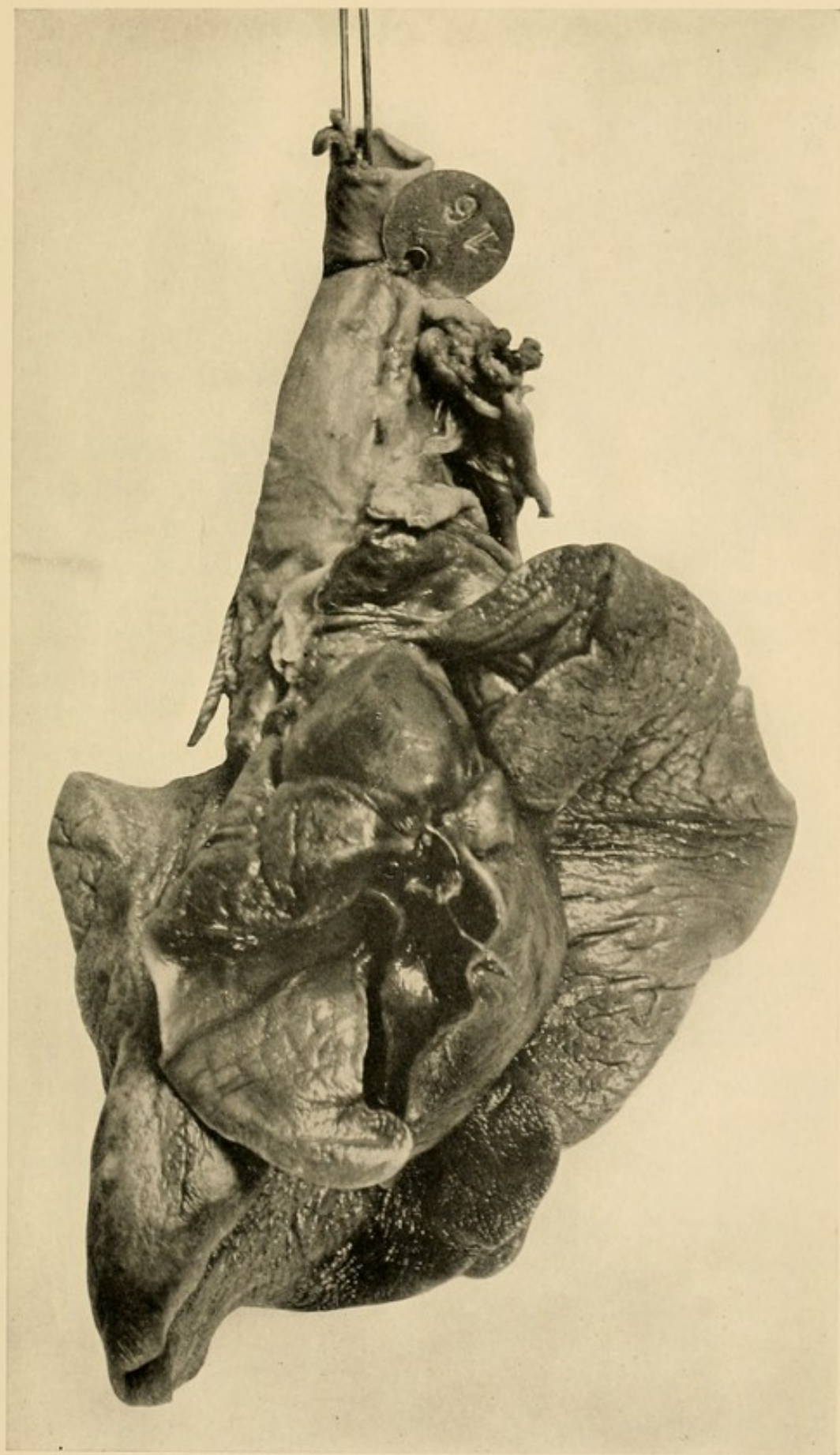
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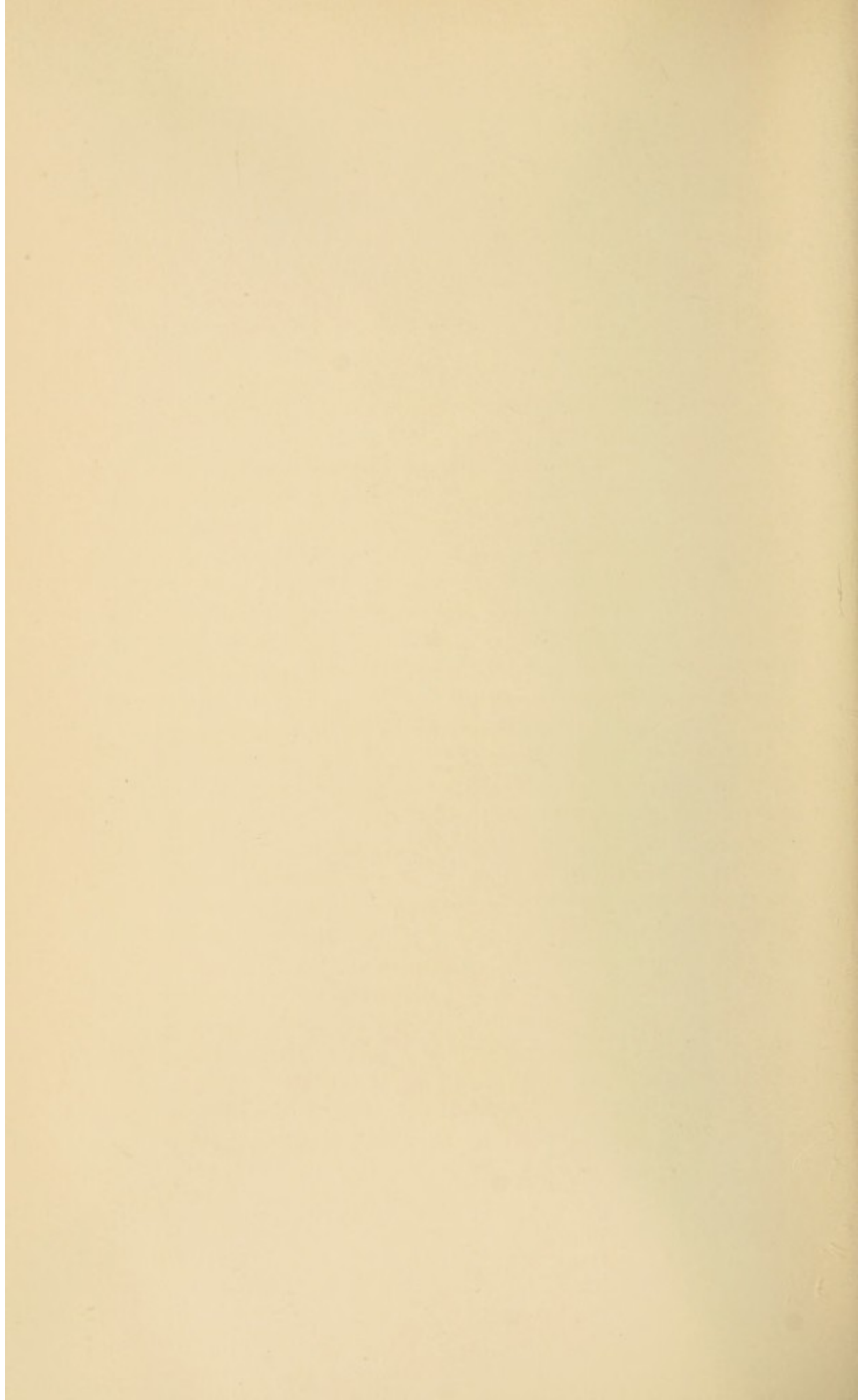
OIDIUM ALBICANS.—Oidium is frequently found in the bronchia, involving the mucous membrane, and occasionally in the tissues immediately underlying it. It is usually found in clusters, and more frequently in the medium-sized bronchia. It may be primary or secondary, and involve the parenchyma of the lung.

It is primary, where there is a direct opening from the bronchus into cysts or abscesses; secondary, when the fungus has first involved the oral or bronchial mucous membrane with the existence of a cyst, abscess, or laceration of the lung. It may also be secondary by the extension of the filaments into the lung parenchyma, when the fungus has developed upon the smaller bronchia. It may also develop upon lung tissue recently lacerated from any cause, when the fungus is present anywhere in the respiratory tract.

(See chapter on Oidium in heart.)



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CHAPTER XX

ANIMAL PARASITES :—ECHINOCOCCUS, PARAGONIMUS WESTERMANI, CYSTICERCOSIS, TRICHINA SPIRALIS

ECHINOCOCCUS.—*Tænia echinococcus* is the tape-worm in the dog, and its larvæ enter the human body with food or water. The embryo passes through the wall of the stomach, or intestine, to develop in one or more of the abdominal, or thoracic organs; it is usually, retroperitoneal, when the peritonæum is involved. It may, however, be within either the peritoneal or thoracic cavities. It is rarely found on the western hemisphere, but is quite common in Iceland and Australia, especially among herders.

Tænia echinococcus is the smallest of the tape-worms; only the last segment is gravid with eggs. Man is not infected by eating meat containing the hydatid, because it is only the embryo of the *tænia echinococcus* which causes disease in man. If taken into the body in the mature state, the hydatid will become encysted without injury to its host. Here it forms its eggs, and is thus prepared to infect any animal into which it gains entrance. If the hydatid does not become encysted it is either digested, or passes out through the alimentary tract.

Fifteen per cent. of all cases of echinococcus are of the lung, and are usually secondary when found there. Their entrance into a vein may cause instant death. Normal fluid in the cyst contains mineral salts in abundance, but no albumen. Occasionally the fluid contains sugar. The cyst may be destroyed by

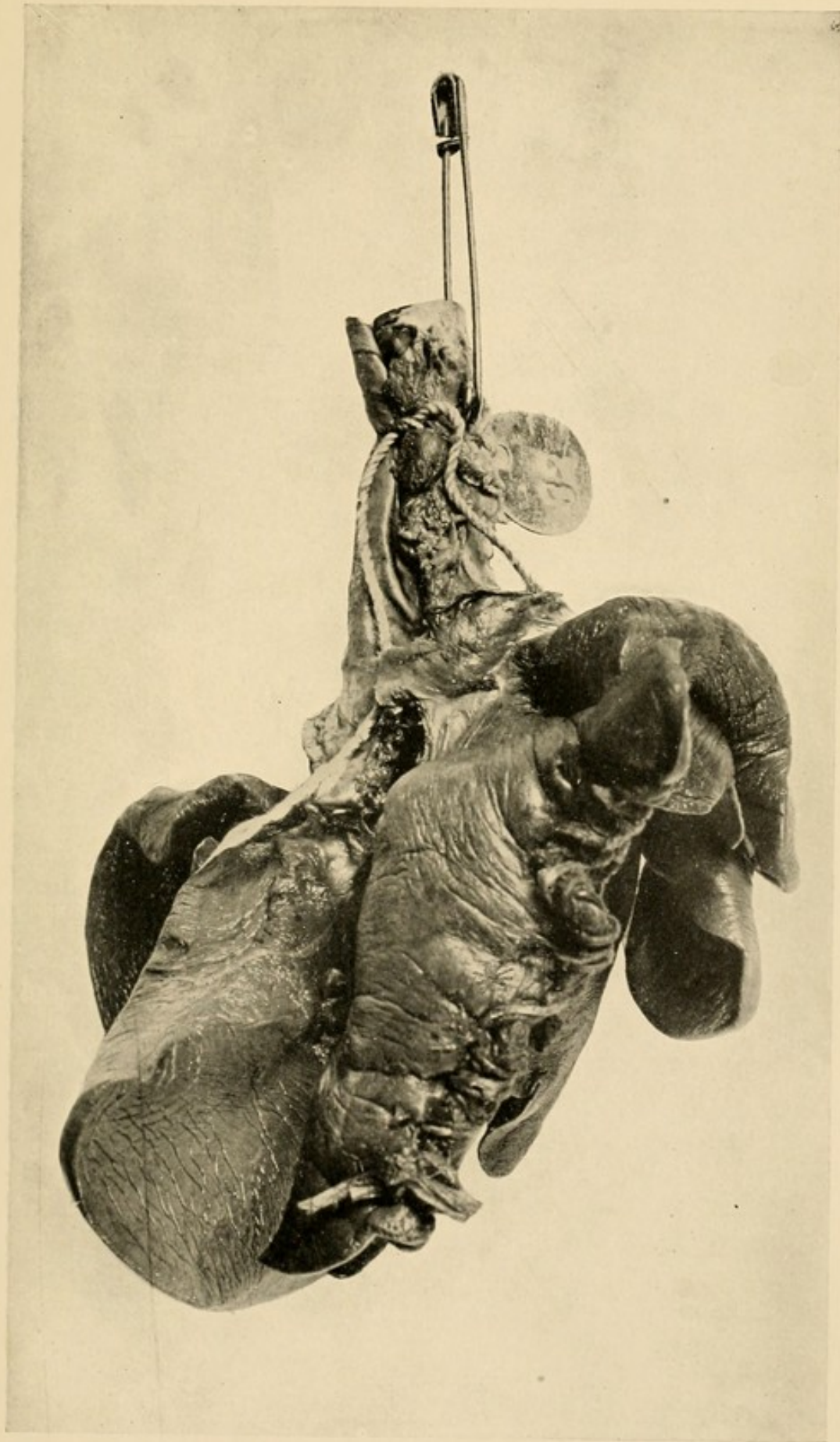
calcification, or it may rupture into the pleura, or peritoneal cavity, into the alimentary, or bronchial tract, into the uterus, Fallopian tubes, bladder, kidneys, or ureters, or it may escape externally at any point through the thoracic or abdominal walls. The cyst is usually solitary, and is found at the base of the lung. It may, however, occupy the entire pleural cavity. The lung is usually invaded by an acephaloid cyst, which does not contain echinococci.

Historical (1828-1903).—Todd (1852) reported a case of hydatid of the right lung, with recovery after expulsion of the hydatid. Bailey (1861) reported a case treated by incision of the sac after internal rupture. Hearne (1875) collected one hundred and forty-four cases. Of these, sixty-six recovered and eighty-two died. Forty-five of the sixty-two recoveries were cured by the bursting of the cyst into the air passages. Five were punctured, and twelve incised.

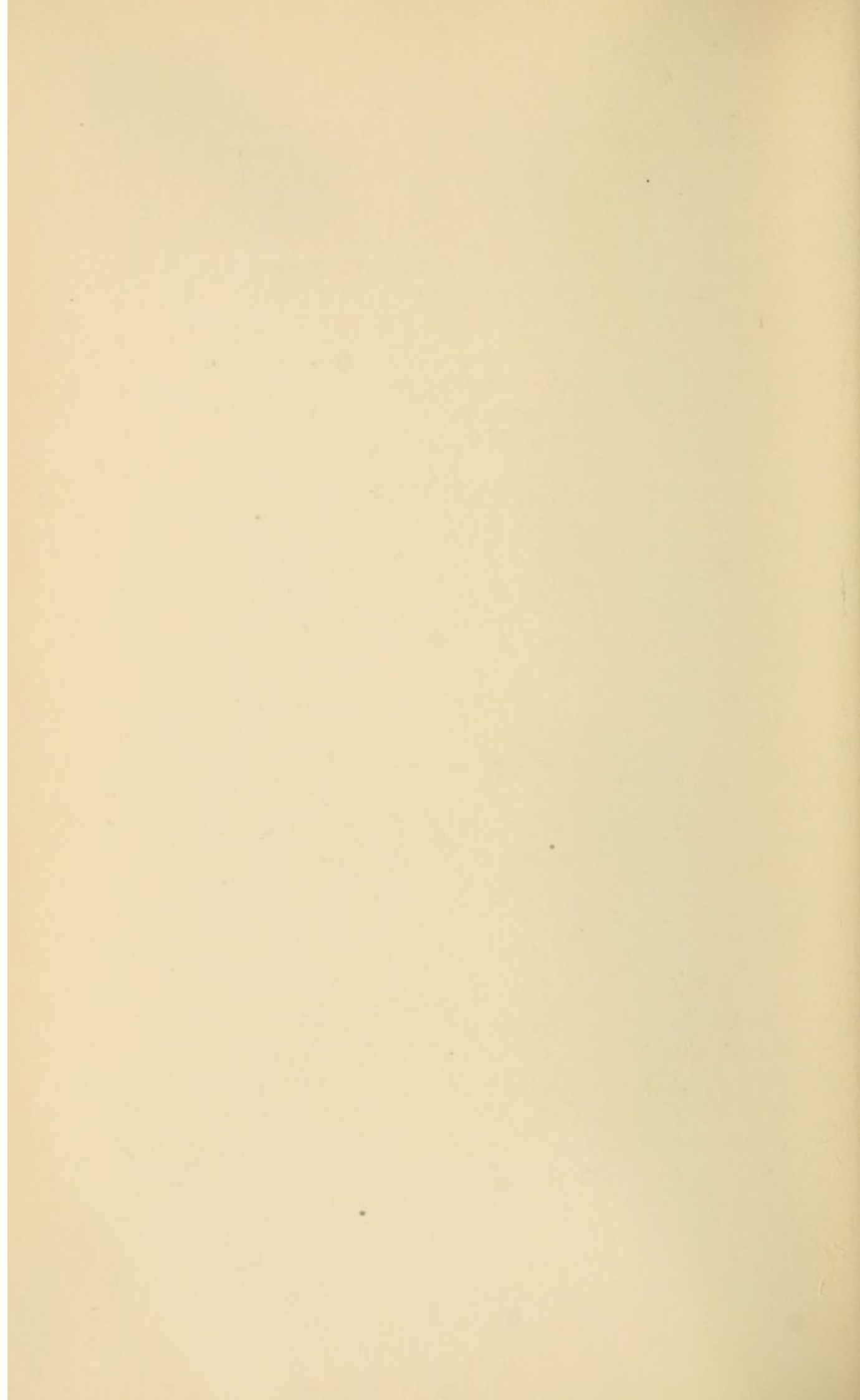
McGillmary, quoted by Greenfield on case of Hydatid of the Lung (*Clinical Society Transactions*, 1877, Volume X, p. 103), reported sixty-five cases, of which nine were in the lung; he says that no portion of the lung seems especially prone to attack. Maydl reported four cases in which echinococci were found in the lung.

Lehmann (1882) reported eight cases of cyst in the lungs with only one recovery, and that by operation. De Zouch's (1883) case of suppurating hydatid of the lung is one of the few reported in which any attempt was made at removal.

Little was said concerning such a procedure for more than a century, not until Thomas (1885) suggested the treatment of cysts by the establishment of large openings into the sac, and subsequent free drainage. Thomas (1885) collected thirty-two cases of hydatid of the lung treated by incision, with twenty-five recoveries. He says there is a mortality of fifty-four per cent. if they are left alone; twenty-seven per cent. when puncture is employed, and one per cent. when resection and incision are resorted to.



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Lopez collected thirty-six cases treated by incision of cyst, with thirty cures. Madelung reported nineteen cases of hydatid of the lung, in which there was no operation. Ten recovered, three were relieved by opening into the bronchus, and six died.

Richeralle (1888) reported a case and Lorieux furnished contributions (1889) to the study of hydatid cysts. Thomas (1889) reported another case, that of a large echinococcus cyst of the left lung, spontaneously rupturing into the bronchus, and thus causing sudden death. Nicholson (1890) reported a case of primary hydatid of the left lung, and Danlos gave notes on a similar case.

Ferraud (1890) reported a case of hydatid cyst, opening spontaneously into the bronchus. Mackenzie (1890-91) reported a case, which he treated by paracentesis. He reported later a case of hydatid of the lung, which proved fatal, by rupturing into the bronchus nine hours after treatment by aspiration. (*Transactions Clinical Society*, London, 1891-92, XXV, 215-220).

Ord and Robinson (1891) incised the right lung in a case of a suppurating hydatid cyst, and drained, but the patient died. Marconnet published observations on hydatid cysts in the lungs. Revilliod (1891) published a paper on echinococcus infiltration of the superior lobe of the right lung. Pardy (1891) had a case of hydatid of the lung bursting into the pleura. Thoracotomy was employed, a piece of rib removed, and the patient recovered. Miers reported a case of hydatid cyst of the right lung rupturing into the bronchus.

Bristowe (1891) treated a case of living hydatid of the lung by aspiration, followed immediately by subcutaneous emphysema; death resulted from suffocation, due to the rush of hydatid fluid into the bronchus. Maydl (1891) collected sixteen cases treated by puncture. Of these eleven died, five from suppurating pleurisy, six from puncture alone, making a total

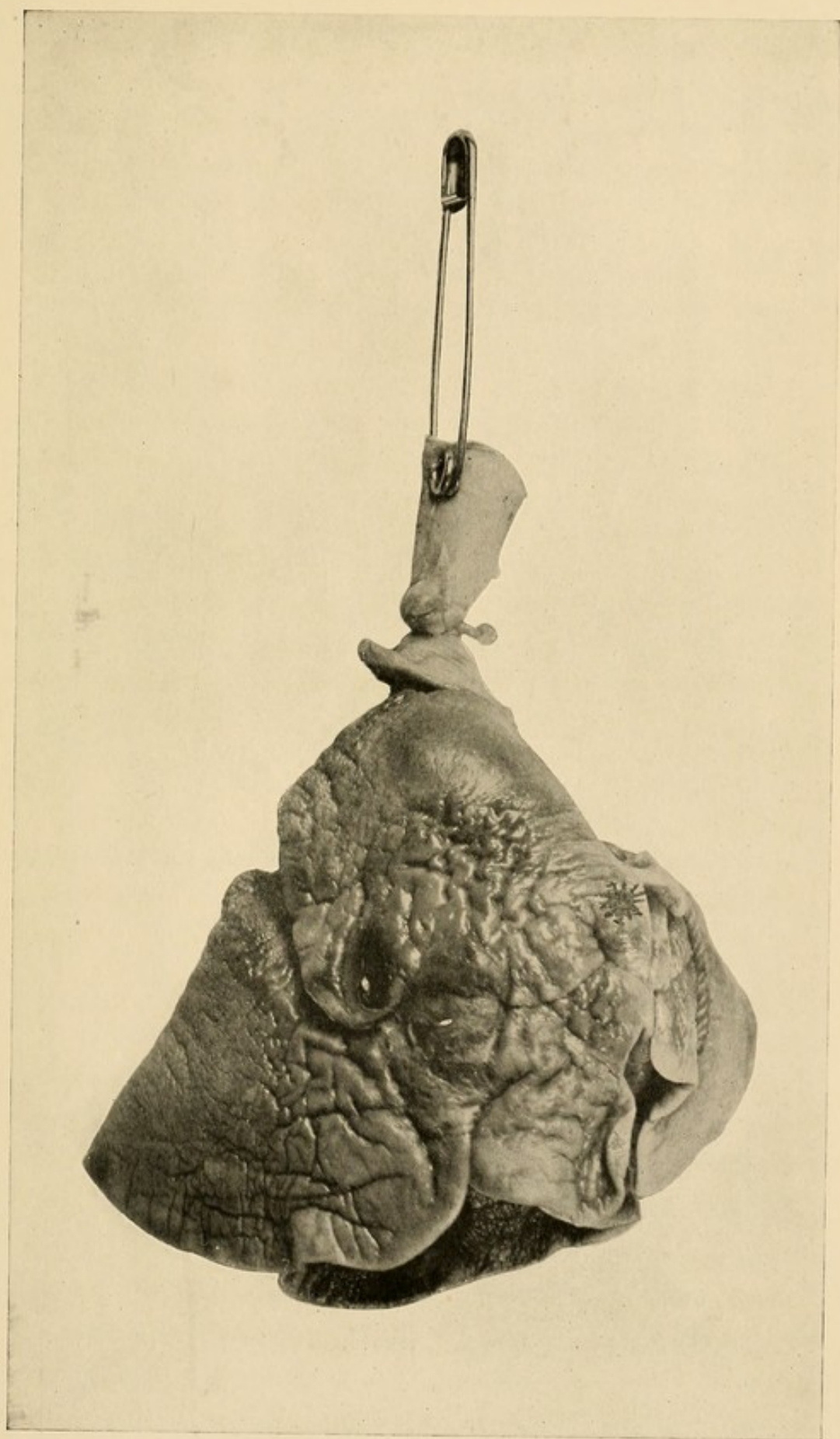
mortality of sixty-nine per cent. The hydatid may extend from the pleura into the lung.

Laveran (1892) reported a case; Clyhorn and Mackenzie, each treated a case of hydatid of the lung by paracentesis; Nuvoli (1892) treated a case of lung hydatid surgically; Bouilly (1892) employed pneumonotomy in a case of hydatid of the lung, as did Netter (1892-93). Miralle and Scott (1893) also reported cases.

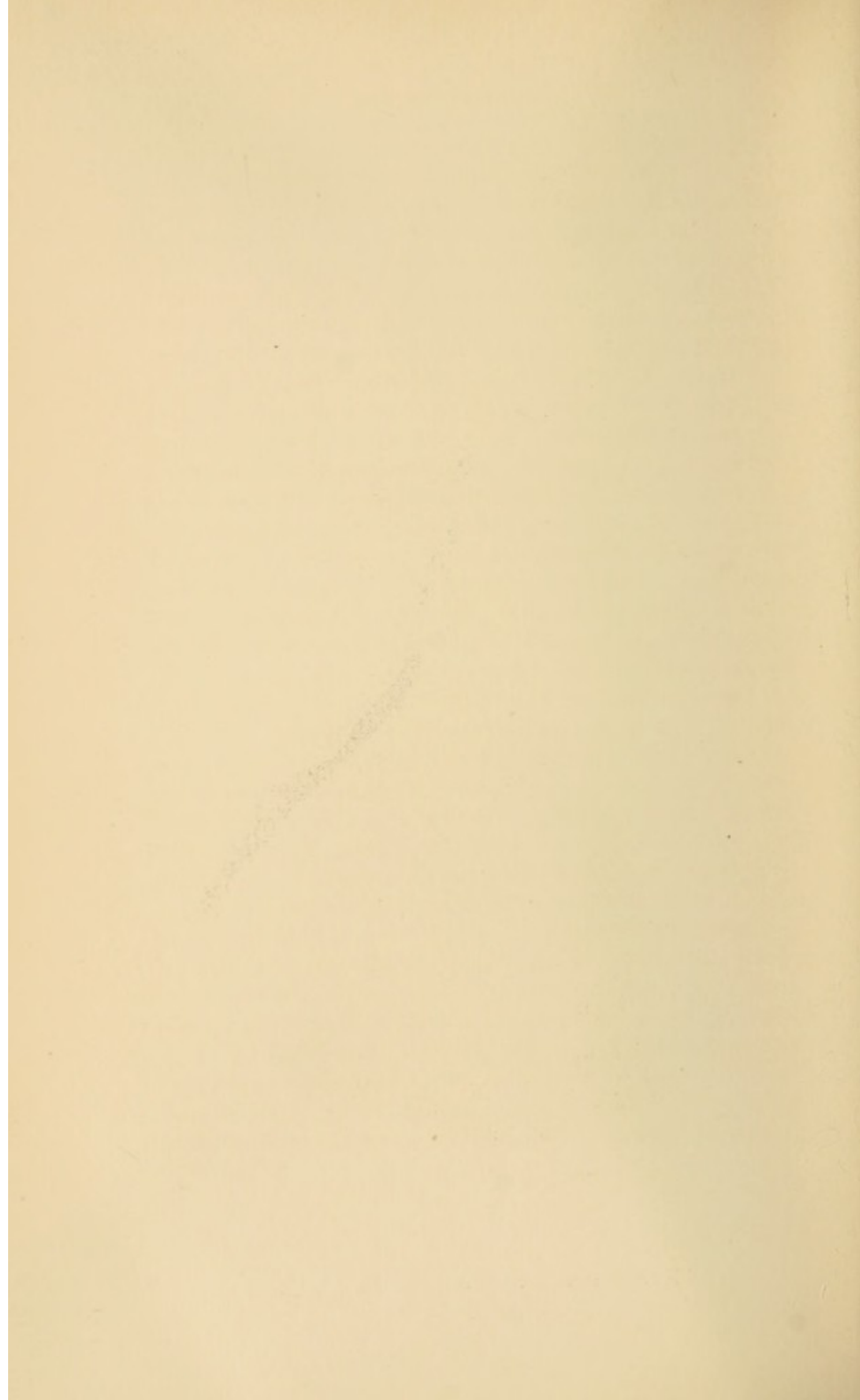
Trzebicki reported forty-five operations. There were thirty-seven complete cures; one fistula resulted; then six deaths, and in one case, the result was not known. Sophianopoulos and De Villeneuve (1894) published reports of cases. Todd (1894) operated upon a case of hydatid of the lung, and Chepple, Tatusescu, Thomas, and Troquart (1895), each reported cases. Cooke (1895) published short notes on two cases of suppurating hydatid of the lung, simulating phthisis, which were cured by operation. Tuffier (1896) also employed pneumonotomy in a case of hydatid of the lung, and Vespa, Eberson, and Clerc (1897) increased the literature of the subject by their published reports.

Geraud (1897) published his paper on diagnosis of hydatid of the lung, and Reed (1897) is another Australian to whom we are indebted for reports on this subject.

In Milan there appeared (1897) a report on a case of parenchymatous suppurative echinococcus cyst, and Nicodemi, an Italian, reported cases, followed by Potherat (1897), of Paris. Sterner (1898) published his operative methods in treating echinococci of the lungs. Bacelli and Penrose (1897) reported cases of hydatid cysts. From Australia, which has given so much to the literature on this subject, came Wood's report of three cases. His fellow-countryman, Hinder, reported a fatal case of hydatid of the lung. Beck, Pitzorno, Reid, Nicodemi, Lipari, and Piazza-Martini (1898), made contributions to the literature of hydatids of the lungs. Davies treated a hydatid cyst of the left lung by resection of a rib, and incision of the cyst wall.



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Symptoms.—Often there is no pain, only a bulging of the chest wall. It may be confounded with solid tumor of the liver, but it must be remembered that a cyst in the liver may burst through the diaphragm into the pleural cavity. In such a case there is severe pain and urgent dyspnœa. Death may result from shock, or pleuritic inflammation. Such a state of affairs is shown by sudden expectoration of fluid, generally purulent or bloody in character, containing echinococcus vesicles, entire or in fragments, and usually followed by a pneumothorax.

Diagnosis.—Bulging of the chest wall, and circumscribed dulness are characteristic. The respiratory sounds are absent. There is no biliary coloring when the lung alone is involved, but this occurs if the liver is also involved. The diagnosis is doubtful until the cyst ruptures; then the microscope is the only sure means of diagnosis. If the instrument reveals shreds of membrane, scolices, or hooklets, in the fluid the diagnosis is certain. Fluid withdrawn by aspiration will contain hooklets, etc., but at times it is necessary to supplement the work of the microscope by chemical analysis.

There are cases in which all means of diagnosis result in failure. The most eminent authorities agree that only forty per cent. of all cases are diagnosticated during life. Devine says that two-thirds of lung cases die when left to themselves. The growth is very slow, ten to fifteen years being the average duration. As it is not malignant, and seldom painful, patients do not seek aid; for this reason there are, doubtless, many more cases than the published statistics would lead us to suppose.

Treatment.—Those who have had the most experience in treating this disease claim that it is not amenable to internal medication. Some writers state that nitrate of silver, ferric sulphide, iodine, carbolic acid, or bichloride of mercury taken internally, or injected into the cavity have been beneficial. Also, that small doses of arsenic will prevent the eruption of potassium iodide, which is much used in treating this disease. Tuberculin, injected as in tuberculosis, has also been beneficial.

The majority of writers agree that surgery offers the surest and safest mode of treatment.

When it has been deemed best to resort to surgery, divide the ribs posteriorly, and ligate the bleeding points. The cavity once located, the finger may then be introduced through the lung into the cyst wall. The mother cyst is to be grasped with the forceps and delivered. If ruptured in this attempt, irrigation, which should always be resorted to, will probably deliver the daughter cysts. The subsequent treatment should be as for an open chest wound.

"Prevention is better than cure," applies with special force to this disease. The experience of Iceland is that it is necessary to exclude dogs from those localities in which their fæces may contaminate the food or drink, not only of man, but even of sheep and cattle; for it is probable that cattle are infected chiefly by the deposit in their pastures of the fæces of infected dogs, or by their drinking water thus contaminated. Neither should dogs be allowed to eat the refuse of viscera of dead or slaughtered animals, or in fact, any uncooked flesh.

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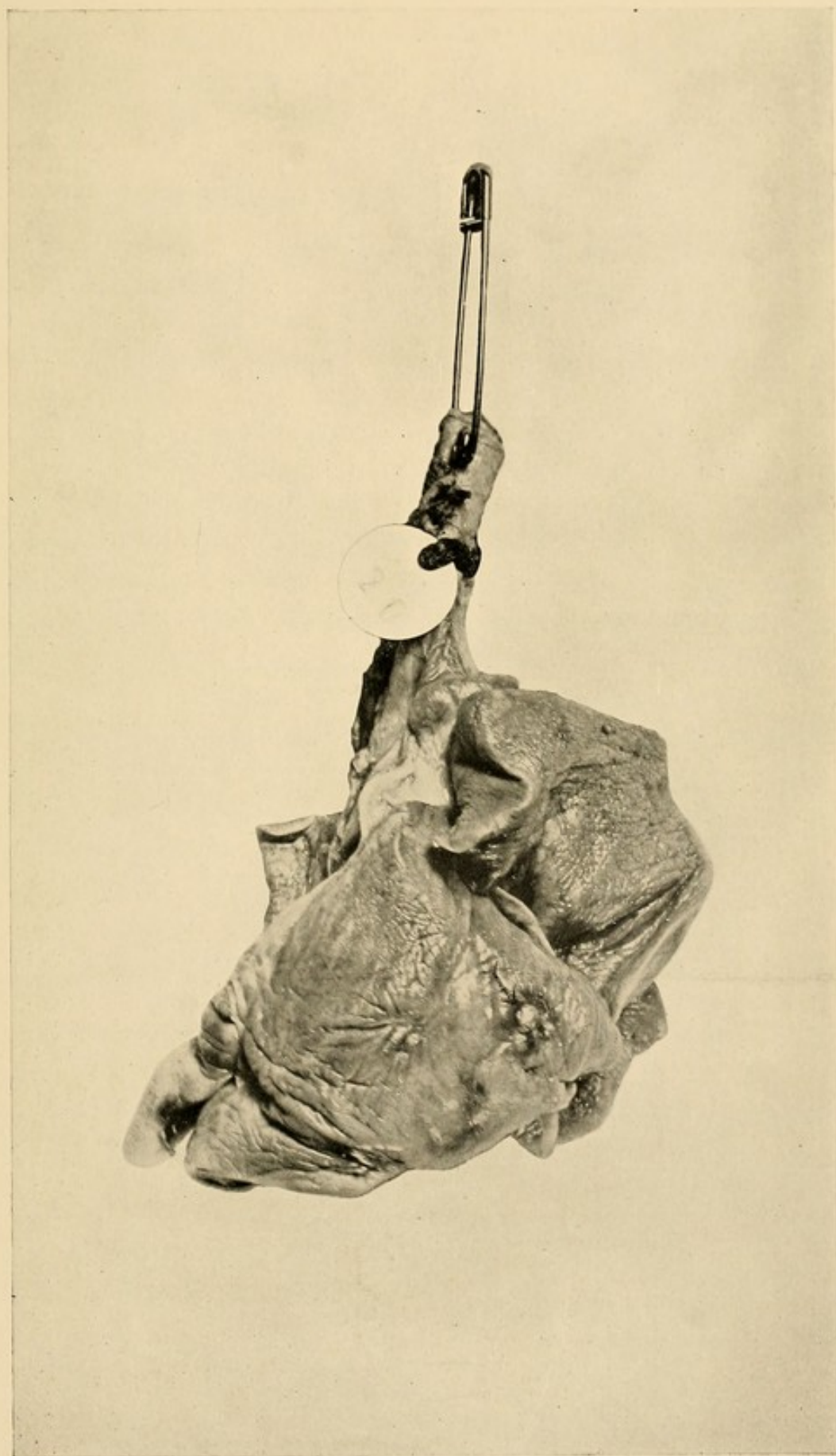
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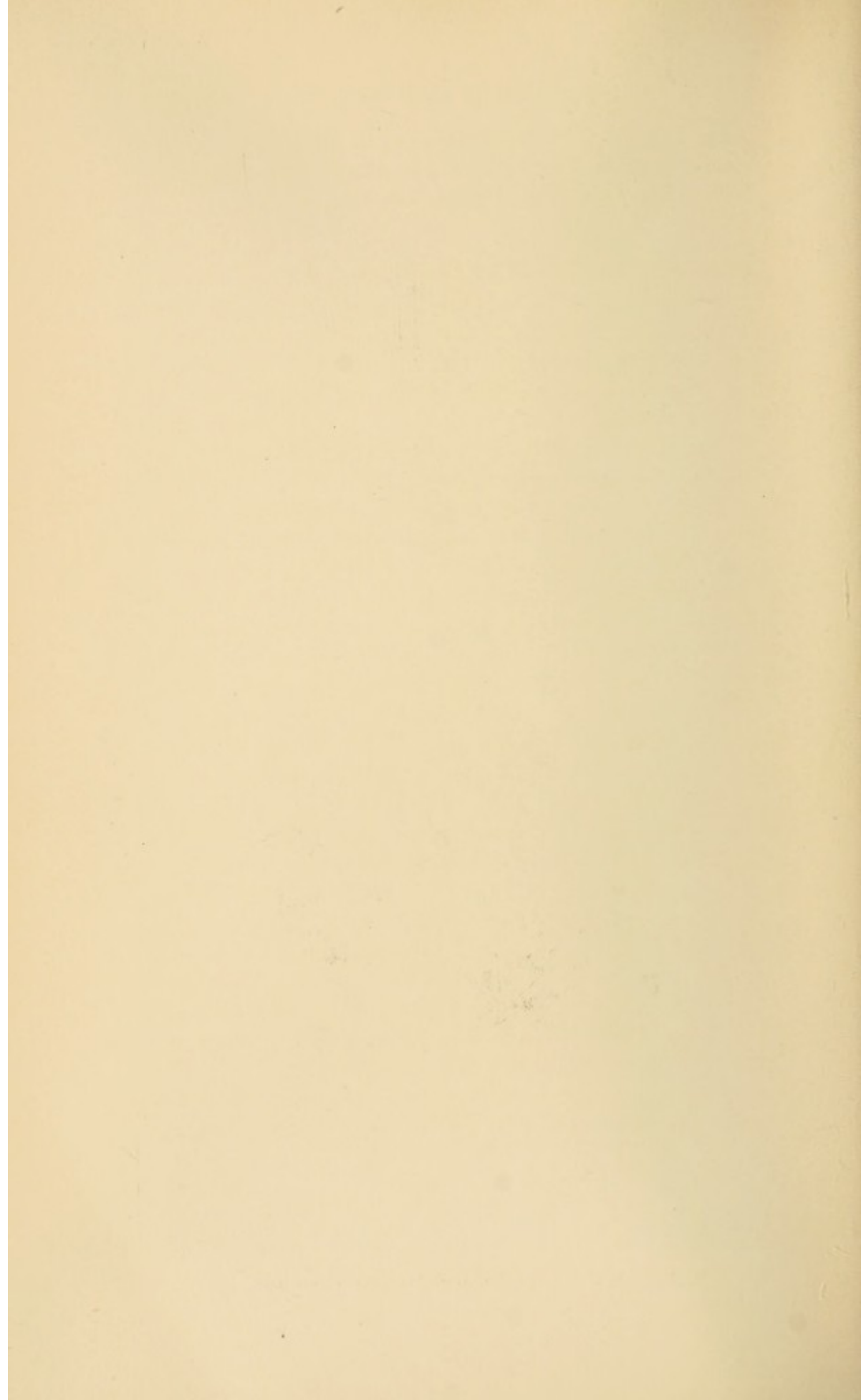
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GIARRE, C., Un caso di cisti voluminosa da echinococco del polmone destro in bambina di 7 anni curato colla estirpazione. *Riv. crit. di Clin. Med.*, Firenze, 1902, III, 6.

PARAGONIMUS WESTERMANI.—This distoma is a trematode, indigenous to Asia, found in China and Corea, and especially prevalent in Formosa and Japan, where it has never, however, been found in the hog. It is found in both man and domesticated animals, such as the dog, cat, and hog, in the United States.

Paragonimus Westermani usually attacks the lungs by the formation of nodules, generally near their roots. As a rule, the nodules are occupied by two, probably male and female, parasites. The brain has been found infested by them, in which case the cortical substance is involved, causing epilepsy. Manson, who first described this disease, terms it parasitic hæmoptysis. It is very common in Japan; we owe most of our knowledge of it to the Japanese physicians. Baelz said that in one village in Japan nearly all the inhabitants harbored lung worms.

Historical.—Kerbert (1878) described a distoma that had been found in a Royal Bengal tiger. This is one of the earliest published reports. Ward (1894) of the University of Michigan, reported that a parasite discovered by Professor Kellicott, of the University of Ohio, was identical with that of Kerbert. The United States Bureau of Animal Industry reported fifty cases in the dog, found in Ohio. The sixteenth report gives a number of instances in which it was found in the hog. This same report contains a résumé of the literature on the subject, and it has been largely drawn upon for the following matter.

In Japan and Formosa from fifteen to twenty-five per cent. of the inhabitants suffer from hæmoptysis caused by this parasite. It is often confounded with tuberculosis, since it can only be diagnosticated by aid of the microscope. It is not found in the very young or in the very old. Some of the au-

thorities state that persons of strong constitutions are more subject to this disease than others. It has been found in persons following various pursuits and occupying various stations in life. In fifty-nine cases the ages were known; of these, forty-five were between eleven and thirty. Of sixty-six cases of known sex, fifty-eight were males, and eight females.

This parasite has been found in the same domesticated animals in this country as in Japan. It is also now found in man in this country, having been brought here by soldiers returning from Asia.

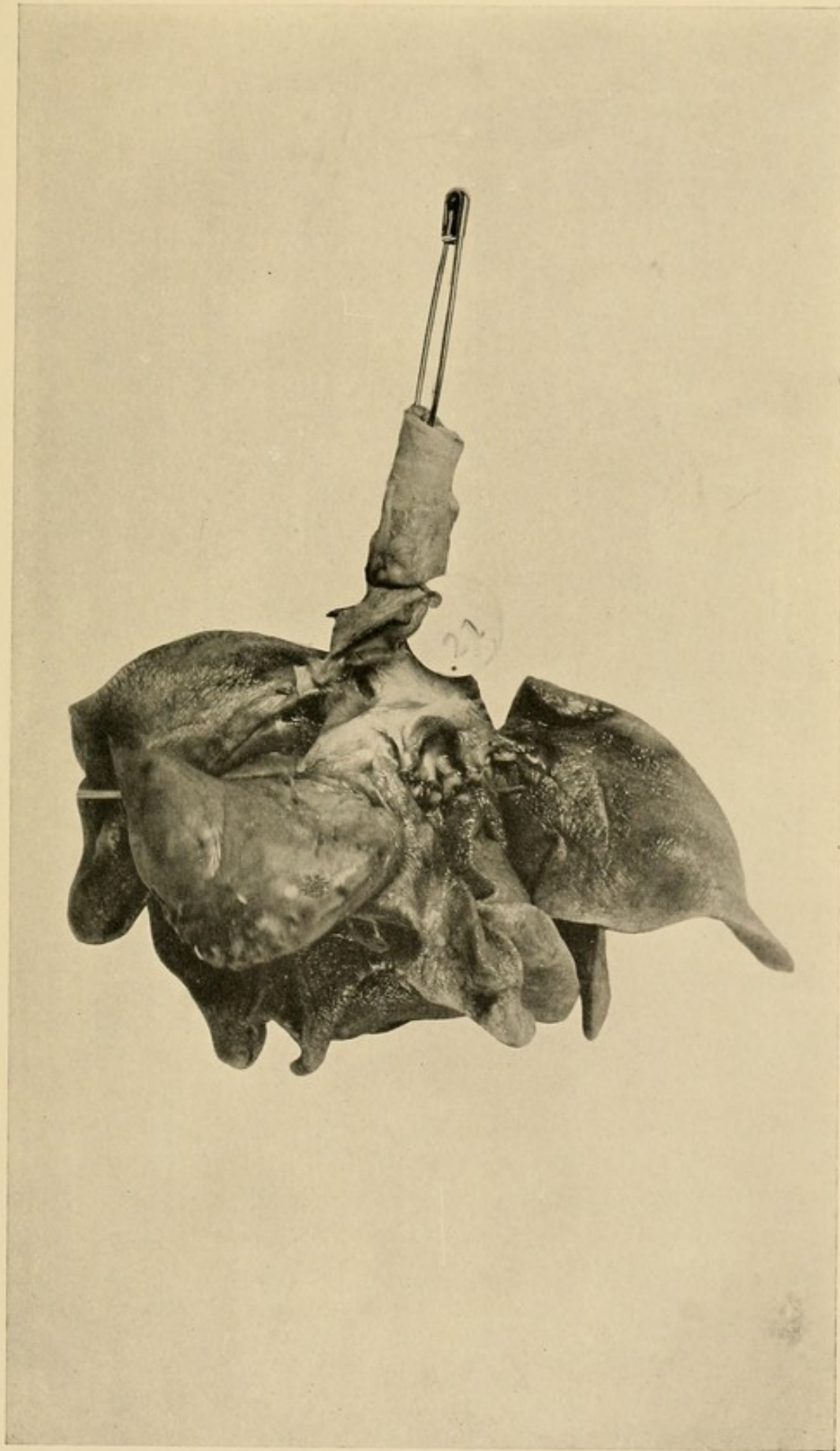
Father Clos, S.J., who has recently returned from the Philippines, says that he has observed numerous cases of hæmoptysis among the natives.

It should be remembered that infection of the lung may be complicated by infection of the brain, liver, or other organs.

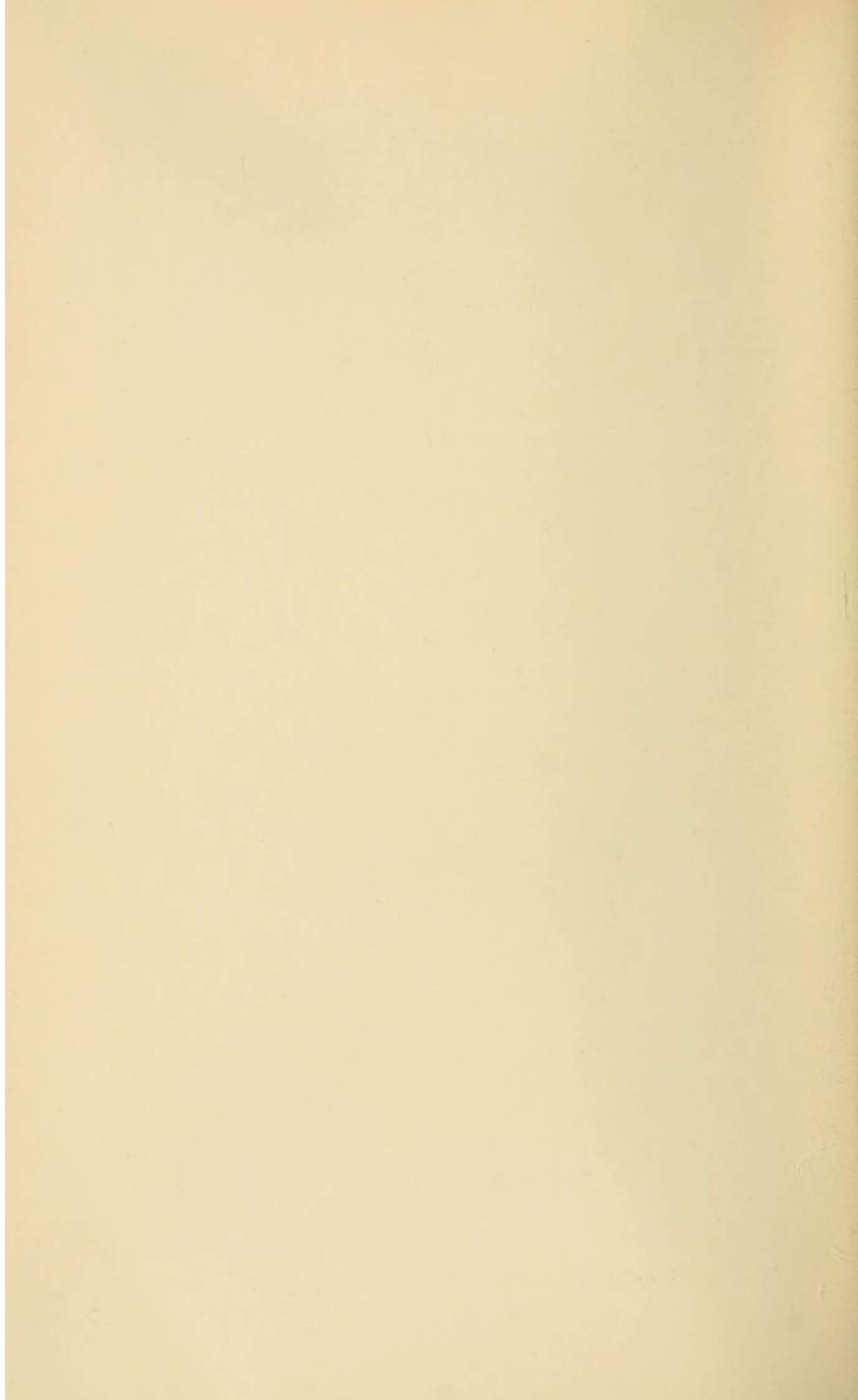
Symptoms, Diagnosis, and Treatment.—The sputa are similar to those of pneumonia, of a dirty brown or red color, due to the microscopic worm eggs. Spitting of blood is common; intermittent cough is common but not constant. The only constant factor is the presence of the eggs in the sputum. As much as ten or twelve ounces may be expectorated daily, containing thousands of eggs. Usually the disease makes slow progress, and at the end of several years, six, eight, or ten, the patient is no worse. This form of hæmoptysis is seldom associated with other serious lung troubles.

Physical examination reveals nothing abnormal, except in the worst cases. The temperature is normal, or only slightly elevated. Frequently there is slight œdema. Patients describe a sensation in the chest of oppression, or of heat, or mere irritation. Occasionally, there are neuralgic pains in the chest. The sufferer may get out of bed, and months pass before a relapse occurs. But the relapse will come sooner or later. This happens over and over again, until the patient is worn out.

No benefit has been derived from medicine in treating this disease. General treatment is, undoubtedly, useful; but rest



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and good food are essential. Exertion aggravates all the bad symptoms.

Yamagiwa thinks surgery might be tried if the exact location of the more superficial cysts could be learned.

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PULMONARY CYSTICERCOSIS.—Cysticercosis is a parasitic disease caused by the presence of entozoons. These entozoons, known as cysticerci, are the larvæ of various species of tæniæ (tapeworms). Before their identity as embryonic forms of tapeworms was discovered, the cysticerci were considered to be a distinct genus of the order Cestoda. Hence, the many names which have been given to them. The cysticerci are the spherical or oval embryos from which the head (scolex) of the tapeworm develops. It is not the most primitive form of the tapeworm, as it is developed from another embryonic form.

Many of the animals which are found about the habitations of men harbor the various embryos of the tapeworm. Thus the embryos gain entrance into a human host to develop into the mature strobila, or fully developed tapeworm. The cysticerci are found in all the domesticated animals whose flesh is used for food. The use of uncooked meat; soiling of the hand by working, or handling dirt, etc., in which the fæces of these animals, or of fowls may have been deposited, are fruitful sources of infection. So, too, persons who harbor tapeworms, or from whom a tapeworm may have been expelled, become self-infected through the hands coming in contact with the anus in sleep, from eggs which may escape per anum and stick to the undergarments, etc.

The cysticerci have been known to invade all parts and organs of the human body. Cysticercosis of the lungs, however, is comparatively rare, but by no means unknown, as witness the reports of cases (see bibliography). It is quite probable that some of the cases diagnosticated and reported as hydatid cysts of the lungs, have been, in reality, cases of pulmonary cysticercosis. A mistake of this character could be

made easily, since the dog tapeworm (*tænia echinococcus*) is the smallest tapeworm known, and greatly resembles certain kinds of cysticerci.

Measly pork or beef is caused by cattle and hogs being infected with cysticerci, which have become encysted. The cysts can be seen with the naked eye in salt pork or corned beef when dry; but they become invisible when the meat is damp. In meat, these cysts appear as small, white, calcareous spots, about the size of a pin-head. While in man, the cysts range in size from that of a pin-head to that of an adult head.

The lungs may become infected by carrying soiled hands to the mouth; by cysts of infected meat being broken in the mouth and the cysticerci, thus set free, penetrating the œsophagus; and by the migration of cysticerci from other organs or parts of the body.

The author found cysticerci in the sputum and urine of a woman fifty-five years of age, under the care of Dr. W. E. Langdon. She resided on a farm and cared for several kind of fowl.

Symptoms, Diagnosis, and Treatment.—The cysts, themselves, rarely give any trouble, but the increase in size may produce grave complications, mechanically. If the cysticerci are free, or if they escape from the cyst, many grave complications will result.

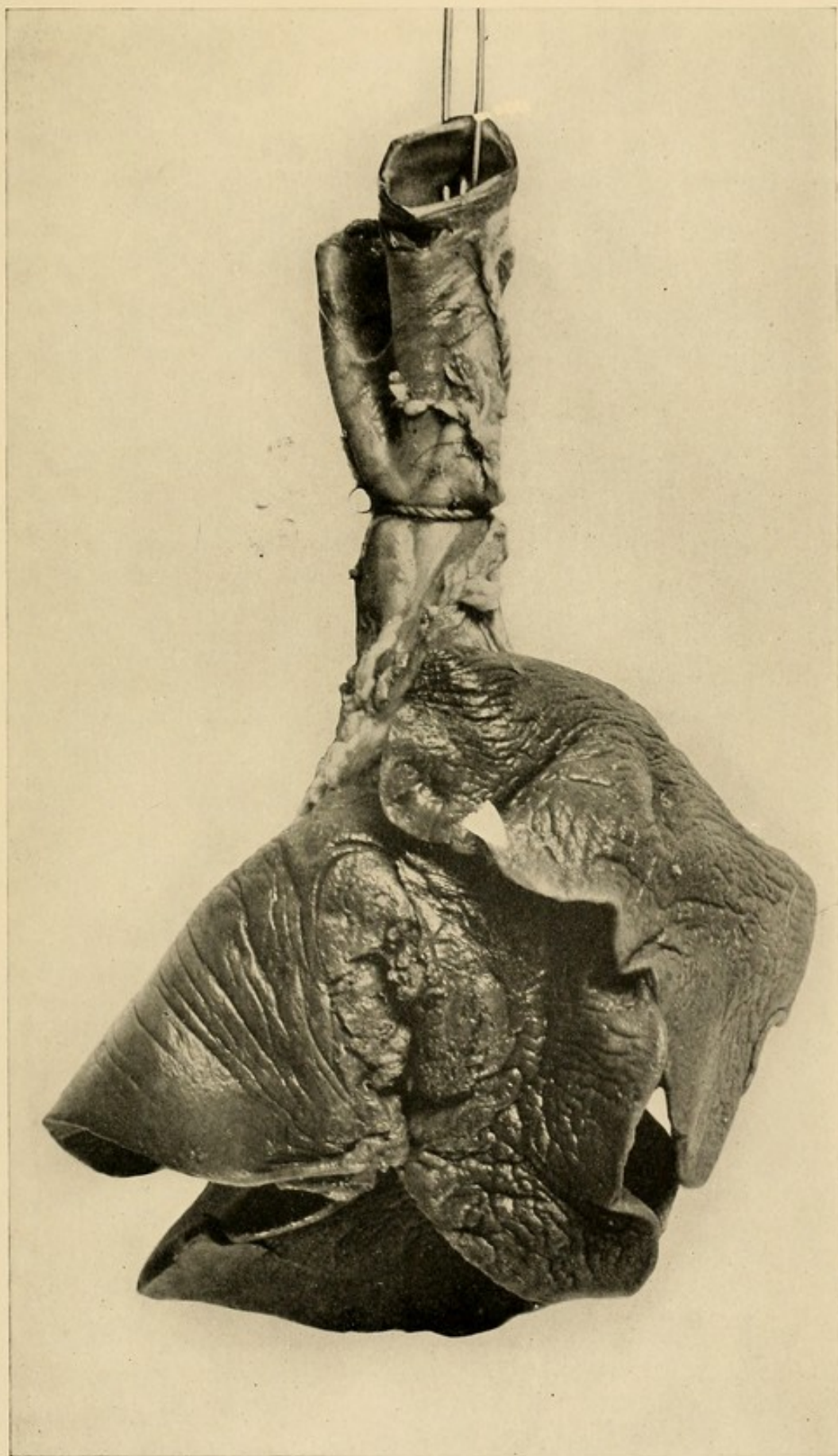
The symptoms of pulmonary cysticercosis present nearly the same clinical picture as hydatid cysts of the lungs. In addition there are frequent asthmatic attacks, emaciation, loss of appetite, etc. A microscopical examination affords the only means of making a positive diagnosis. At times the microscopical examination may need to be supplemented by a chemical analysis, but, generally, a microscopical examination is sufficient; eggs, encysted embryo, heads, etc., being found in the fluid. The microscope should be used as a regular routine procedure in all clinical examinations. Very often a chemical analysis fails to reveal the most important thing.

A bottle of urine, and also of sputum, were left at one time for examination. As is the usual practice in the office, the urine was first placed under the microscope. At first, there were only evidences of diabetes, and intravesicular inflammation. A chemical analysis would have confirmed this diagnosis, but a little further search discovered the true cause of the disease and explained all the clinical symptoms. For, there, in plain view, were two cysticerci. Here were evidences, which vitiated the inductions previously made.

It is claimed that no medicine will do any good in certain forms of cysticercosis. But in case of pulmonary cysticercosis some hold that arsenic, iodides, etc., may be effective. All, however, agree that when the cysticerci are accessible, the surgeon's knife furnishes the most reliable means of treatment.

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TRICHINA SPIRALIS.—*Trichina Spiralis* is a nematode worm found principally in the pig, but occasionally in man after the ingestion of pig meat. The parasite perforates the intestinal wall, and enters the various muscular tissues thereafter. It becomes encapsulated chiefly in the diaphragm, muscles of the back, shoulder, neck, eye, larynx, tongue, and occasionally the muscles of the lung. The cyst is ovoid in shape, at first transparent, becoming opaque and ultimately calcifying. It is coiled, and the female is larger and more numerous than the male.

Treatment.—The same surgical measures are applicable to all lesions produced by parasites, whether fungoid, animal or bacilli. A positive diagnosis, even with the microscope, cannot always be made. *Trichinæ* are said to be especially difficult to detect. The most important features in all are the complete removal and evacuation of the cyst, with annihilation of its occupant. In all cases the resection of one or more ribs is necessary, together with fixation, if possible, of the cyst wall to the thoracic wall, at a point corresponding to the greatest prominence of the cyst. This is to be done whether it occupies the anterior or posterior surface of the lung, or its base or apex.

If the mediastinal wall should be involved, the sternum should be sufficiently removed to permit of free drainage through the mediastinal space. The cavity, in either event, should be thoroughly irrigated with sterilized water; great care being exercised to see that all débris is removed. When this is done, the inner wall of the cavity should be brushed with a saturated solution of carbolic acid, iodine or formaldehyde; and the cavity packed with gauze, the end of which should be secured externally. The amount to be used must be governed by the necessity of controlling bleeding. The frequency of changing the packing, and the amount to be used should be governed also by necessity.

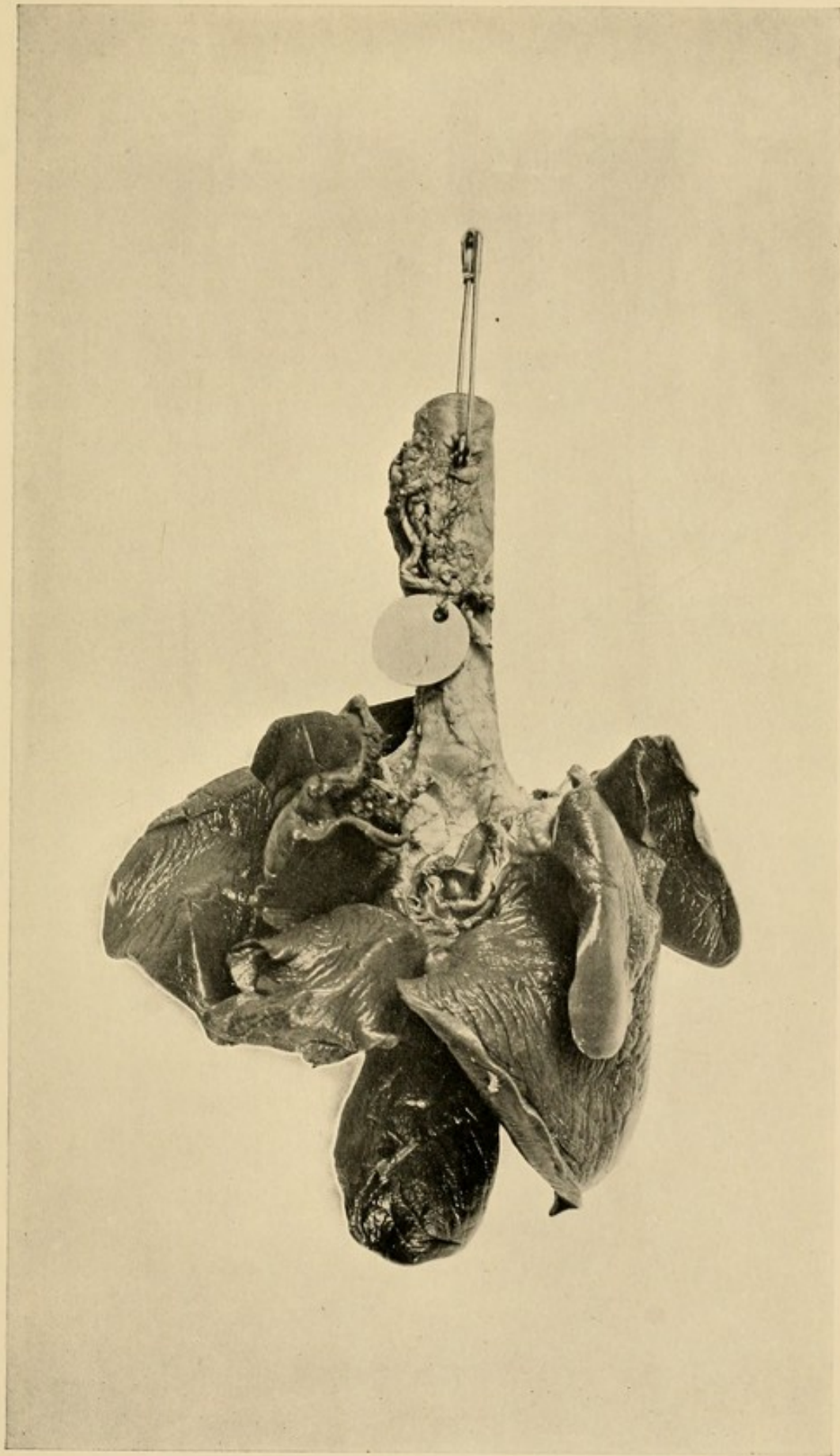
If the cyst wall cannot be fixed to the chest wall, one should not hesitate to incise it freely and expose it through the pleural

cavity; care being taken to have perfect drainage at the lowest point in the cavity. If the bronchus has been opened by rupture of the cyst, firm packing of the cyst cavity will be the more essential, as such a rupture in connection with an external opening, might cause partial or complete apneumotosis of one or all of the lobes of the lung involved.

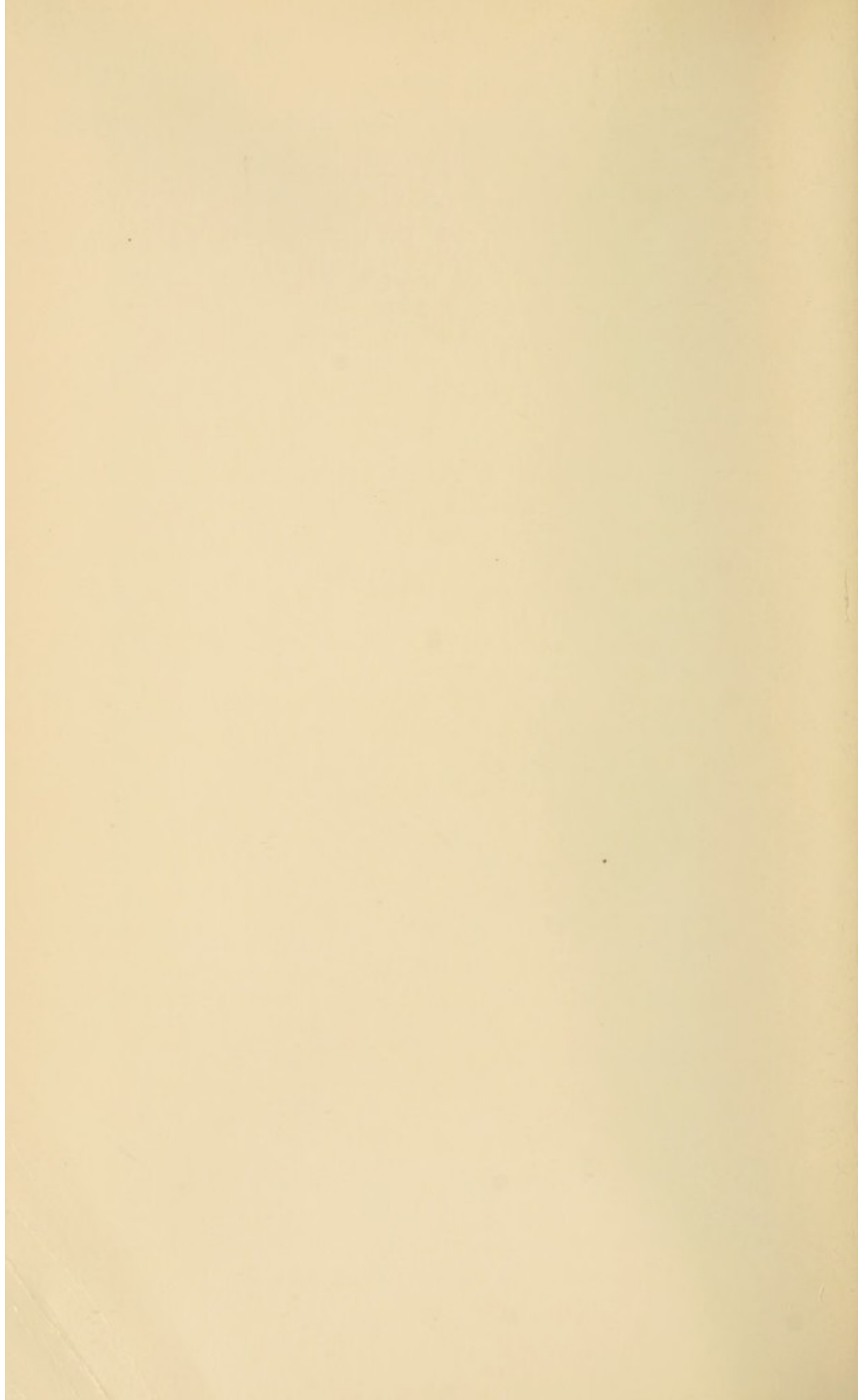
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PLATES, PART II.

Repair of Lung.

Sutures.

Dog's Lungs, in situ (Anterior view).

Dog's Lungs, in situ (Posterior view).

Sections of Dog's Lungs (7).

Photos of dogs' lungs after operation (22).

EXPERIMENTAL RESEARCH ON THE LUNGS OF THE DOG.

THIS series of experiments was conducted at the laboratories of the University of Cincinnati from June 25 to Sept. 1, 1900, for the purpose of demonstrating how far surgical interference with the lung could be carried, and also to establish the best technics in lung surgery.

Although the anatomy of the lung has been rather extensively treated, the physiology and pathology have been only considered as they bear directly upon the surgery.

The author takes this opportunity to thank Drs. J. Stuart Wallingford, T. G. Sellew, and his student, C. T. Souther, for their most valuable and devoted services.

Fifty dogs were used in conducting these experiments. No abnormalities, or parasites were found in any of the dogs. Neither were any malignant or benign growths found. Only one dog had hernia, and that was ventral. No case of host-operative hernia developed. One hundred and sixty-five dogs were used for all purposes, and none of the above conditions was found. Only one dog had tuberculosis (No. 48).

After No. 5, each dog was thoroughly scrubbed, the chest shaven, and skin washed with turpentine. Ether was invariably employed, except for producing death, for which purpose chloroform was used. No antiseptics were used, except turpentine, which was applied to all wounds, after the incision had been closed with silkworm gut. Dressings of any character were discarded after dog No. 5, the wounds being left unpro-

tected. Drainage was employed in only one case, No. 18, which died on the fifth day, from infection.

The food consisted of water, bread and milk, and raw beef. The ages and weights given are only approximate.

In no case did an abscess of the lung follow any of these operations.

CHAPTER XXI

THE LUNG OF THE DOG

EXPERIMENTAL RESEARCH

AN anterior view of the thoracic organs of a dog shows how nature provides protection for the more delicate and vital organs. The heart will be seen surrounded, and overlapped in part, by the lobes of the lungs. The right upper lobe of the lung overlaps the entire upper portion of the heart, while the left upper lobe affords like protection to the other side. The middle lobes too, close in around the heart, forming a natural, living, air cushion, thus warding off injuries to the heart.

The right lower lobe is the largest lobe of a dog's lung, while the right middle lobe might be taken for a process of the former.

The shape of the butterfly lobe shows why it received its name.

The left upper lobe overlaps the right upper lobe for a short distance, and thus aids in completing the air cushion-like protection of the heart. The left middle lobe overlaps both the upper and lower lobes, and fills in the space between the two; the left lobe extends downward more than the others.

A posterior view of a dog's thoracic organs, *in situ*, is also interesting.

The arrangement and connection of the various lobes may be very clearly comprehended. The thoracic aorta is perfectly visible, as are the intercostal branches, which are seen shooting off in pairs at regular intervals. Viewed from this aspect, the bronchial gland can be seen. When all the bronchial, pul-

monary, and arterial vessels are injected with a solution of starch, aniline, and formalin, the thoracic organs will assume and retain their natural shape and appearance, after removal. It will be found that some of the injected material will escape, but sufficient material will remain to keep the organs distended.

Now, if the lungs be viewed from a posterior aspect, the thoracic aorta, the great pulmonary veins, the bronchus, *in situ*, in the lung tissue, etc., can be seen easily. Such an examination will give one not only a better knowledge of the dog's lung, but of the human lung as well.

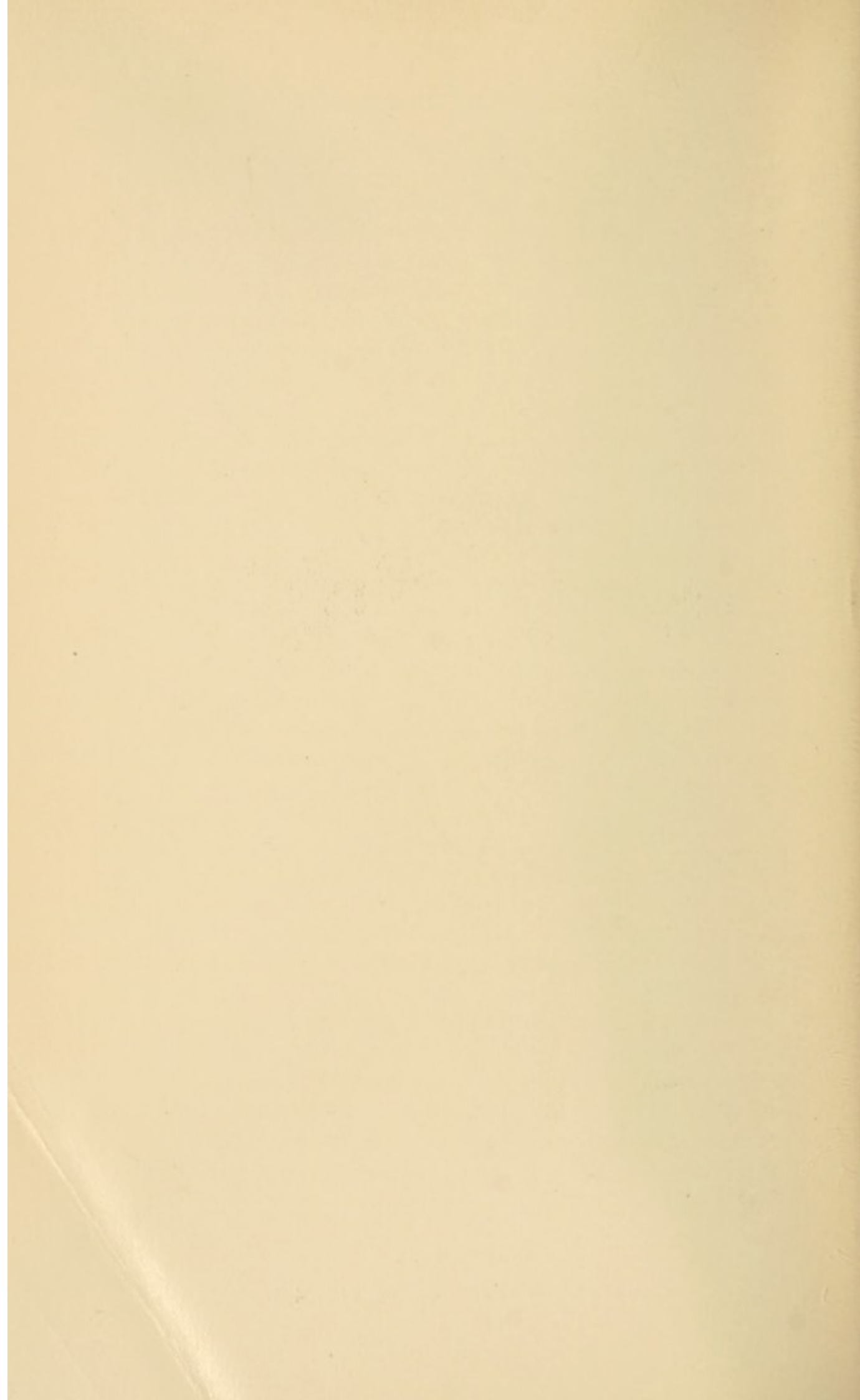
The plates numbered I and LVII to LXIII show the normal appearance of the dogs' lungs, while plates numbered LXIV to LXXXVII show the appearance of the dogs' lungs, after the various operations described thereunder.

These experiments proved that, in case of a dog, the middle of the right upper lobe may be severed by throwing a kangaroo tendon around its middle, and occluding the bronchial lumen; the inferior lobe of the right lung may be split, and, if sutured at once, recovery will ensue. A dog will recover, even after a piece has been torn from a lobe. An incision may be sutured with perfect confidence. An entire lobe may be removed, at least in case of traumatic injury. In one case, the inferior lobe of the right lung was removed with perfect success; in another, the lower half of the inferior lobe of the right lung was removed, by transversely cutting out a wedge-shape portion of tissue. The edges of the visceral pleura were coaptated. Autopsy showed the operation to have been a success. In another experiment, a perforation was made, and the perforated area was sutured, and the lung replaced; the dog recovered. Again, a lobe was punctured through its centre with a knife; perfect recovery resulted. In still another case, one-third of the inferior lobe of the right lung was cut away transversely. The dog recovered in a remarkably short time. Several experiments were made by puncturing the lung, and, also, by removing parts, or, the whole of a lobe. In all cases the operations were successful. Once two ribs were resected, in order to



PNEUMONOPEXY.

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reach the upper lobe of the right lung. This, too, proved successful.

It has been found during these experiments, that all cases of simple incision of lung, when returned to the cavity without suturing, have recovered.

Unless a lacerated lung has been sutured previously to being returned to the thoracic cavity, the cut surfaces have become adherent to the parietal pleura, at the point of normal apposition. But when it has been sutured before being returned, the lung has healed without pleuritic adhesions.

It was also found, that after a lung had receded upon opening the chest, the probabilities are, that it will never regain its original distention, if a permanent opening be left in the chest wall, and adhesions are not formed.

The removal of the superior border of any lobe was more easily accomplished than the removal of the inferior border of any lobe.

In no case were clots found in the post mortems.

Air will re-enter compressed lung tissue if the pressure be not too great, or sustained too long. In each case, where a portion of a lung was excised, the remaining portion of the lung became distended sufficiently to occupy the entire pleural cavity.

Acceleration of respiration and circulation, immediately after operation, was remarked in all cases, the degree varying with amount of lung tissue excised, and the consequent loss of lung capacity. This was true whether it was a case of removal, or simple occlusion by ligation, or otherwise.

The stomach was not distended with gas in all cases of infection.

Large dogs withstood the operation better than smaller and younger dogs.

The lungs were the only organs examined microscopically after autopsy.

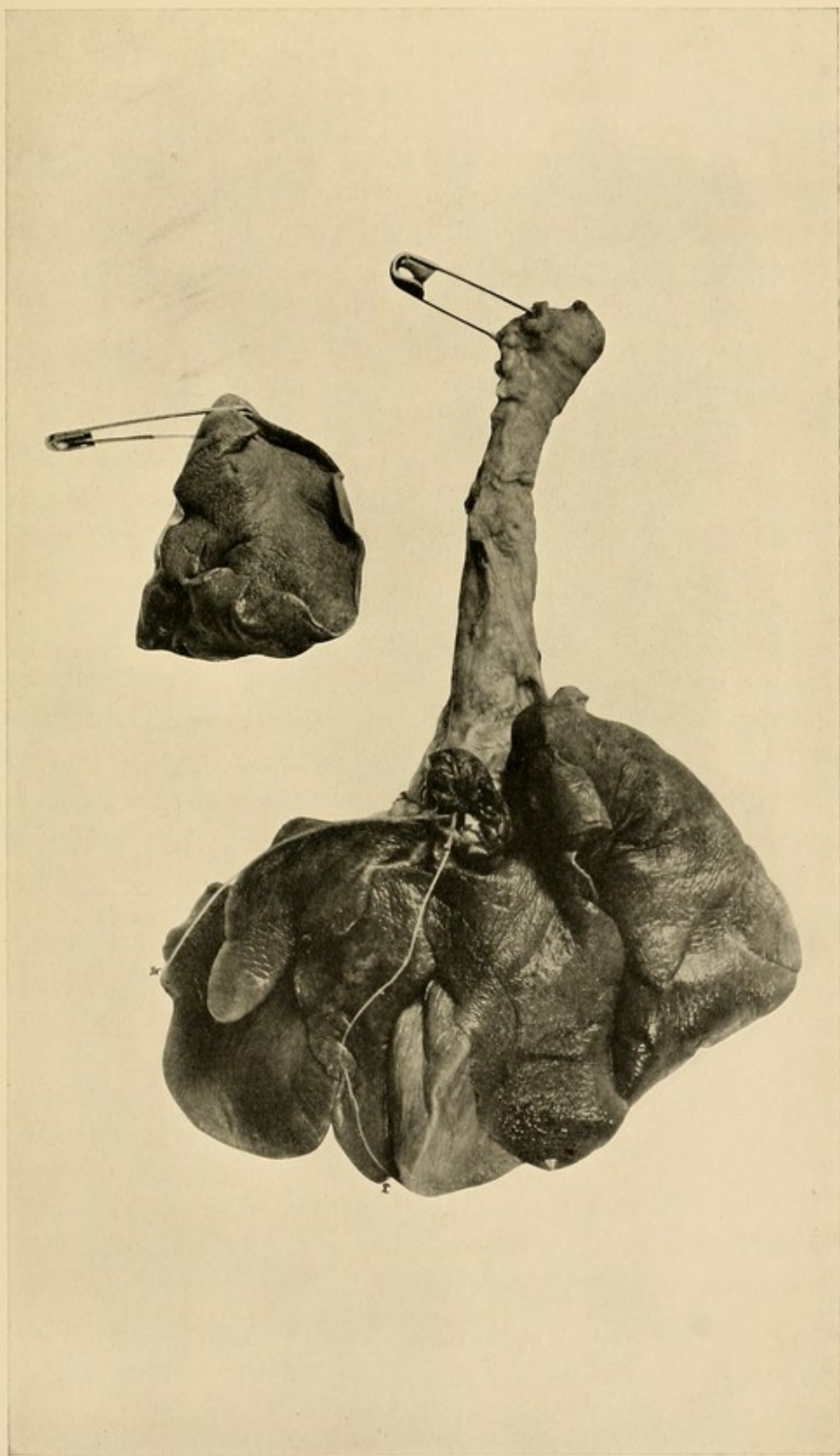
PRACTICAL HINTS AND THEORETICAL CONSIDERATIONS, DEDUCED AND SUGGESTED BY THESE EXPERIMENTS

THIS series of experiments corroborates the conclusions to be drawn from the reports of cases, and operations for lesions of the lungs.

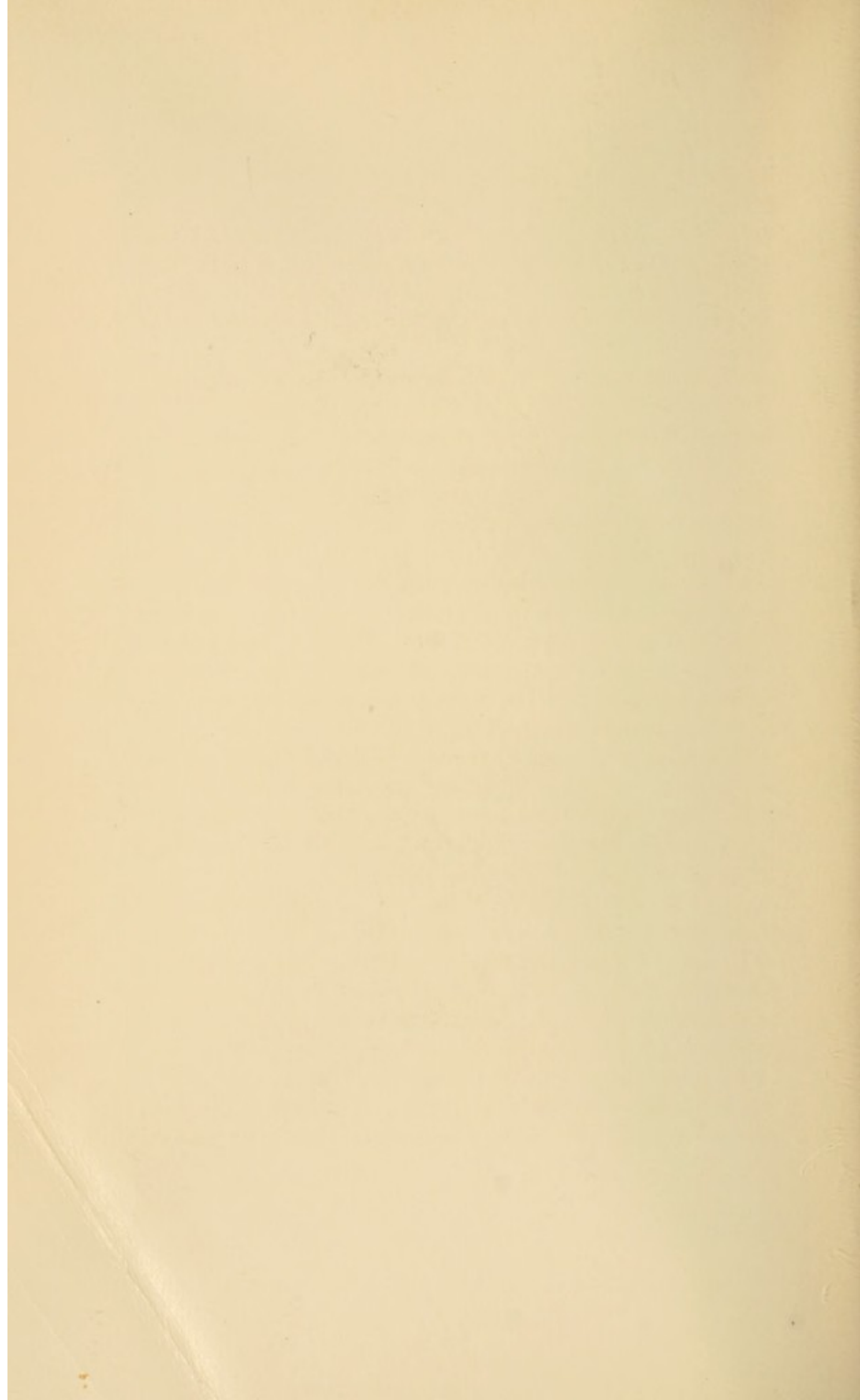
The surgeon should never hesitate to operate, if other measures fail. There should be no hesitation, even though the case seems particularly desperate. There is much greater prospect of success in operating for all forms of pulmonary disease than some writers would have us think.

Tait claimed that deductions from experimental operations on dogs, or other deep and narrow-chested animals, were misleading. These experiments, however, prove that surgical interference in pulmonary troubles is far from being impractical, or unjustifiable. The reason offered for decrying the application of the results of experiments, is based on the fact that only healthy animals or organs are operated upon.

The experiments which form the basis of these remarks were made on such dogs as could be obtained. No effort was made to secure healthy dogs. Even when several dogs were obtained at the same time, the dog first at hand was used without making any selection. On account of several reasons (which are not germane to the subject) no special care was exercised in the performance of the operations; neither did the dogs receive any particular care after the operations. Anti-septic precautions were generally neglected, too. Hence the results obtained under such circumstances are all the more re-



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markable. It is fair, therefore, to assume that if the same operations had been performed on human subjects, the results would have been as good, if not better. For in making such operations on human patients, greater care would have been exercised, and greater precautions observed to secure asepsis.

These experiments showed that stab wounds bleed more than bullet, or similar wounds, unless important vessels be injured.

The best mode of operating in these cases is to excise portions of the injured lung, and suture the cut edges, and it is better to excise portions of the apices of a perforated lung, when the wound is at the border, and suture the edges, than to attempt to close it with puckering sutures. In some cases, it may be best to incorporate a portion of the lung into the chest wall, and relieve it later.

A portion of one, or both pneumogastric nerves may be removed without danger, or permanent ill effect. The intimate connection of the vagus with other cranial or cerebrospinal nerves, and with the sympathetic, accounts for the danger from injuries to this nerve. It is impossible to separate the fibres of the one from the other.

In case of an external laceration of a lobe, and if the control of hæmorrhage be impossible, or doubtful, it is safer to extirpate the lobe. This is the proper procedure in cases of certain forms of abscess, active destructive gangrene, or destruction of a greater portion by necrosis.

The character of a wound in the lungs is influenced by several factors, *i.e.*, size of foreign body; velocity of missile; proximity to source of injury; character of chest wound, whether fracture or not; direction of missile; whether wound be received during inspiration or expiration; environment; and extent of injury to the vessels.

In pulmonary operations, the incision should be made nearer the spine than to the sternum, as it will be easier to palpate, and deliver the lung. Perforating instruments should not be used

on lung tissue that is to be left in the chest cavity. It is better, too, to lacerate the lung, than to cut it, as there will be less bleeding. The less the amount of lung tissue incorporated in a ligature the better.

In cases requiring the ligation of the bronchus: first, ligate the bronchus; second, ligate the vessels, and dissect away the lung tissue. This must be done sooner or later. In ligating the bronchus, the ligature should be applied only after denuding the rings of mucous membrane. The bronchus may be closed by inverting its ends and suturing.

Always cut or ligate transversely to the bronchial vessels; parallel sections may be removed this way.

When an entire lobe of a lung is removed, several ligatures should be used. The remaining portion of the lung should not be ligated "en masse," but only small portions of lung tissue should be incorporated in any one ligature. It is better to have too many than too few ligatures. The operator must be careful to make sure that the ligatures are drawn sufficiently tight, to preclude all danger of their dislodgement.

Drainage is to be used in gunshot, incised and lacerated wounds. It is to be used in all cases of operation for abscess, gangrene and parasites. Counter drainage is only to be employed when adhesion to the parietal pleura has not taken place. Drainage is just as important in operations on the thoracic organs, as in operations on the abdominal organs.

In case of a punctured wound, do not be afraid of placing the sutures too deeply.

In case a lobe has been removed, and, if for any reason, it is thought best to fix the stump in the intercostal space, the cutaneous structures should be sutured over it, first having secured the blood-vessels and bronchi. Care must be observed to occlude the bronchia, that there may be no emphysema. These experiments proved that it is not always necessary to suture the lung tissue itself; ligating the blood-vessels and bronchia is sufficient. In such cases the lung will usually become adhe-

rent to the chest wall. In case blood should escape into the pleural cavity, no danger need be apprehended in traumatic injuries of the lung, if the removal of the damaged portion of the lung has been properly accomplished.

Trauma, from forceps in grasping the lung, will produce sub-pleural œdema. This appears soon after the operation, when a portion of the lung has been extirpated. Hence flat forceps, with rubber coverings, should be used to grasp lung tissue, and the forceps should not be removed, until this portion of the lung is removed, or the operation completed.

If a lobe be badly lacerated, by a piece of shell or otherwise, it is infinitely safer to remove the lobe, after having transfixed it to its base, or to the undisturbed tissue, than to do anything else.

It is also better to allow an injured lobe or lung to remain contracted with an open chest wall, than to close the chest with gauze packing. In the latter case the lung will become distended, and thereby ceases to be at rest, a condition most favorable for the repair of any tissue. This is especially true of the lung, because the lung alternately expands and contracts upon itself from twenty to fifty, and even more, times per minute in severe injuries. If the lung can be kept quiescent with an open chest for twenty hours, it is very probable that it will become safely distended with air when the chest wall is closed.

In cases of wounds of the chest wall involving the lung, this retraction of the lung always occurs. The retraction of the lung favors the stoppage of hæmorrhage, because it causes a forcible contraction of the blood-vessels; a clot is formed, which stops the bleeding. But when the external wound becomes closed, by the formation of a clot, or otherwise, the lung will suddenly expand. The force exerted by the expansion of the lung, under these circumstances, is greater than in normal expansion. The pressure thus suddenly exerted forces the clot out, and the hæmorrhage will be renewed. This will occur again and again, until the wound finally heals. If immobility

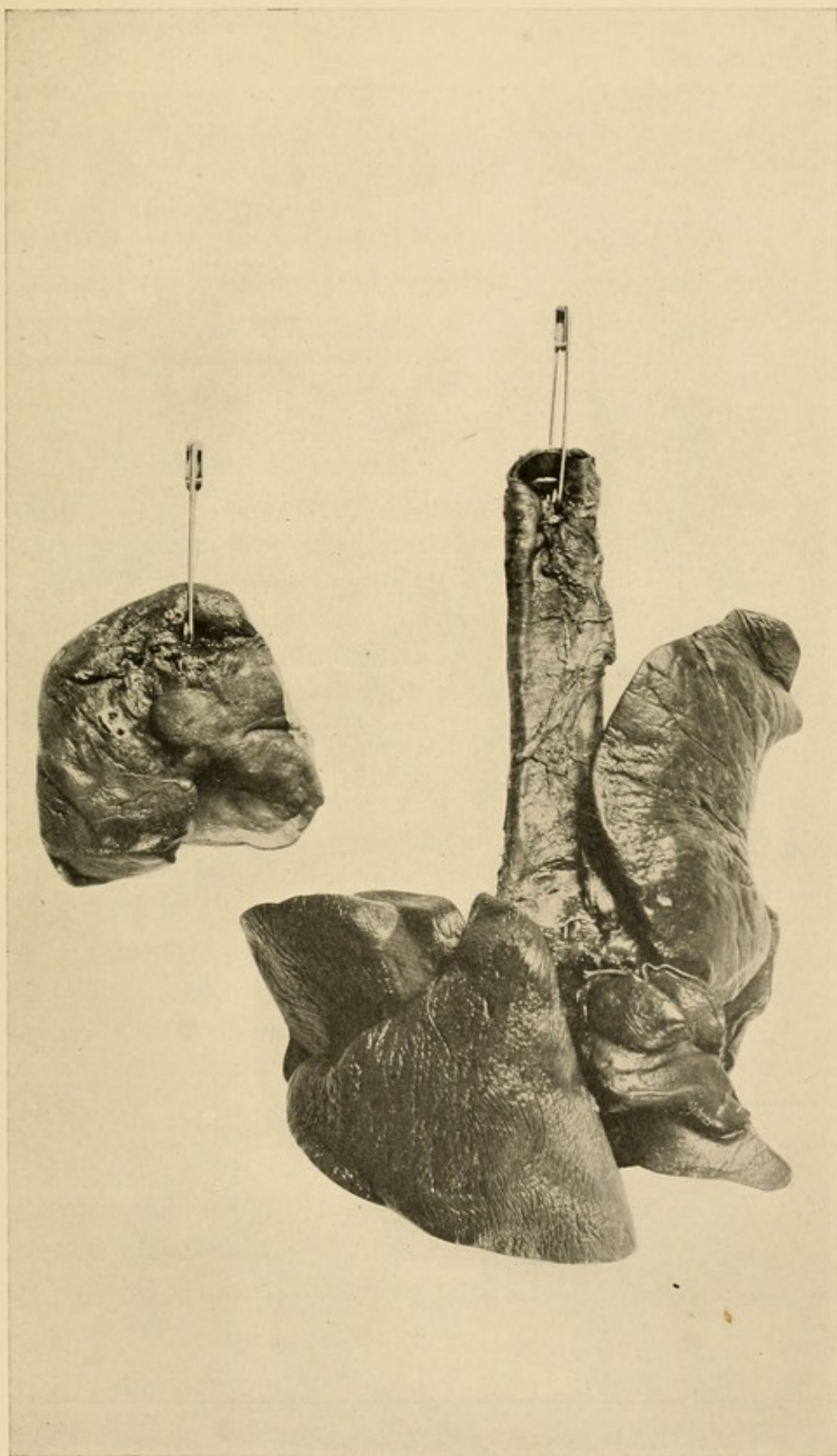
can be maintained for a few days, or a week, there will be no question of recovery.

There is, apparently, no limit to the degree to which the lung may be compressed. There have been no accurate observations made on this point. It can hardly be determined experimentally, because animals cannot be kept sufficiently quiet except by the use of anæsthetics, or by force. In either case the validity of the results obtained would be questionable. Anæsthetics, if they did not cause death, would, very likely, cause complications that would vitiate results. The use of force would defeat the very object which it was intended to secure. Hereafter, no doubt, greater care and accuracy will be employed in making observations on this point in man.

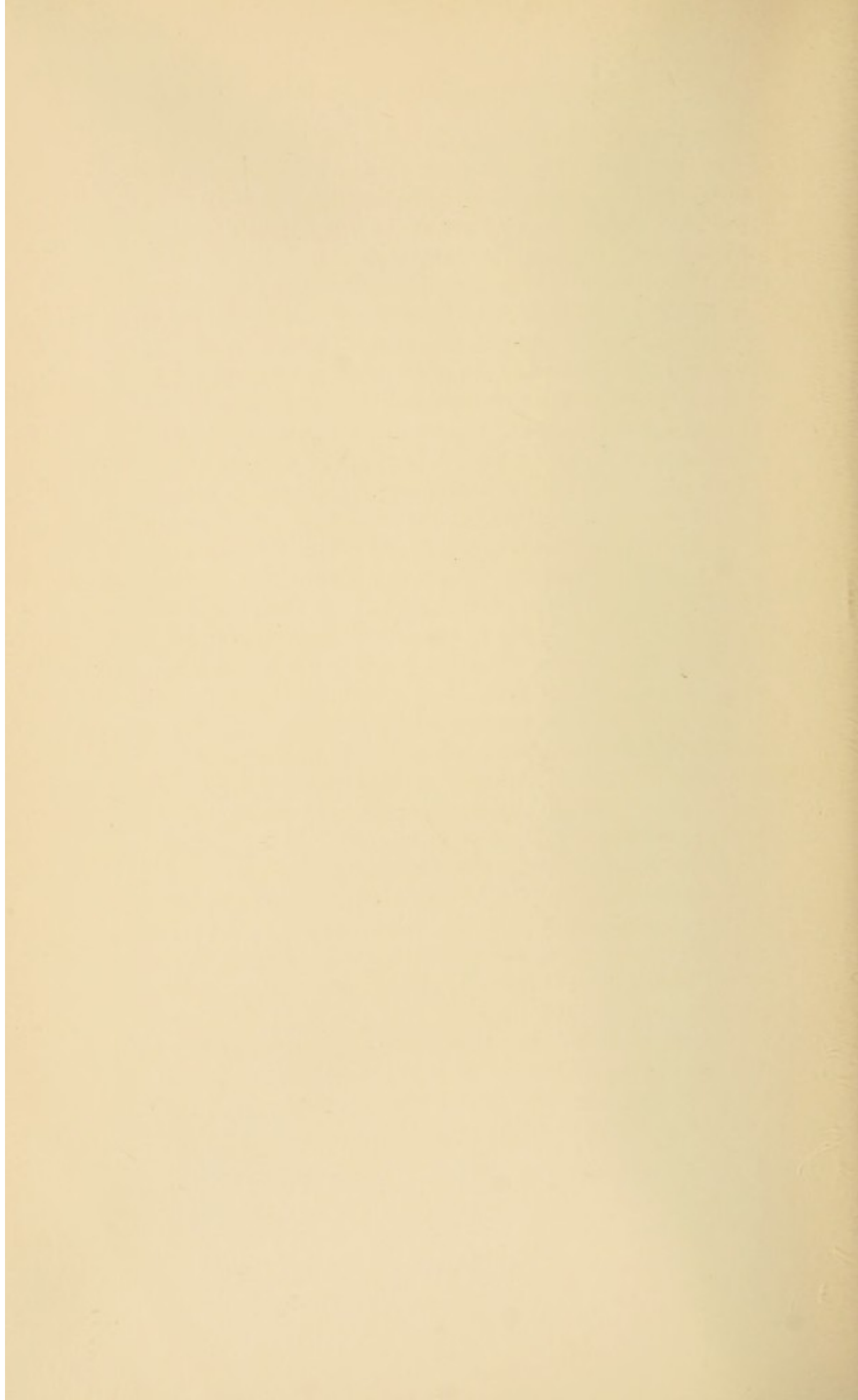
In case the apex of a lung is lacerated, or incised, while distended, and the laceration, or incision, is not over three inches in length, it is safer to allow it to be undisturbed, especially if there is no bleeding. It may become adherent to the parietal pleura, but this is better than to cause additional injury by an attempt to suture.

The treatment of an injured bronchus depends upon the character of the wound; whether the laceration, or incision, be transverse, or longitudinal to the bronchus. If the bronchus has been opened for the purpose of making an exploration, it is the practice of some to pack instead of suturing. But this procedure is not advisable if it is necessary to divide the bronchus transversely, because of the possibility, and probability, of end to end anastomosis not occurring. In all cases where the bronchus is severed transversely, and in cases of longitudinal wounds produced by injury, it would be better to suture, applying the same methods as are used in similar wounds of the intestines. It is a question whether it would not be safer to suture all wounds of the bronchus.

A stout, healthy, normal dog can withstand the removal of either the right or left lung, entire. This has been done with the left lung in one of these experiments.



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The removal of one or more lobes of a healthy, normal lung is likely to produce more serious results than the removal of one or more lobes of a diseased lung; for, during the progress of the disease, there has been a gradual loss of lung capacity, proportional to the extension of the disease; while the loss of lung capacity following the excision of one or more lobes of a healthy lung is sudden. In cases of this kind, the remaining portion of the lung will expand, and together with the diaphragm fill the space originally occupied by the whole lung. Of course, a part of a lung cannot perform the functions of a whole lung. Just how large a portion of a lung must be left, in order that the cavity may be filled by the expansion of this remnant together with the upward movement of the diaphragm, is not exactly known. The alveoli may be expanded to almost any degree, but from experiments, it has been determined that the alveoli lose their elasticity when excessively dilated. The loss of elasticity causes a cessation of function. The exact amount of lung tissue that may be lost, without causing loss of function in the remaining portion of the lung, has not been accurately determined. It is a question, too, whether this expansion for the purpose of helping to fill the space occupied by the whole lung, in compensation for the lost portion, does not cause a diminution of function. It is extremely probable that there is a decrease of function in the mutilated lung greatly out of proportion to the amount of lung tissue lost.

It is probable that if a lung were excised lobe by lobe, in successive operations, that the mortality would be much less than if the entire lung were removed in one operation. If sufficient time is permitted to elapse between each operation, for recovery from the preceding, it is probable that the shock would be less with each successive operation.

It is very probable that the percentage of recoveries, from the excision of one or more lobes of a diseased lung, would be greater than the percentage of recoveries from the excision of one or more lobes of a healthy lung.

In case of a wound of the lung, or when there are grounds for supposing the lung to be injured, the patient should not be disturbed in order to make a positive diagnosis. Immobility, and quietude are absolutely essential in all wounds of the lungs.

No man is infallible—even with all the aids provided by modern science, it is not always possible to make a positive diagnosis. At times, diagnostic signs, which almost always indicate certain conditions, are misleading. Some of the most prominent and experienced surgeons have had such experiences.

The success or failure of pulmonary operations centre about the kind of sutures, and the kind of material employed.

There has always been controversy over the kind of material that should be used for ligating and suturing. Absorbable and nonabsorbable suture materials have their advocates. It is true that there are operations, the success of which will be more assured by the use of absorbable suture material; there are other circumstances when it would be better to use non-absorbable material. It is only by experience, combined with a thorough knowledge of the anatomy, physiology, etc., of the tissues involved in the operation, that one is enabled to make the proper selection of material, and kind of suture to employ.

Many pulmonary operations have, no doubt, been failures because wrong selections have been made of the kind of material used in suturing, or the wrong kind of suture used, or both. Failures have been caused also, by sutures being placed too near the lips of the wound, or by the punctures of the needle being too close together.

It is better to have too few sutures than too many, but with regard to ligatures it is better to have too many than too few.

When an antiseptic ligature is placed in aseptic tissues, there is no destructive change to weaken the vessel walls, therefore the ligature should include a minimum amount of vascular tissue, and should never be applied in such a way as to lacerate the walls of an artery.

The best needle for lung surgery is a coarse, blunt one, just

large enough to take whatever material is selected for suturing. By the use of a blunt needle, the danger of wounding the delicate vessels and bronchia which ramify through the lung, is reduced to a minimum.

The puncture of a needle should not be closer than one-half inch to the margins of the wound.

All stumps of lung tissue should be secured by transfixion; that is, the needle armed with kangaroo tendon should be passed through the thickness of the lung, and tied. It is a combination of ligature and suture.

At times it is not advisable to suture, and in such cases, a clamp or clamps should be applied. The clamp may be allowed, if necessary, to protrude through the opening in the chest wall.

Under no circumstances should torsion or acupressure be employed to secure blood-vessels in the lungs. In all cases of chest wounds involving the lung, the lung will retract. It will also retract on an attempt to suture it, if it is not already retracted; but as soon as the external chest wound is closed, the lung will immediately expand with greatly increased force. Torsioned vessels will give way to a force of one-half an atmosphere, in addition to the normal blood pressure; vessels, secured by acupressure, will not withstand a force of one atmosphere in addition to the normal blood pressure. The force exerted by the sudden expansion of the lung, under the above circumstances, will amount to at least two atmospheres. Ligation is the only method of securing blood-vessels that will sustain this pressure.

Do not place sutures near the edges of a wound, especially if it is an incision. If there is hæmorrhage, ligate the bleeding vessels by transfixion.

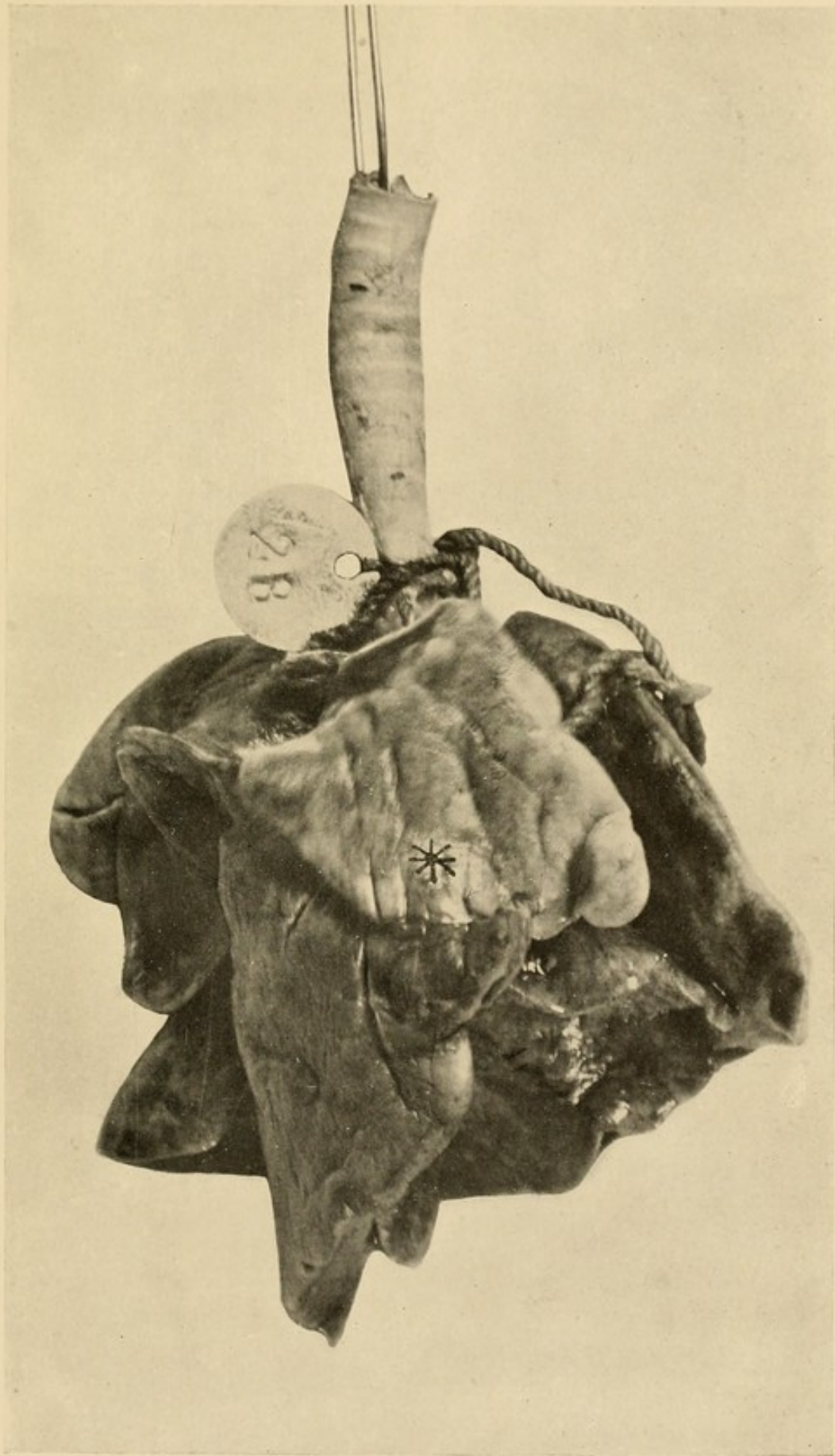
The "concealed," or "interrupted" sutures should never be used in operations on the lung.

If fine suture material is used, or if sutures are placed too close together, or too near the edges of the wound, the sutures

will tear out. Fine material, even if placed at the proper distance from the margins of the wound, will cut the lung tissue. For all purposes, kangaroo tendon is the best material to employ for suturing the lung; because of its relatively large size, the sutures may be placed farther apart, and may also be tied more tightly without danger of cutting the lung tissue, and the swelling caused by absorption of serum will aid in preventing bleeding.

This series of experiments demonstrates certain kinds of sutures to be more suitable than others. Among those that proved of special value were the "whip-stitch," which is simply an over and over continued suture; the "tug-stitch"; the "continued" suture; the "mattress" or "quilted" suture; the "glover's" suture; the "lace," and "Bell's."

The whip-stitch is to be used in simple superficial incision, or lacerations. The ordinary continuous suture is also useful for the same purpose. A combination of the mattress and continuous sutures is useful in extensive superficial incisions, and lacerations. The glover's is best adapted for incisions near the base of the lung, as it will keep the margins of the wound from everting. The Bell suture is best adapted for wounds in those parts of the lung where there is the least strain from the activity of the lung. The herringbone stitch is also of great utility in preventing the lips of a wound from everting. The mattress, or quilted suture is best adapted for deep incisions, or lacerations which do not extend through the entire thickness of the lung. The tug-stitch is the only suture that will answer in case of an incision, or laceration extending through the entire thickness of a lobe at its base; in other words, when a lobe is split. This suture is only an adaptation of the saddlers' stitch, which he employs in sewing a trace, etc. Two needles are used; one is passed through the entire thickness of the lung, at a distance of one-half inch from the lip of the wound; it emerges posteriorly, on the same side of the wound as it entered. The second needle is passed from the posterior surface of the lung,



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through the entire thickness of the lung; it emerges anteriorly through the puncture made by the first needle. The puncture of the second needle is made on the same side of the wound as that of the first needle. Then the second needle is passed, still on the same side of the wound, from the anterior surface of the lung, through the entire thickness of the lung, to the posterior surface, and there emerges, on the same side of the wound as it entered. The first needle is then passed through the puncture, just made by the second needle, to the anterior surface, where it emerges from the opening made by the entrance of the second needle. This procedure is continued until this side of the wound has been sutured in its entire length. Then the other side of the wound is sutured in the same manner.

The author devised a suture which he found to answer better than any other for cases where the wound was caused by a puncture, or perforation, and a piece of lung tissue had been torn out.

This suture is a combination of the lace and tobacco-pouch, or tug-stitch. A single curved needle is used. The needle is dipped rather deeply into the lung tissue about one-half inch from the edge of the wound, then it is made to emerge about one-half inch from place of entrance; this procedure is repeated until the entire wound is encircled with sutures. Then a second row of sutures is made; each stitch of the second row being so placed as to alternate with the first. In other words, wherever the kangaroo tendon, of the first row of sutures, is on the surface of the lung, that of the second row will be below the surface. By this means the wound is not only entirely encircled by sutures, but the tissue, surrounding the perforation, is compressed. This compression of the tissues also compresses the vessels, which have been severed, and the hæmorrhage is stopped.

DESCRIPTION OF PLATES I AND LVII TO LXIII

PLATE I

This plate gives an anterior view of the heart and lungs, *in situ*, of a dog weighing about forty-five pounds. The arteries, veins, and bronchia were injected with starch. This procedure completely distended the organs, and caused them to assume, and retain the shape of the thoracic cavity. The most striking feature, perhaps, which reveals itself at a first glance, is how nature provides protection for the most important organs. It shows that the right upper lobe of the lung overlaps the entire upper portion of the heart, while the left upper lobe affords like protection to the other side; the middle lobe too closes in around the heart, thus forming a natural, living air cushion, to ward off injuries, and sudden shocks to the heart.

The right upper lobe (1) extends across the upper part of the chest, meeting the left upper lobe. At (2) is the right middle lobe (the cord seen, is a rubber band used to hold the lungs while being photographed). Immediately below is shown the curled edge of the right lower lobe (3); this lobe is much larger than the others. In fact, it appears as if the right, middle lobe (2) was but a process of the right lower lobe. Just below the right middle lobe, is seen a cord; this is the end of a ligature around the aorta.

The heart is shown in its nest-like surroundings at (5). The left upper lobe (6) overlaps the right upper lobe, completing the air-cushion-like protection of the heart. The left middle lobe (7) overlaps the upper (6) and lower (8) lobes, thus filling the space between the two.

The white spots are caused by the escape of some of the starch, used to inject the vessels.

PLATE LVII

This plate gives a posterior view of the same organs shown in plate Ia.

The arteries, veins, and bronchia are distended with starch. The left upper lobe is shown at (1). The thoracic aorta (2), is clearly seen, together with its intercostal branches. The latter are placed in pairs, opposite one another. The left lower lobe (3) extends more toward the neck but not as low down as does the right lower lobe (7). The bronchial gland (4) is well brought out in the plate. Only a point of the right middle lobe (6) can be seen in this view. The right upper lobe (5) extends higher toward the neck, and not so far down as does the corresponding left lobe.

PLATE LVIII

A TRANSVERSE SECTION OF THE LOWER LOBES

The posterior aspect is shown at (6). The white spots are caused by the exuding of the starch with which the vessels were injected.

The lower wing of the butter-fly lobe (1) is shown resting on a rubber band.

(2) The left middle lobe.

(3) Apex of the heart.

- (4) The right middle lobe.
- (5) Upper wing of butterfly lobe.

As has been remarked, in explanation of Plate Ia, the lung forms an air-cushion-like protection to the heart anteriorly, while it is partially protected in the same way posteriorly, in addition to the support, and protection afforded by the spinal column and ribs.

PLATE LIX

A TRANSVERSE SECTION OF THE LOWER LOBES, TOGETHER WITH THE LOWER WING OF THE BUTTERFLY LOBE, AND APEX OF THE HEART

The white spots in this plate, as in all the others, are due to the starch escaping from the various vessels.

- (1) The œsophagus; just above, is seen one of the mediastinal vessels.
- (2) A transverse section through apex of the heart.
- (3) Section of lower wing of butterfly lobe.
- (4) The upper wing of butterfly lobe.

PLATE LX

A POSTERIOR VIEW OF A TRANSVERSE SECTION OF THE LOWER LOBES

- (1) A section of the bronchus.
- (2) Section of a bronchus in the body of the lung.
- (3) Section of heart.
- (4) A venesection.
- (5) The bifurcation of bronchus in right lower lobe.
- (6) End of middle lobe.
- (7) End of middle of butterfly lobe.
- (8) The œsophagus.

PLATE LXI-A

FOURTH POSTERIOR VIEW

- (1) Section of left middle lobe.
- (2) Œsophagus.
- (3) Left upper lobe.
- (4) Section of left bronchus.
- (5) Section of the right upper lobe.
- (6) Part of right upper lobe.

PLATE LXI-B

FIFTH POSTERIOR VIEW

- (1) Arch of the aorta, distended with starch.
- (2) The great pulmonary vein.
- (3) Portion of the left upper lobe.
- (4) The thoracic aorta.
- (5) Portion of heart.
- (6) The œsophagus.
- (7) The trachea, from which the starch is exuding.
- (8) Under side of the right upper lobe.

PLATE LXII-A

SIXTH POSTERIOR VIEW

- (1) Section of the left upper lobe.
- (2) The left bronchus.
- (3) The œsophagus.
- (4) The trachea, partially injected.
- (5) Section of the right upper lobe.

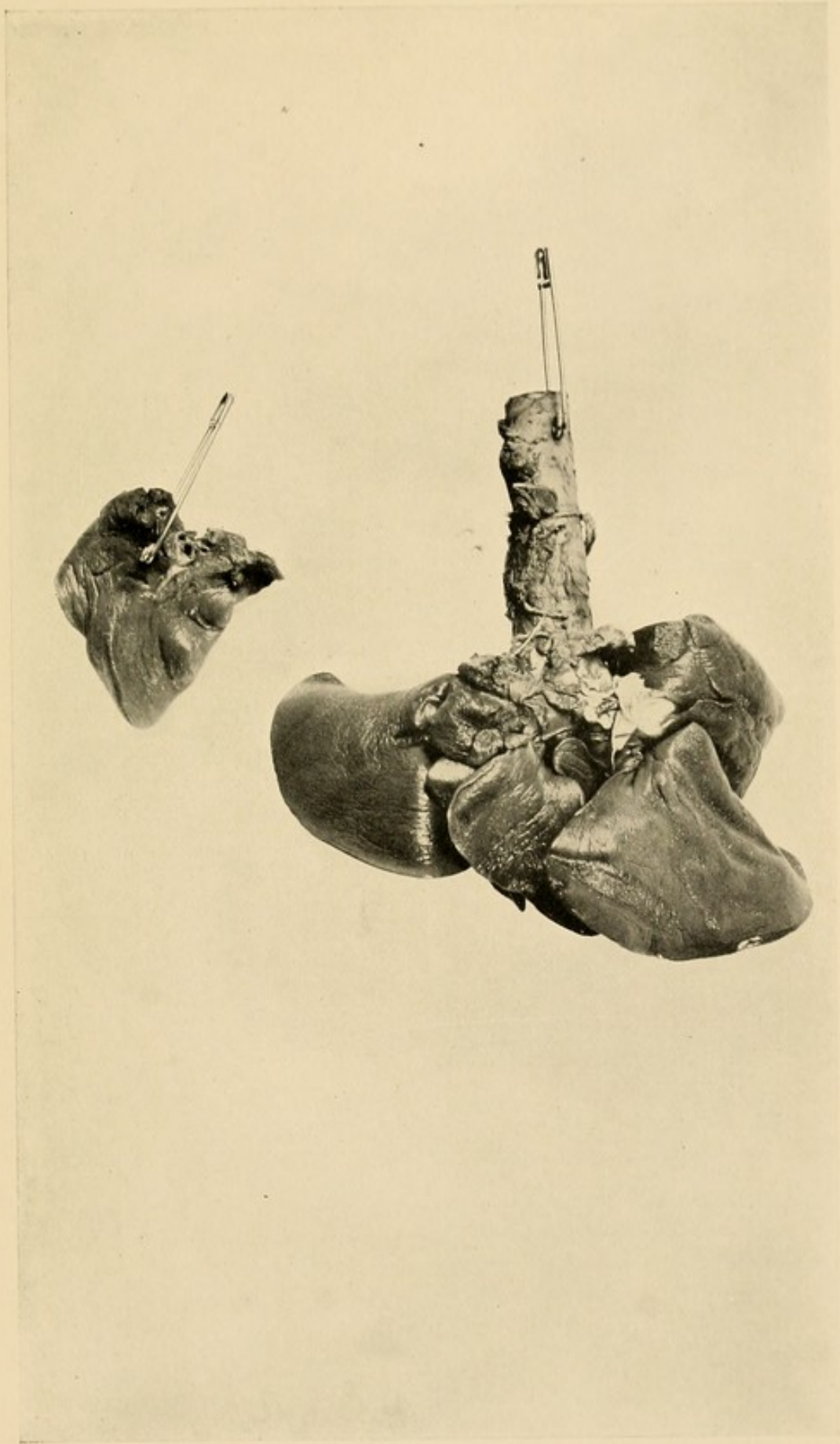
PLATE LXII-B

- (1) The posterior aspect of the main bronchus.
- (2) The œsophagus.
- (3) Trachea, partially injected.
- (4) Section of the right upper lobe.
- (5) A section of the left upper lobe.

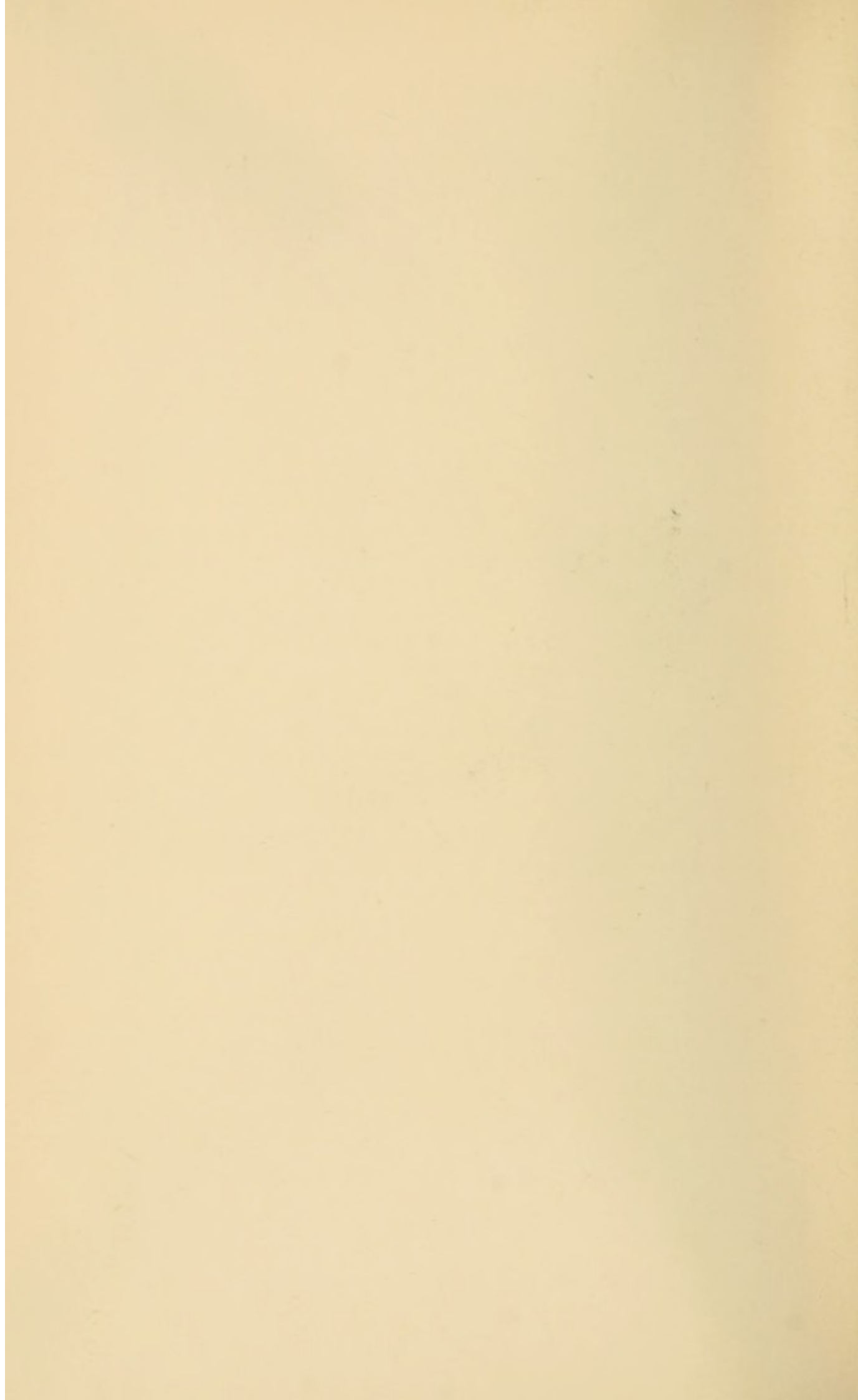
PLATE LXIII

A POSTERIOR VIEW OF A TRANSVERSE SECTION OF THE LOWER LOBES, FROM A STILL
DIFFERENT ASPECT

- (1) Extreme end of the left upper lobe.
- (2) The œsophagus.
- (3) Section of the trachea.
- (4) Extreme end of the right upper lobe.



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RECORD OF EXPERIMENTS

1. June 30, 1900.—Black curbstone setter; weight, 20 pounds; age, 8 months. Right side of chest. Death occurred while operating.

Autopsy made one hour later. No special cause of death discovered, probably due to anæsthetic. Specimen was not photographed, because of no special interest.

2. July 8, 1900.—Water spaniel bitch, one year old; weight, 22 pounds. At 11 A.M., one-third of inferior lobe of right lung removed through the fifth intercostal space after resection of fifth rib, and stump of lung anchored to chest wall. All tissues sutured with silk-worm gut, and stump covered with skin. Dog died at 10:30 A.M., July 12, 1900.

Autopsy.—Pleural cavity was filled with pus; all organs appeared normal. Death due to exhaustion, from infection. Stump of lung, soft, and adherent to the chest wall. Infection probably due to want of caution, while chest cavity was open.

3. July 10, 1900.—Bitch, 3 months old; weight, 10 pounds. Inferior lobe of right lung removed, after ligating the bronchus, and vessels at base, with silk without transfixion (purposely). Thirty minutes after operation respiration registered 80 per minute; pulse, very rapid. Death occurred July 19, 1900.

Autopsy showed perfect repair in stump; exhaustion, from infection, was the probable cause of death.

4. July 19, 1900.—Cur dog, one and a half year old; weight, 20 pounds. Inferior lobe of right lung removed, and stump ligated with silk by transfixion, and chest closed by silk-worm gut. Death occurred at 7:30 A.M., July 21st.

Autopsy.—Liver much enlarged; gall bladder greatly distended with bile; stomach was also distended with gas. The ligature around stump had cut through a mass of lung tissue, which had by accident been included within it. Pleural cavity on right side contained six ounces of bloody fluid, indicating that death was probably due to a slow hæmorrhage, from an imperfectly ligated stump. There were no adhesions of the parietal with the visceral pleura. The ends of the silk-worm gut are to be seen in the photograph. (Plate LXIV.)

5. July 20, 1900.—Common cur bitch, seven months old; weight 30 pounds. A silk ligature was applied to one-half of middle lobe of

right lung, after having delivered it through the chest wall with forceps. The transfixed, and ligated portion of the lung was cut away with scissors. There was no hæmorrhage from the stump, which was returned to the pleural cavity. Death, July 22, 1900.

Autopsy.—The ligature had cut through stump, allowing about five ounces of blood to escape into the pleural cavity. Death was due to exhaustion from hæmorrhage. No doubt, the amount of blood contained within the pleural cavity had been lessened by constant absorption.

6. July 20, 1900.—Common dog, six years old; weight, 30 pounds. A kangaroo tendon was passed through one-half of lower lobe of left lung, close to bronchus, allowing the incorporated mass to remain. Closed wall with silk-worm gut. Dog died during the night of July 23, 1900.

Autopsy showed ligature to have escaped by sloughing of stump; there was also general pleurisy and about half a pint of flocculent pus.

A white pleuritic membrane extended over the entire visceral and parietal pleura, upon the left side. (Plate LXV.)

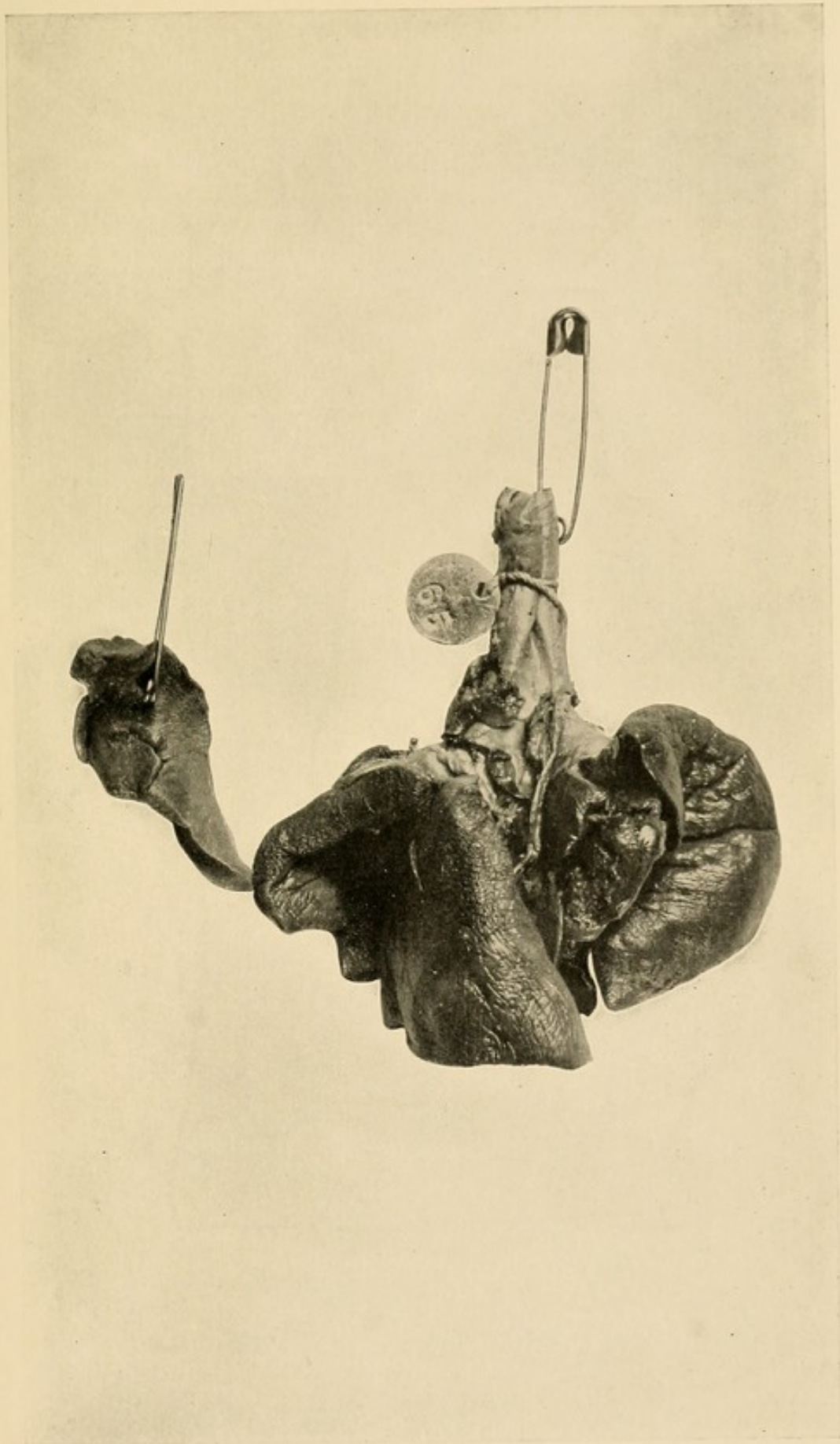
7. July 20, 1900.—Bulldog, one year old; weight, 40 pounds. The same procedure as in No. 6, except that the middle of the upper lobe of the right lung was ligated, by throwing a kangaroo tendon around the middle of the lobe, including the bronchus, the lumen of which was occluded. None of the strangulated portion of the lung was removed. The chest wall was closed in the usual way. The dog was killed on the ninth day following the operation. (Plate LXVI.)

Autopsy demonstrated the perfect repair of the lung. There were pleuritic adhesions, here and there, in both the right and left sides, those upon the right having occurred subsequent to the operation. The age of those upon the left side was doubtful. The photograph shows the perfect union. The large white spot is the cicatrix.

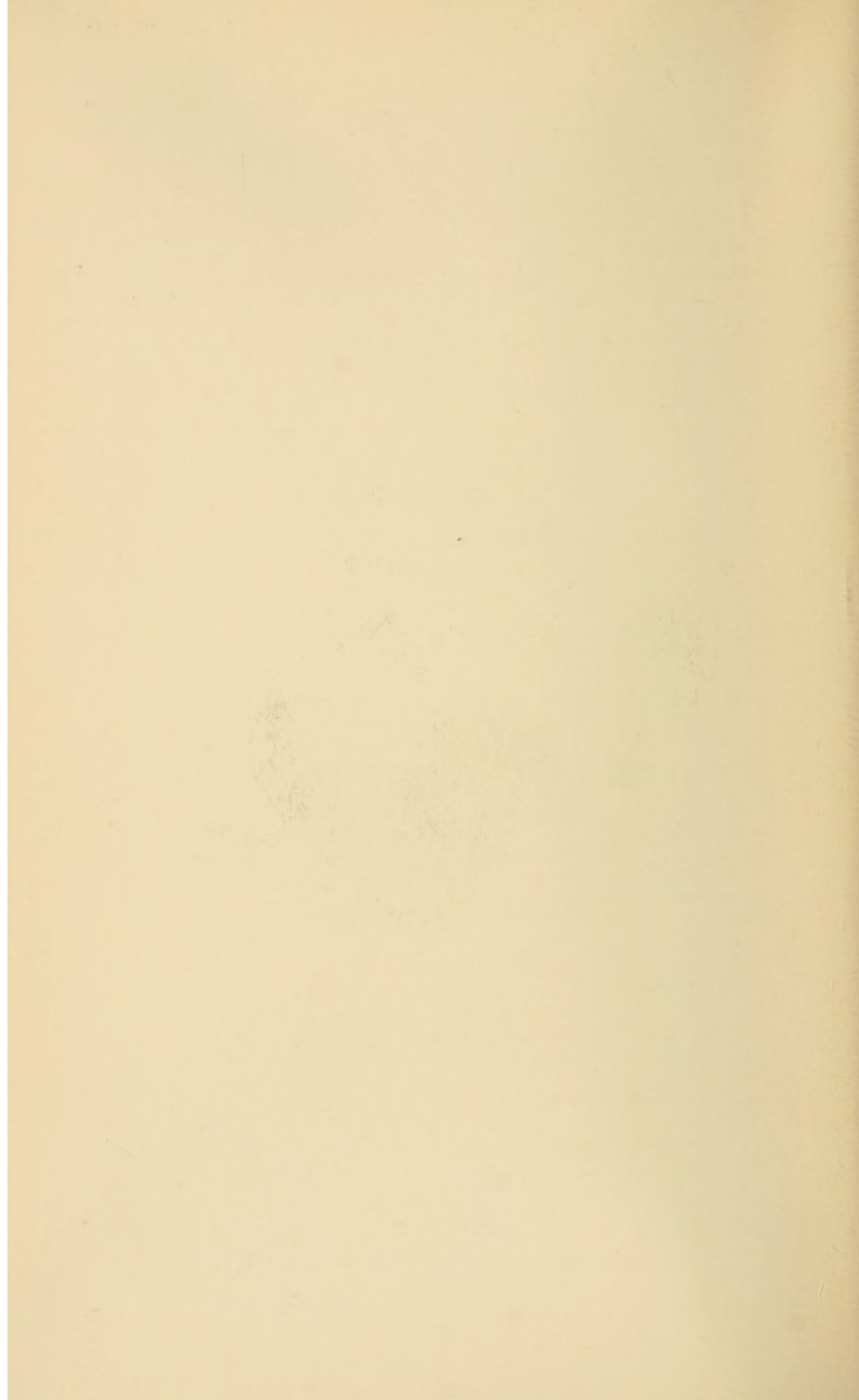
8. July 21, 1900.—Black mongrel dog, one year old; weight, 20 pounds. The inferior lobe of the right lung was divided by the knife, for two-thirds of its length; no special bleeding. The edges of the wound were coaptated, using the glover's suture through and through, and lobe returned to the pleural cavity. The dog was killed nine days after the operation.

Autopsy revealed perfect repair, with adhesions of the visceral to the parietal pleura. The denuded lung was found adherent to the chest wall, at its proximity, during normal expansion. The illustration shows the point of perfect repair. (Plate LXVII.)

9. July 21, 1900.—Brown cur, one year old; weight, 14 pounds. The butterfly lobe of right lung was removed; silk-worm gut was used for ligature, and also to close the chest. The lower lobe was considerably lacerated with forceps, in an endeavor to deliver it for attack. Dog died 4 P.M., July 24, 1900.



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Autopsy.—Right pleural cavity contained four ounces of purulent pleuritic effusion. No pleuritic adhesions present. Death probably due to infection.

10. July 21, 1900.—Brown water-spaniel, one year old; weight, 20 pounds. A portion of the fifth and sixth ribs upon the right side was removed with forceps. The lung was then exposed, and forceps thrust through the entire thickness of the lung, near the base of the inferior lobe. A piece, about the size of a silver quarter, was torn from the centre of the lobe. The opening was closed by the puckering, or lace suture, using silk-worm gut. The entire circle was traversed, by passing the needle back and forward. The lobe was returned to the pleural cavity, and opening in chest wall closed with silk-worm gut. (Plate LXVIII.)

• 11. July 22, 1900.—Black spaniel, eight months old; weight, 18 pounds. The lung was exposed, and an incision, one and a half inches long, made in the superior lobe of right lung. The lung was then returned to the pleural cavity, without suturing, or any other attention, and the chest wall closed.

Autopsy, seven days after operation, showed perfect repair, with adhesions of visceral and parietal pleura. The edges of the wound united nicely. There was only a line-like cicatrix. (Plate LXIX.)

12. July 22, 1900, 7 A.M.—Common cur, eight months old; weight, 22 pounds. The inferior lobe of the right lung was removed. Silk-worm gut was used to ligate the stump, which was transfixed. The dog died thirty-six hours after the operation.

Autopsy.—There were found one and a half pints of bloody serum in the right pleural cavity. Stump was found to be in good shape, except a small portion of the lung, which was not incorporated in the ligature. Death, probably due to hæmorrhage, from non-incorporated portion of the lung.

13. July 24, 1900.—Mixed bull, one and a half year old; weight, 35 pounds. At 6:30 A.M., removed one-half of the inferior lobe of the right lung, using kangaroo tendon for tug stitching. The chest wall was closed with silk-worm gut. August 9th the dog was killed.

Autopsy revealed complete recovery and perfect repair. (Plate LXX.)

14. July 24, 1900.—Fox-terrier bitch, one and a half year old; weight, 15 pounds. Removed inferior lobe of right lung, by tying stump in three sections. The vessels were first ligated at the base, with silk-worm gut on either side of bronchus. The bronchus was then occluded by silk-worm gut. Killed dog August 9th.

Autopsy showed that repair was far enough advanced to assure the preservation of life. The illustration shows stump, and silk-worm gut ligature, firmly fixed in the lung tissue. (Plate LXXI.)

15. July 24, 1900.—Fox-terrier bitch, age ten months; weight, 12 pounds. Cut off portion of inferior lobe of right lung with knife;

silk-worm gut was used for Bell sutures. Stump was fixed in the intercostal space; edges of the integument were sutured, to allow the lung stump to be exposed. Dog died on the seventh day.

Autopsy showed pneumonia of middle, and butterfly lobe of right lung.

16. July 26, 1900.—Tall dog, two years old; weight, 50 pounds. Removed inferior lobe of right lung; using kangaroo tendon and silk-worm gut to whip-stitch stump. Dog killed on fourteenth day after operation.

Autopsy revealed perfect repair of stump, and complete recovery. A portion of silk-worm gut, and a small piece of kangaroo tendon were seen—the latter was in process of disintegration. The photograph shows all these features. (Plate LXXII.)

17. July 25, 1900.—Black mixed spaniel; age, one year; weight, 25 pounds. Removed entire inferior lobe of right lung, using trans-fixed, braided silk for tug suture. Death six days later.

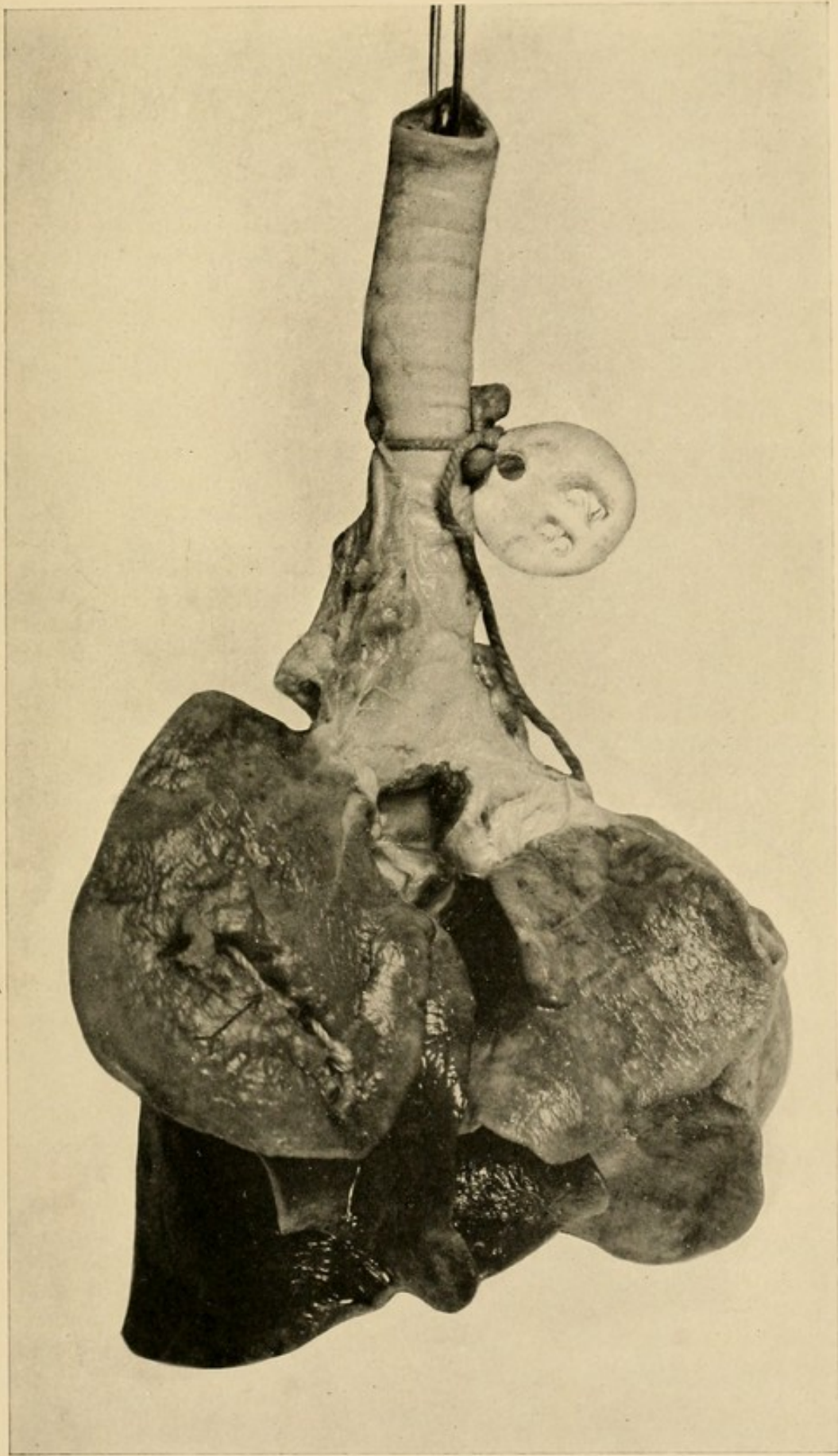
Autopsy showed open stump. The ligature had been drawn tight enough about the lung tissue, which was degenerated. Although the ligature was loose, the bronchus had become occluded. No satisfactory explanation for cause of death could be formed from appearance of the organs, since they all seemed normal.

18. July 25, 1900.—Gray shepherd dog, one year old; weight, 25 pounds. Removed the lower two-thirds of inferior lobe of the right lung by cutting, transversely, a wedge-shaped portion of lung tissue. This was done, to allow the edges of the visceral pleura to be coaptated, first with catgut, and then with kangaroo tendon. The right pleural cavity was packed with gauze, one end of which was allowed to protrude out of the chest wall. Dog died five days later. (Plate LXXIII.)

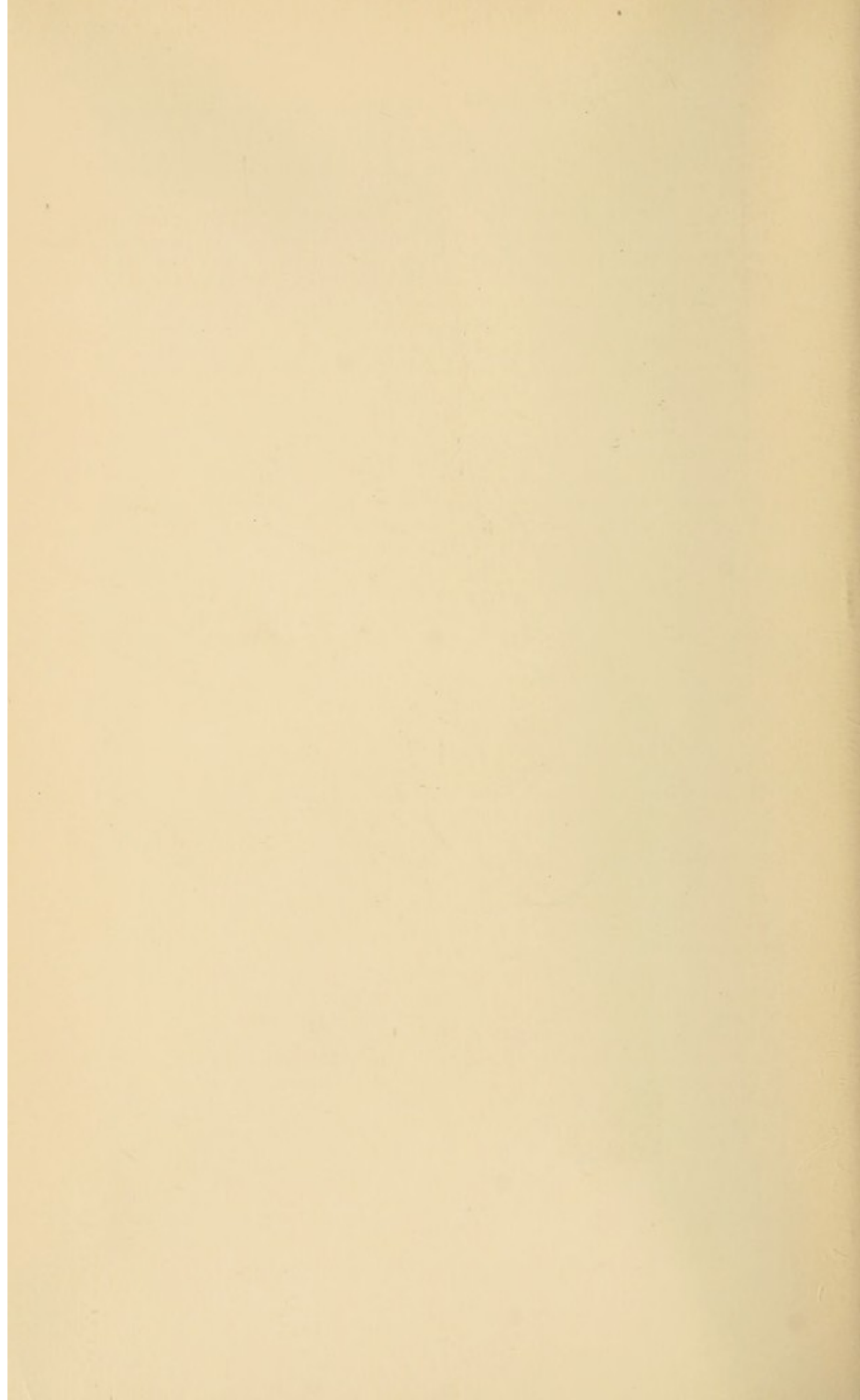
Autopsy did not reveal the cause of death. It was probably due to infection. The gauze was slightly discolored with serum; no pleuritic adhesions; no pus in pleural cavity. Repair of stump had been progressive, as shown by the complete absorption of the catgut, and union of coaptated edges of the divided lung tissue. This case well illustrates the comparative life of cat-gut, and kangaroo tendon.

19. July 25, 1900.—White terrier bitch, one year old; weight, 15 pounds. Chest wall opened, and a pair of large forceps thrust through the inferior lobe of the right lung. There was but little hæmorrhage. Kangaroo tendon used for tug stitching. The suture used was not exactly the tug stitch, but the one devised by the author. It is a combination of the tug and lace sutures. In this case, the wound was completely encircled by a double row of sutures. Only one needle was used. (See Section on Sutures in Part I.)

Autopsy showed complete recovery, and repair, leaving a small, hard, white cicatrix, extending through the lobe, which was apparent to the sense of touch. The photograph plainly depicts the hard, white, circumscribed cicatrix. (Plate LXXIV.)



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20. July 30, 1900.—Black terrier, ten months old; weight, 12 pounds. The left lower lobe of the right lung was punctured and lacerated, using both knife and finger. Kangaroo tendon was employed to circumscribe the wound, with the author's combination suture. Killed dog nine days after the operation.

Autopsy showed perfect and uneventful recovery, with complete repair of the lung. The photograph shows how perfectly the wound united, and the very slight cicatrix formed. (Plate LXXV.)

21. July 30, 1900.—White terrier, ten months old; weight, 15 pounds. At 5:30 A.M. cut away one-third of the inferior lobe of the right lung, transversely; using kangaroo tendon to whip-stitch the wound. Killed dog nine days after the operation.

Autopsy showed complete repair of the stump, as seen in photograph. (Plate LXXVI.)

22. July 30, 1900.—Black fox-terrier, one year old; weight, 15 pounds. Punctured inferior lobe of right lung, and tug-stitched in a circle around the perforation. The Bell suture was used in tug-stitching, and the sutures were passed through the entire thickness of the lobe. Killed dog nine days later. (Plate LXXVII.)

Autopsy showed perfect union, with a light-colored cicatrix.

23. July 30, 1900.—Black terrier bitch, one year old; weight, 15 pounds. At 5:30 A.M. cut away transversely one-third of butterfly lobe of the right lung; kangaroo tendon used to tug-stitch the wound. Killed dog August 9th.

Autopsy.—There was perfect repair of stump, but with adhesions to the chest wall, at the point of normal proximity, at time of maximum inflation.

24. July 30, 1900.—Mixed fox-terrier and water-spaniel, one year old; weight, 15 pounds. Removed one-half of the middle lobe of the right lung. Kangaroo tendon was employed in suturing.

Autopsy, nine days later, revealed perfect repair and union of stump. The photograph shows appearance of lungs. (Plate LXXVIII.)

25. July 30, 1900.—Yellow cur bitch, one and a half years old; weight, 18 pounds.

Right upper lobe brought into opening in the chest wall and cut off. Stump was fixed in the intercostal space, with silk-worm gut. The cutaneous structures were sutured over it. Killed dog August 9th.

Autopsy showed perfect recovery and union (Plate LXXIX), with stump firmly adherent to the chest wall, at point of fixation.

26. July 30, 1900.—Black and white cur dog, one year old; weight, 60 pounds.

Removed inferior lobe of right lung, after silk-worm gut had been applied for ligature. The ligature became dislodged, and death ensued within two minutes.

Autopsy, ten minutes later, showed pleural cavity filled with blood.

The vessels and bronchus were open. Death was due to hæmorrhage, as a result of carelessness. (Plate LXXX.)

27. July 30, 1900.—White bulldog, two years old; weight, 45 pounds. Same operation with the same results as in No. 26.

Death caused by hæmorrhage, due to carelessness. (Plate LXXXI.)

28. July 30, 1900.—Black dog, two years old; weight, 50 pounds. One-half of upper lobe of right lung was cut away, transversely, using silk to whip-stitch. Silk was also used to ligate both vessels, and bronchus. Dog died August 9th.

Autopsy showed right side of pleural cavity filled with bloody serum. Death probably the result of stump opening in line of suture. This was caused by imperfectly applied ligature. (Plate LXXXII.)

29. August 6, 1900.—Fox-terrier, six months old; weight, 12 pounds. The inferior lobe of right lung was split and returned to the pleural cavity, without suturing the divided portion of the lung. The chest opening was closed with silk-worm gut. Killed dog August 14th.

Autopsy showed perfect repair of lung, with adhesion to chest wall, at the point of normal proximity, at time of maximum expansion.

30. August 2, 1900.—Maple cur, two years old; weight, 18 pounds. Removed upper lobe of right lung, after resecting the fifth and sixth ribs. Kangaroo tendon used for ligating, by transfixing at base of lung. Killed dog August 14th.

Autopsy showed repair of stump to be perfect. (Plate LXXXIII.)

31. August 2, 1900.—Black dog (No. 1), one year old; weight, 20 pounds. At 2 P.M., ligated base of right wing of butterfly lobe, by transfixing with kangaroo tendon. Killed dog August 14th.

Autopsy revealed perfect repair, with kangaroo tendon covered with plastic material. (Plate LXXXIV.)

32. August 2, 1900.—3 P.M.—Black dog (No. 2), one year old; weight 20 pounds. Applied tug-stitch, for three inches across the upper lobe, through the entire thickness of the lung, with silk. Killed dog August 9th.

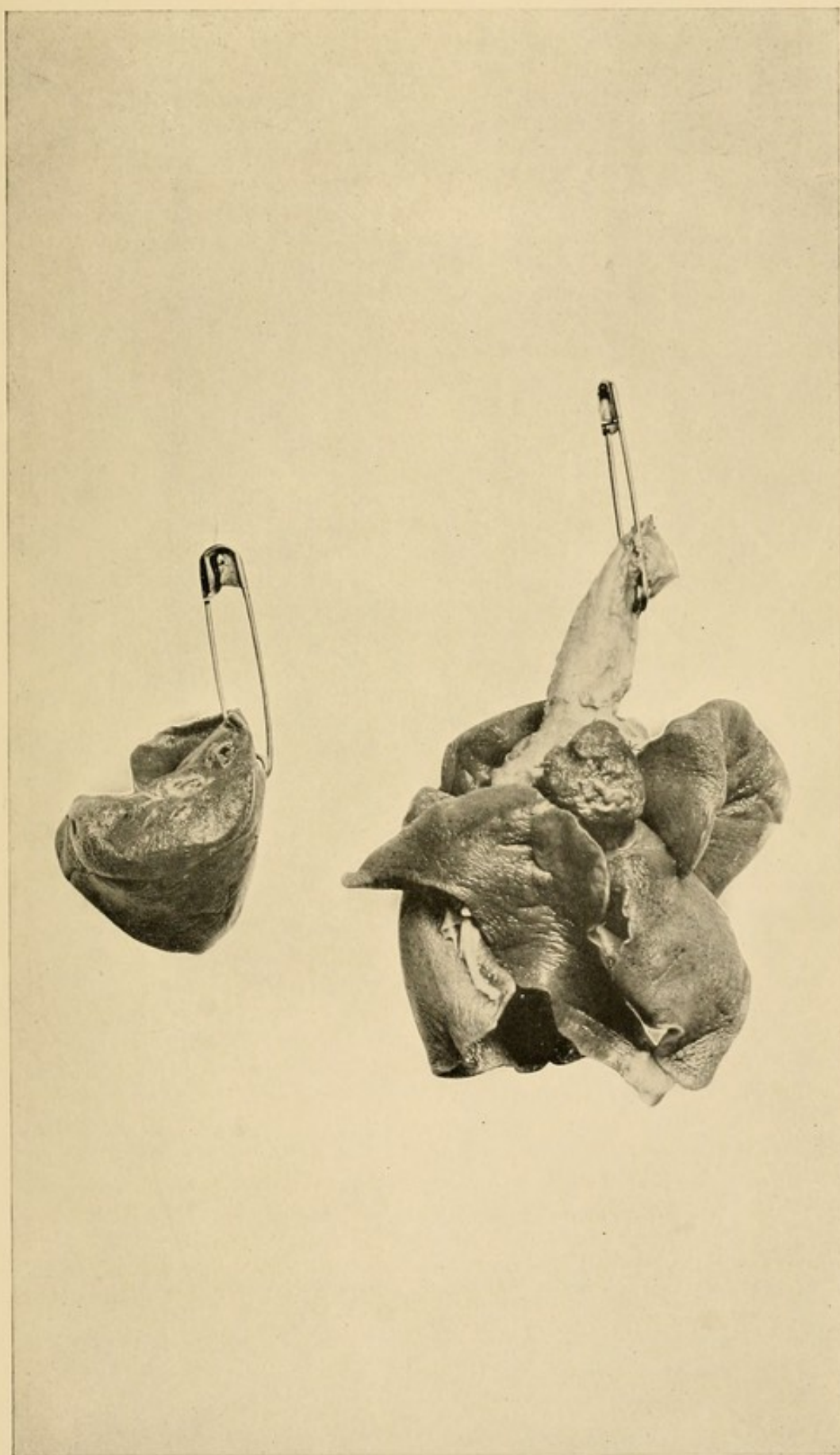
Autopsy showed the silk suture almost entirely covered with new tissue. Recovery and repair perfect.

33. August 2, 1900.—Yellow black-nosed dog; two years old; weight, 25 pounds.

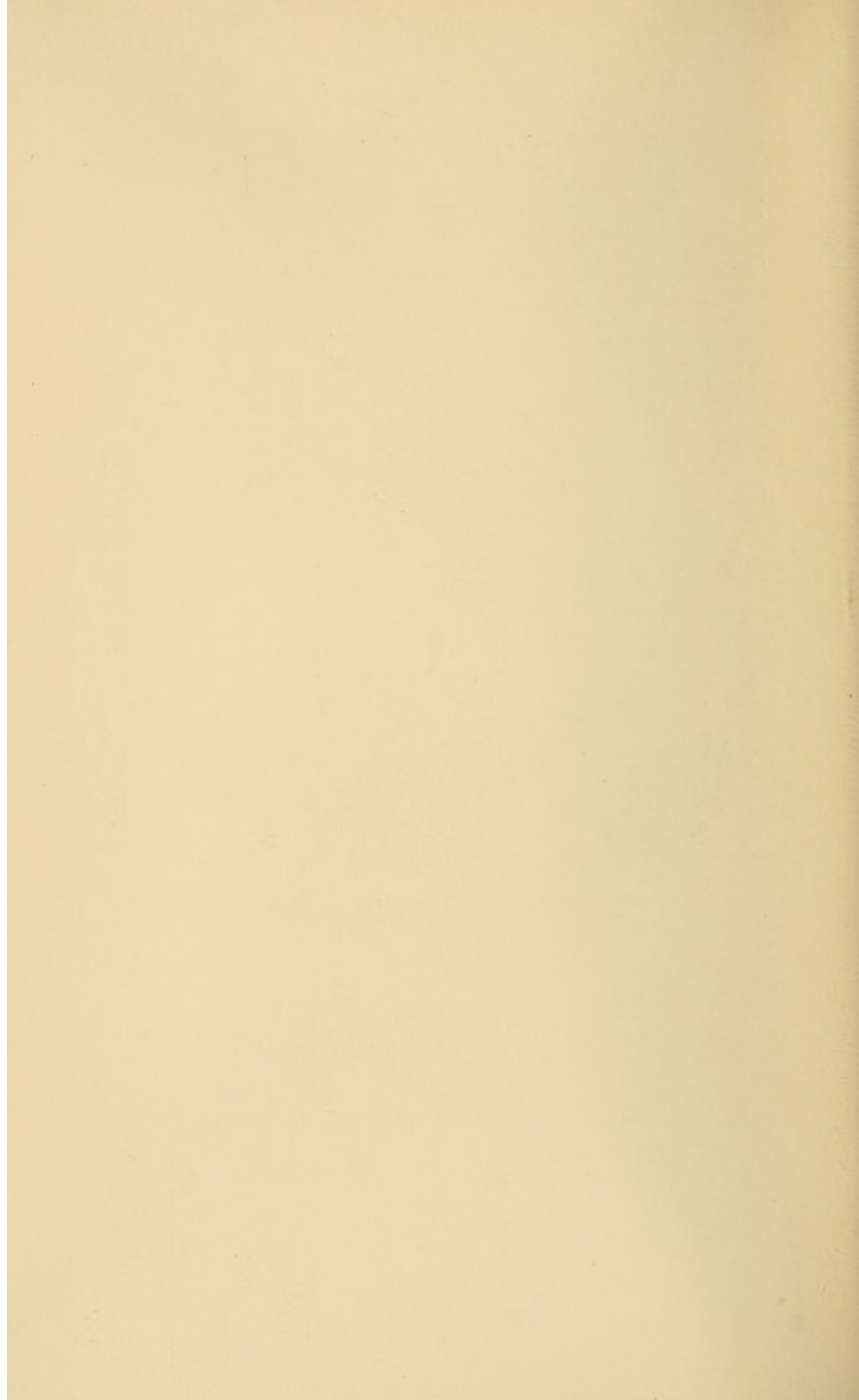
Applied sutures, using silk ligature, across the upper right lobe of the lung, near its centre. (The herring-bone suture was the one employed here.) Killed dog August 9th.

Autopsy showed perfect recovery from operation, and repair of lung. The end of the silk was exposed. (Plate LXXXV.)

34. August 2, 1900.—Bobtail dog, ten months old; weight, 14 pounds. Removed upper lobe of right lung, using kangaroo tendon for three ligatures at the base. The kangaroo tendon was used to transfix the base. The first ligature was placed around all the vessels; the second occluded the bronchus, and the third, the lung tissue. Killed dog August 9th.



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Autopsy showed perfect recovery, and repair of stump. (See Plate LXXXVI.)

35. August 2, 1900.—Black dog, two years old; weight, 25 pounds. Lower lobe of right lung was split perpendicularly, and sutured with kangaroo tendon, using a relief suture (mattress). Killed dog August 14th.

Autopsy showed complete recovery, and perfect repair. Point of repair adherent to chest wall at the point of proximity, at time of maximum inflation.

36. August 2, 1900.—Fox bitch, one and one-half years old; weight, 18 pounds.

Resected the sixth rib on the right side, leaving the pleural cavity open fifteen minutes. The mediastinum was then incised near the heart, thus allowing the left lung to recede. Both cavities were exposed to atmospheric pressure for five minutes. The opening in the chest wall was covered by the hand. Respiration was again established, and lungs allowed to recede. There was more or less motion of the lungs while the chest remained open. At the end of twenty-five minutes the opening of the chest wall was closed with silk-worm gut, and dog sent to his kennel. Killed dog August 14th, 4 P.M.

Autopsy showed nothing abnormal. The mediastinum was closed, and repair complete.

37. August 2, 1900.—Dark brown dog, eight months old; weight, 16 pounds. This dog died as the chest was being opened.

Autopsy gave only negative results. No cause of death discoverable; probably due to ether. All the organs were normal and in good condition.

38. August 6, 1900.—Common dog, eight months old; weight, 12 pounds. Apex of lower lobe of right lung cut away. The bleeding vessels were torsioned, and the lung returned to the pleural cavity, without the lung tissues being sutured. Killed dog August 14th.

Autopsy showed complete recovery, and repair of the lung, but the lung was adherent to the chest wall at point of normal proximity, at time of maximum expansion.

39. August 6, 1900.—Long-haired dog, one year old; weight, 25 pounds. Removed butterfly lobe, using kangaroo tendon for each ligature, at base. The first ligature was placed around the blood-vessels; the second around the bronchus; the third was placed about the lung tissues.

On the tenth of August the dog attempted to escape, and the attendant seized him rather roughly by the back. This caused the chest wall to open; it was not again closed. The dog died at 6 A.M., August 13th.

Autopsy showed the stump in a good state of repair. The pleural cavity contained some pus, the result of suppurative pleuritis. The bronchus and blood-vessels were found occluded. The infection prob-

ably occurred after the reopening of the chest cavity, which was purposely left open. There were no adhesions of the pleura.

40. August 6, 1900.—Black bitch, two years old; weight, 27 pounds. Divided the fifth intercostal artery, on the right side, to allow three or four ounces of blood to escape into the pleural cavity. The chest wall was closed with silk-worm gut. Killed dog August 14th, 4 P.M.

Autopsy showed complete recovery. There were no clots, fluid, or adhesions found in the pleural cavity.

41. August 6, 1900.—Hound bitch, five months old; weight, 10 pounds. Inferior lobe of right lung, split, and returned to the pleural cavity, without suturing the lung. Killed dog, August 14th.

Autopsy showed union to be complete. The end of the lung was adherent, at its point of proximity, to the chest wall, at time of maximum expansion.

42. August 14, 1900.—Chestnut dog, one year old; weight, 27 pounds. Resected the fifth and sixth ribs on the right side. Ligated, with silk, the vessels at base of the upper lobe of the right lung. A silk ligature was placed also about the bronchus. Removed two ounces of clots from the pleural cavity, which was open twelve minutes. Death occurred just as the cavity was being closed.

Autopsy revealed no cause of death. It was probably due to ether. Neither air nor water could be forced through stump, proving that bronchus and vessels were occluded.

43. August 14, 1900, 3 P.M.—Black dog, six months old; weight, 24 pounds. Folded upper part of right lung upon itself, and sutured with silk, using the interrupted suture. This was done in order that the visceral pleura might become adherent. Dog died August 17th.

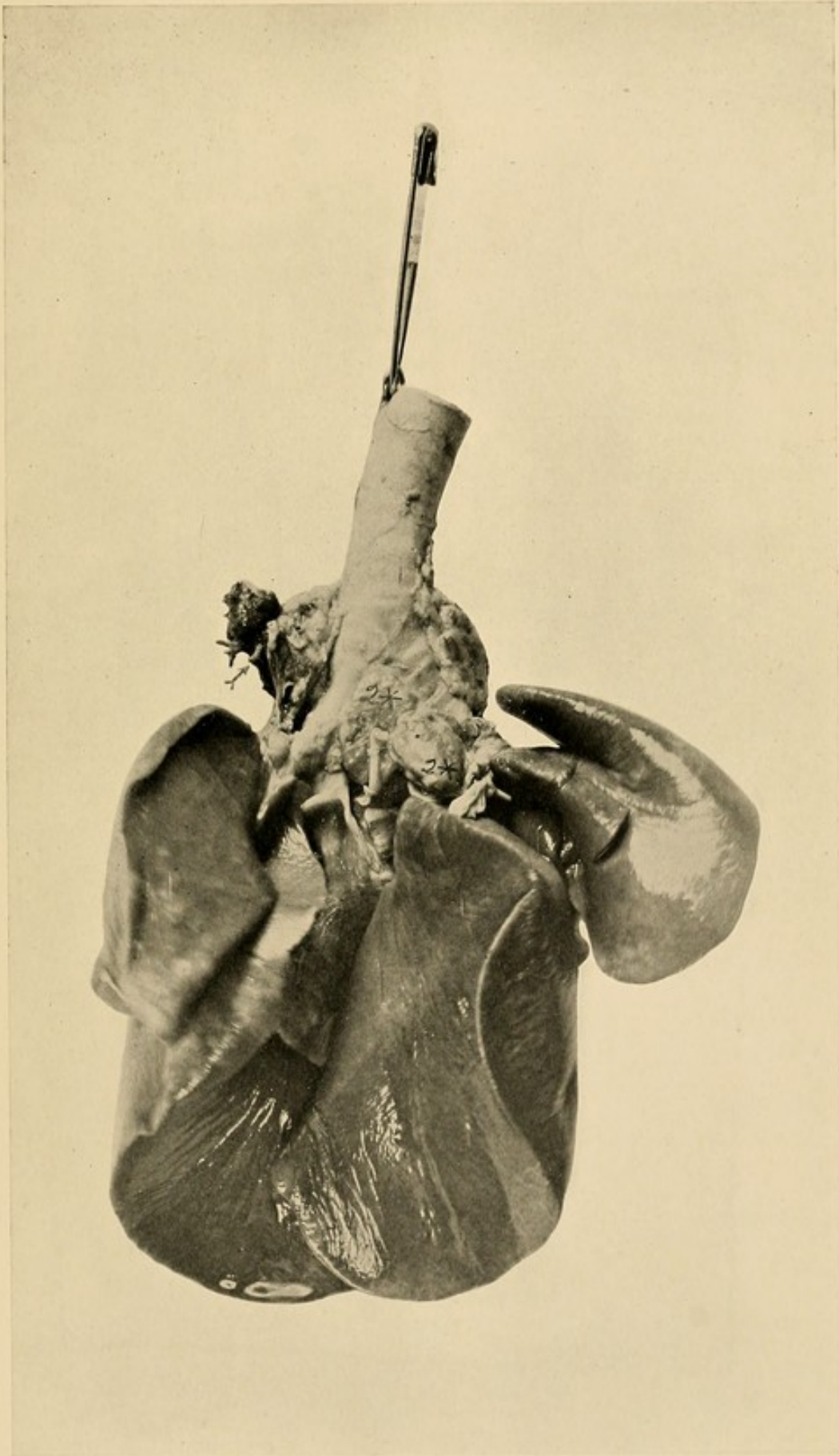
Autopsy showed the lung in good condition. No fluid in cavity, nor any cause of death discoverable. The dog had distemper at time of operation, and but little attention was given him.

44. August 14, 1900.—Black dog, one year old; weight, 18 pounds. Divided sixth rib on right side, incised inferior lobe, transversely, to one-third of its thickness. Sutured with kangaroo tendon, employing the mattress, or quilted suture. Killed dog August 21st.

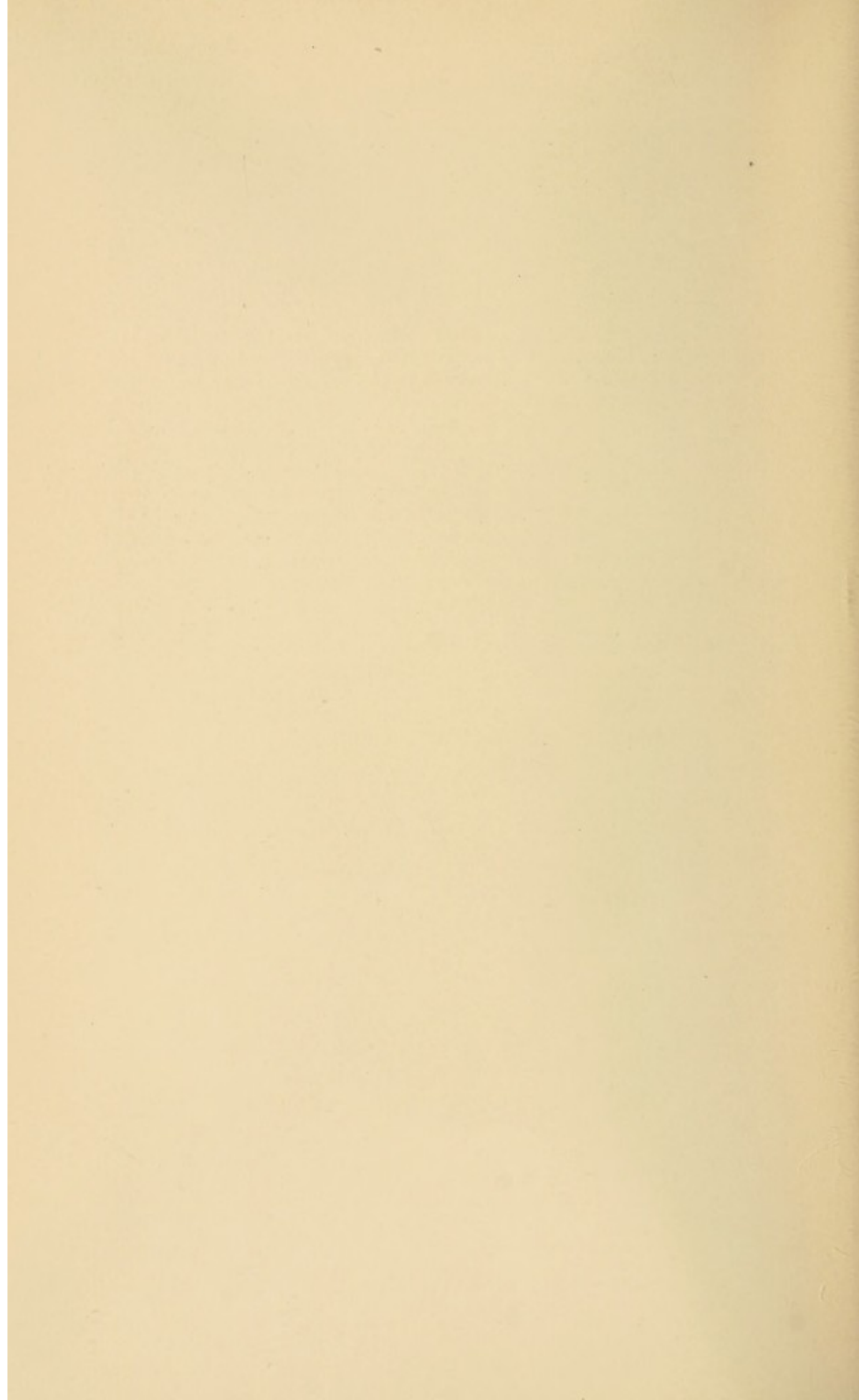
Autopsy.—Lobe, at point of incision, adherent to the chest wall, at a point corresponding to the point of normal proximity at time of maximum distention of the lung. The kangaroo tendon had broken into several pieces, but it still could be recognized.

45. August 14, 1900.—Brown dog, one year old; weight, 18 pounds. Killed dog with chloroform. Removed the lungs, and injected the bronchia with paraffin, while lung was in water, at a temperature of one hundred and twenty degrees F. The process was not at all satisfactory, however, as the paraffin occluded the bronchioles before distention was complete.

46. August 14, 1900, 5 P.M.—White bitch, three years old; weight,



EXPERIMENT ON LUNGS, No. 46, page 492.



40 pounds. Amputated the upper right lobe. Braided silk was used as a ligature, to occlude the bronchus alone, while another ligature, of the same material, was used to occlude the blood-vessel; each ligature being transfixed at base of the lung before it was made taut. Killed dog August 20th.

Autopsy showed repair of stump, practically complete. All the vessels were found to be occluded. (Plate LXXXVII.)

47. August 25, 1900.—Black dog, one year old; weight, 15 pounds. Killed dog with chloroform, in order to secure the lungs. Injected bronchial, arterial, and venous systems with a mixture of anilin, starch, and formalin. Specimen unsatisfactory, owing to tuberculous degeneration of apex of the superior lobe of the left lung, which ruptured during injection. This is the only one, of the series of fifty dogs, in which any signs of tuberculosis were found.

48. August 22, 1900.—Black Newfoundland dog, five years old; weight, 50 pounds.

Killed dog, in order to secure the heart and lungs. Injected bronchial, arterial, and venous systems with starch and anilin, in formalin water (one per cent.). This specimen was divided with the knife, transversely, making seven sections, each one inch thick. Each section was photographed separately, as shown in Plates LVIII to LXIII.

49. August 27, 1900.—Hound bitch, three years old; weight, 35 pounds.

Dog killed with chloroform, for specimen. Injected with starch and anilin, in formalin water, with satisfactory results.

50. August 25, 1901.—Fox terrier, one and one-half years old; weight, 18 pounds. Removed entire left lung. Dog recovered and lived, with no ill effects. Killed on eighteenth day.

ANALYSIS OF TABLES

An examination of the tables reveals the fact, that most of the deaths were avoidable. Seven dogs died from infection, which is about 15.7 per cent. Seven dogs died from hæmorrhage (secondary and primary), or about 15.7 per cent. Lack of care on the part of the operator and attendants was responsible for all these cases of infection and hæmorrhage.

But, as stated in explanation of the experiments and results obtained, no special care was observed, nor were any antiseptics used. Some of the operations were performed hurriedly, and the operator was perhaps a little careless. This was shown by the autopsies. In one case the ligature had slipped, in another, the ligature had been dislodged, because the tissues broke down from infection.

All this could have been avoided, by observing the principles of modern surgery.

There remain only three deaths to be taken in account, in arriving at a just estimate of the mortality in pulmonary surgery.

Of these three cases, one was due to pneumonia, and two to the anæsthetic. This case of pneumonia was probably due to infection; hence could have been avoided. It is also a question, just how far the operator is responsible for deaths from the anæsthetic.

It will also be noticed that the majority of the deaths occurred during the early part of the series. In all kinds of experimental work on the living subject, there are numerous practical details that can only be solved by actual experience. So in this series, as the operator gained experience and skill in this work, he had better success. The needed experience is soon gained.

If it were possible to repeat these experiments, there is no doubt that the mortality would be greatly reduced, even if deaths from infection, etc., were not completely eliminated.

SUMMARY OF RECOVERIES AND DEATHS

	RECOV- ERIES.	DEATHS.	PERCENT- AGE.
From infection (average length of life, 5 1-7 days)		7	14
“ Hæmorrhage, primary (died on the table)		2	4
“ Hæmorrhage, secondary (average length of life, three days)—imperfect ligature		5	10
“ Pneumonia		1	2
“ Accidental opening of wound		1	2
“ Anæsthetic		2	4
Killed for autopsy and specimen			54
Killed for specimen of normal lung		5	10
	28	23	
Number of operations	46		
Number of recoveries	28		
Number of deaths	18		

STATISTICAL REPORT OF LUNG SURGERY ON FIFTY DOGS

(Experimental)

SECTION NO. 1, UNSUCCESSFUL RESULTS.

NO.	CAUSE OF DEATH.	TIME LIVED.	CONDITION AT DEATH.
1	Infective pleurisy	10 days.	Discharging pus.
2	General infection	4 days.	Discharging pus.
3	General infection	9 days.	Discharging pus.
4	General infection	2 days.	Ligature slipped.—Clot infected.
5	Secondary hæmorrhage	2 days.	Clot in cavity.
6	Infection	3 days.	
9	Infection	3 days.	
12	Imperfect ligature	2 days.	
15	Pneumonia	7 days.	
17	Imperfect ligature	6 days.	Slough.
18	Infection		Open wound (lung stump).
26	Hæmorrhage	Died during operation.	
27	Hæmorrhage	Died during operation.	
28	Secondary hæmorrhage	3 days.	
37	Anæsthetic		
39	Accidental opening of wound	7 days.	
43	Unknown		Had distemper at time of operation.

STATISTICAL REPORT OF LUNG SURGERY ON FIFTY DOGS

(Experimental)

SECTION NO. 2. SUCCESSFUL RESULTS.

NO.	WAS KILLED ON	CONDITION.	RECOVERY.
7	19th day.	Perfect repair.	Complete.
8	19th day.	Perfect repair.	Complete.
10	19th day.	Perfect repair.	Complete.
11	19th day.	Perfect repair.	Complete.
13	16th day.	Perfect repair.	Complete.
14	16th day.	Perfect repair.	Complete.
16	14th day.	Perfect repair.	Complete.
19	15th day.	Perfect repair.	Complete.
20	10th day.	Perfect repair.	Complete.
21	10th day.	Perfect repair.	Complete.
22	10th day.	Perfect repair.	Complete.
23	10th day.	Perfect repair.	Complete.
24	10th day.	Perfect repair.	Complete.
25	10th day.	Perfect repair.	Complete.
29	8th day.	Repair going on	Complete.
30	12th day.	Perfect repair.	Complete.
32	7th day.	Repair progressing.	Complete.
31	12th day.	Perfect repair.	Complete.
33	7th day.	Good.	Going on.
34	12th day.	Perfect repair.	Going on.
35	12th day.	Perfect repair.	Complete.
36	12th day.	Perfect repair.	Complete.
38	8th day.	Perfect repair.	Complete.
40	8th day.	Perfect repair.	Complete.
41	8th day.	Perfect repair.	Complete.
44	7th day.	Repair progressing.	Complete.
45	6th day.	Repair progressing.	Complete.
46	Killed in order to secure lung for other purposes.		
47	Ditto.		
48	Ditto.		
49	Ditto.		
50	18th day.	Perfect repair.	Complete.

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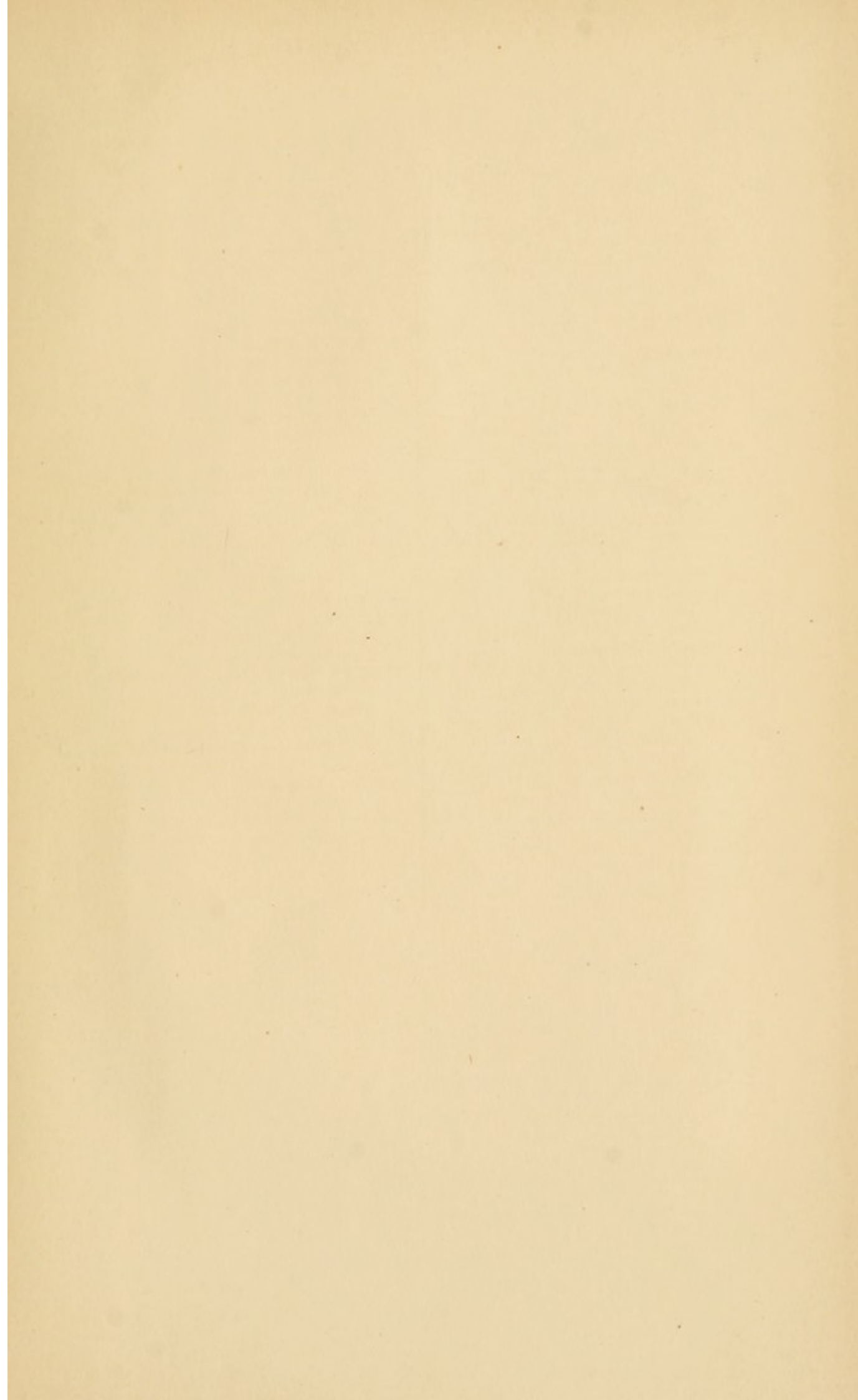
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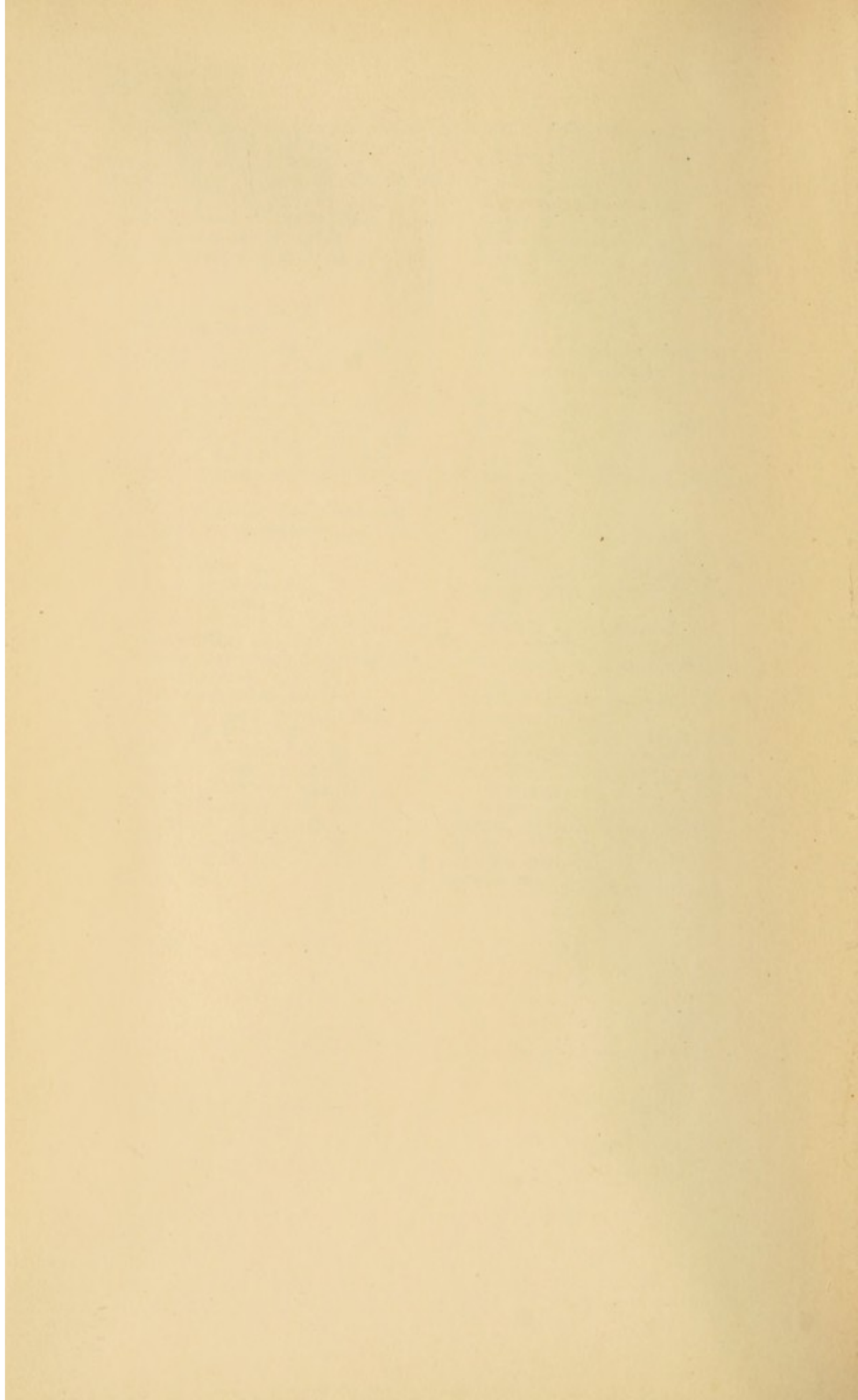
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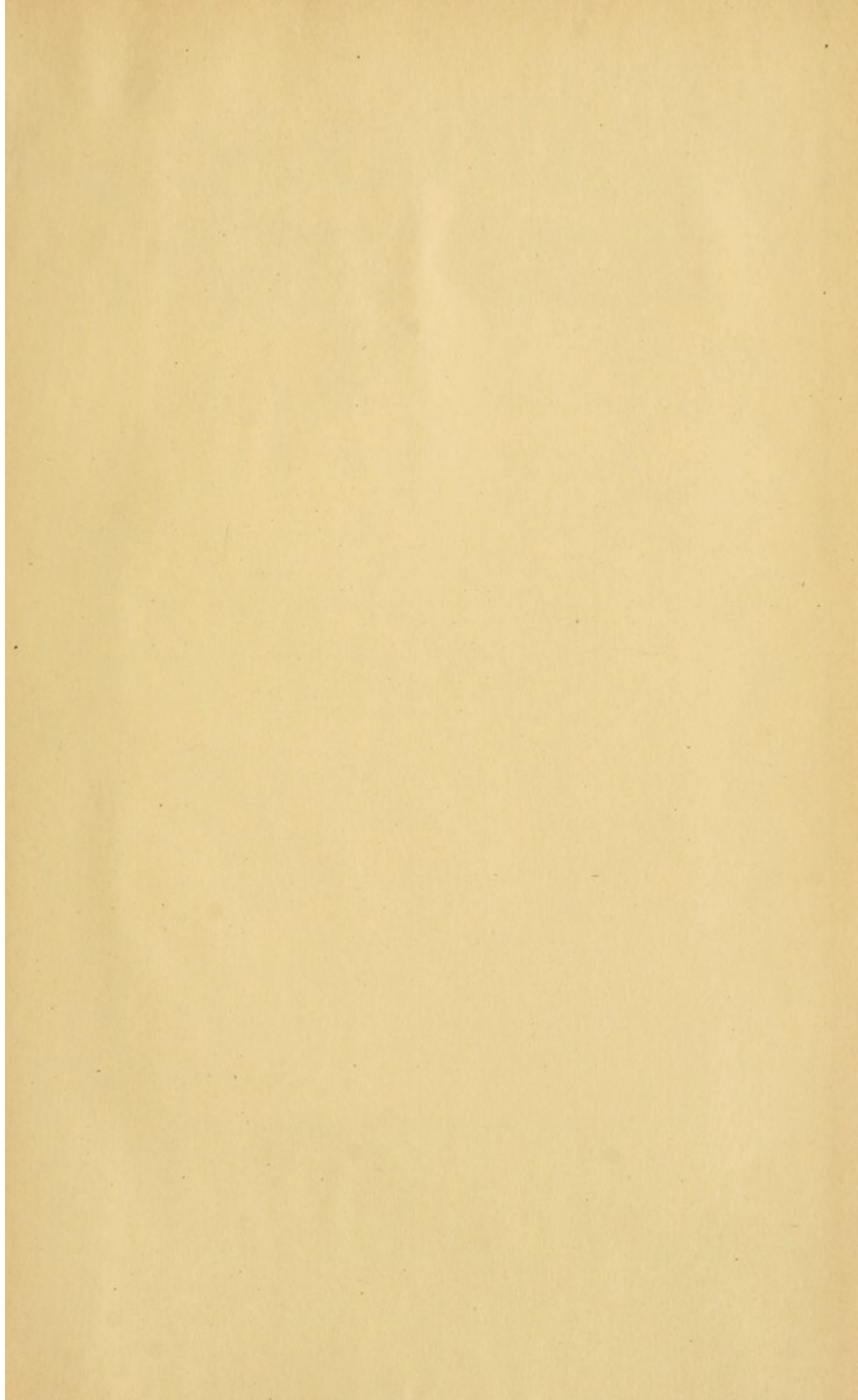
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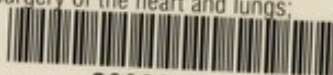
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