MANUAL

OF

PHYSICAL DIAGNOSIS.

TYSON.

BY THE SAME AUTHOR.

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IN PREPARATION.

A TEXT-BOOK OF THE PRACTICE OF MEDICINE. For the use of Physicians and Students.

MANUAL

OF

PHYSICAL DIAGNOSIS

FOR THE USE OF

STUDENTS AND PHYSICIANS.

BY

JAMES TYSON, M.D.,

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SECOND EDITION, REVISED AND ENLARGED.

PHILADELPHIA:
P. BLAKISTON, SON & CO.
1012 WALNUT STREET.
1893.

PRESS OF WM. F. FELL & CO.
1220-24 SANSOM ST.,
PHILADELPHIA.

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PREFACE TO THE SECOND EDITION.

The occasion for a new edition of this manual has given the author an opportunity to enlarge it in such manner as to cover more fully the title of Physical Diagnosis, while he has endeavored, also, to improve it in other respects.

He has also seen fit to add, under the heading "Appendix," several subjects not strictly belonging to physical diagnosis, viz., the examination of blood, that for the more important bacilli associated with the infectious diseases, the various chemical examinations required in diagnosis of diseases of the stomach, and directions for making an autopsy. These are added more especially because they form an important part of the instruction to the classes in the University of Pennsylvania, but it is hoped that they may also prove useful to others. The shortest and simplest methods have been selected, with a view to maintaining the original purpose of the book, conciseness with practical sufficiency.

October 1st, 1893.

PREFACE TO THE FIRST EDITION.

It cannot be said that the making of a new book on Physical Diagnosis is demanded by reason of the fewness of existing treatises on the subject. It is, however, but natural that it should occur to one, a part of whose duty it is to teach physical diagnosis to large classes of medical students, that he might accomplish more satisfactorily his task by having a text-book of his own preparation. In this I have sought to secure conciseness with sufficiency, a task acknowledged to be difficult, but which experience in teaching is, perhaps, best calculated to overcome. It is the object I especially sought in my Manual on the Examination of Urine, which has now reached its Seventh* Edition. The present book is not intended to be pretentious, and if it effects its simple purpose in being useful to students I will feel repaid.

JAMES TYSON.

1506, Spruce Street, October 1st, 1891.

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*The Eighth Edition was issued April, 1893.

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MANUAL

OF

PHYSICAL DIAGNOSIS.

GENERAL CONSIDERATIONS.

The term physical diagnosis strictly defined would include the diagnosis or investigation of disease by the aid of all the special senses, but practically it is confined to eliciting such information as can be furnished by vision, touch, and hearing, whence come the terms inspection, palpation, and auscultation. The information acquired by hearing is further subdivided—1st. Into that gained by listening directly to the normal breathing sounds and heart sounds, and to their abnormal modifications; and to certain new sounds produced by diseased states. 2d. Information gained by striking or percussing the part to be investigated. Hence, too, the words auscultation and percussion are constantly used in association.

The information furnished by inspection is also rendered more accurate by measuring or mensuration, when this can be applied. Thus constituted, physical diagnosis is applied to any portion of the body, but it is more especially in the study of diseases of the thoracic and abdominal contents, and particularly the former, that it is useful. The phenomena thus learned are known as physical signs. The use of the term "physical" is based upon the fact that it is through alterations in the physical properties of the tissue or organ investigated that information is obtained, such as the shape, density, transparency. On the other hand, in its usual application there is a limitation inconsistent with strict accuracy. Thus there is no more accurate means of recognizing physical states than by thermometry, yet thermometry is not one of the measures employed in physical diagnosis.

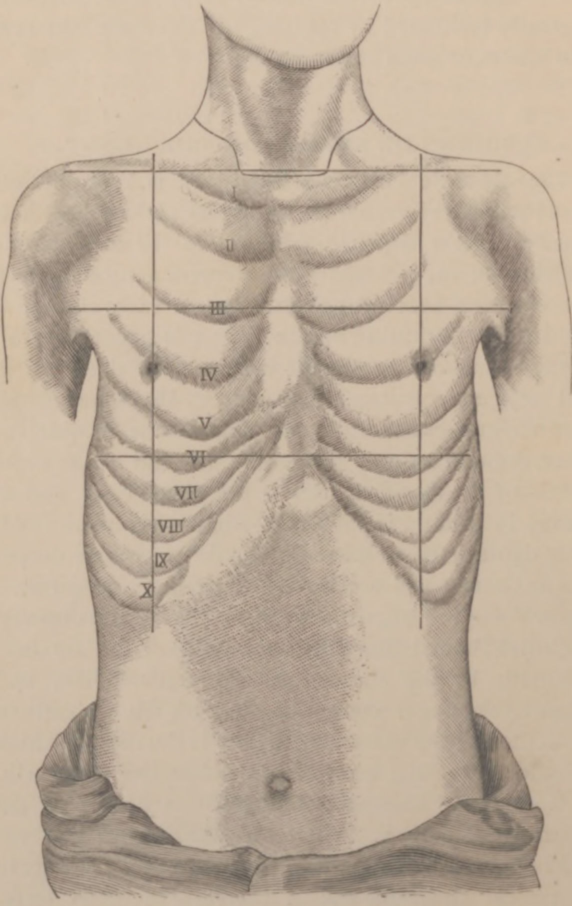
It is very true that physical signs cannot be acquired from books and must be learned at the bed-side; but we may record their import and significance in the recognition of disease and render somewhat easier their study. To this end is indispensable a familiarity with the physical condition of the organs of the body in a state of health. This, too, can only be learned on the living subject by giving the student an opportunity to listen until he is thoroughly familiar with the normal breathing and heart-sounds, to observe the normal shape and configuration of the body, and to learn the percussion note characteristic of different regions over important organs, as the heart, lungs, and various abdominal viscera. Such a study of the situation of internal organs in relation to external parts, for the purposes of the physician, constitutes medical anatomy.

The attainment of the objects of physical diagnosis is greatly facilitated by mapping out the chest into certain spaces or areas known as the

REGIONS OR SPACES OF THE CHEST.

The **clavicle** itself is a useful landmark in physical examination, while above each clavicle in health is usually a slight depression known as the **supra-clavicular fossa,** and above the sternum another known as the **supra-sternal notch.** Below each clavicle is the **infra-clavicular space,** which is somewhat arbitrarily bounded below by the upper edge of the third rib and adjacent cartilage, internally by the edge of the sternum, and externally by the base of the shoulder or a line drawn vertically from the inner end of the outer fourth of the clavicle. Below the clavicle, as well as above, in health, is usually a slight depression. All these depressions or spaces are liable to become deeper in emaciation, and are less conspicuous in fat persons. Below the upper edge of the third rib is the **mammary region,** bounded internally by the edge of the sternum, externally by the above-described vertical line, and below by the upper margin of the sixth rib. Nearly in the center of the mammary region is the nipple, which in males and young girls is just below the fourth rib. A line drawn vertically through it is known as the **mammillary line.** The **mid-clavicular** line coincides with the mammillary line when the nipple is in its typical situation, and is therefore a better term.

FIG. 1.

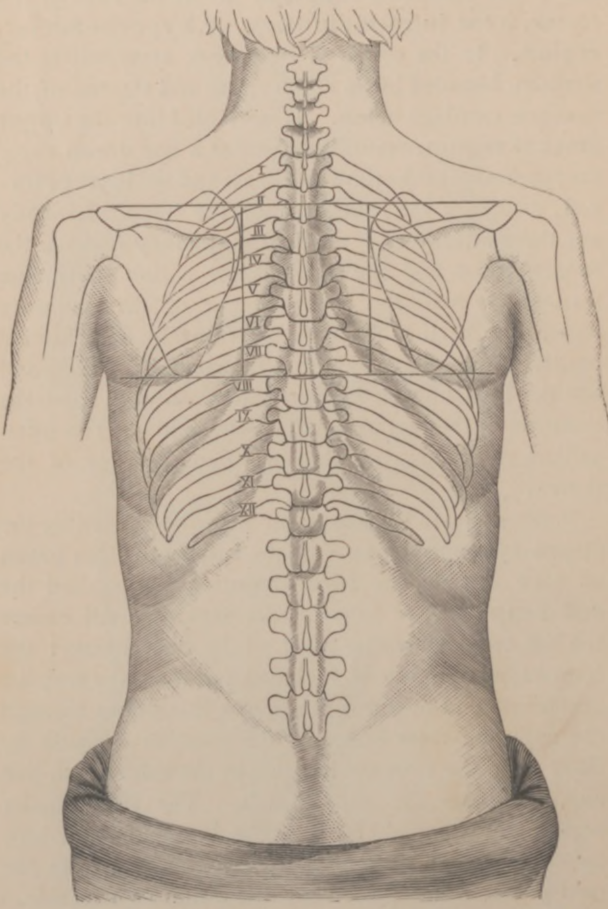


Regions of the thorax, anterior aspect.

Below the mammary region, as far as the edge of the thorax, is the **infra-mammary,** or **hypochondriac, region.** In the center of the thorax anteriorly is the sternum, bounded by its notch above and the end of the ensiform cartilage below. It is divided into the **upper sternal region,** extending as far as a line drawn along the upper edge of the third cartilage, and the **lower sternal,** including the remainder of the bone. Laterally are the **axillary** and the **infra-axillary** regions, the former above and the latter below a line continuous transversely with the lower border of the mammary region (sixth rib); bounded in front by the external border of the mammary and infra-mammary regions and behind by a line drawn vertically downward from the insertion of the posterior fold of the axilla. The infra-axillary region extends downward to the edge of the thorax.

Posteriorly are the **scapular regions,** including the **supra-spinous fossa** and the **infra-spinous fossa** of each scapula, the **interscapular** region, and the **sub-scapular,** or infrascapular regions. All except the last are sufficiently indicated by their names; the interscapular region is included between the scapulæ posteriorly and bounded below by a line drawn through the angles of these bones in the position assumed by them when the arms are hanging at the side. Such line usually crosses the seventh rib. The infrascapular regions are bounded above by the line just described, below by the edge of the thorax, and extend from the median line to the posterior axillary line on each side.

FIG. 2.



Regions of the chest, posterior aspect.

In addition to the mammillary line, are lines drawn vertically down the middle of the axilla and through the angle of the scapula behind, called the **mid-axillary** and **scapular** lines—also landmarks useful in description. The **parasternal** line, frequently used, is a vertical line drawn midway between the edge of the sternum and the mammillary line.

MEDICAL ANATOMY OF THE THORAX.

For the intelligent study of the physical diagnosis of the chest, it is important that the student should know what viscera or parts of viscera are contained in the areas just mapped out. See Figs. 3 and 4.

1. In the *supraclavicular* region is contained the apex of the lung (4, 10, Fig. 3), which rises above the upper border of the clavicle to the extent of a half inch to an inch and a half, and even two inches, varying in different persons. It is rather toward the inner end of the clavicle. One or other apex is usually a little higher than its fellow, the left more frequently. The apex of the lung is crossed by the subclavian vessels in the first part of their course. In the supraclavicular fossa near the outer border of the sterno-mastoid muscle, and about one inch above the clavicle, the beating of the subclavian artery can be felt. In this hollow, too, is the termination of the external jugular vein.

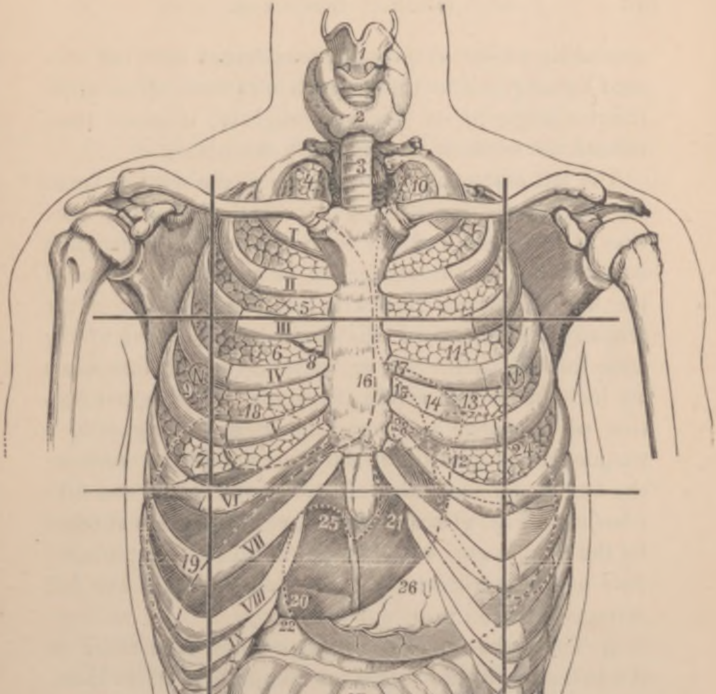
2. Behind the clavicle, in the *clavicular region*, is also found the lung, but the first and second ribs are interposed between the clavicle and the lung, so that no

typical lung note on percussion can be expected in that situation. Behind the inner end of the clavicle is the commencement of the innominate vein; behind this, on the left side, the common carotid; to the outside of this the left subclavian artery, and on the right side behind the sterno-clavicular joint, the bifurcation of the innominate.

3. The *infraclavicular regions* are occupied almost purely by lung structure. The superior cava extends slightly beyond the right edge of the sternum in this region, the pulmonary artery and the left auricle somewhat more to the left of the left edge of the sternum. The latter is in the second intercostal space and extends to the left parasternal line, covered by the edge of the lung.

4. The structures occupying the *mammary regions* differ considerably on the two sides. The right side is the simpler. The fissure between the upper and middle lobes of the right lung begins in the quiescent state of the lung at the fourth costo-sternal junction and passes upward and outward behind the third rib. The fissure between the middle and lower lobes of the right lung is found laterally about the fifth rib. The fissure between the upper and lower lobes of the left lung is behind the fifth rib laterally, terminating in the lower edge of the lung at about the fifth chondro-costal junction; but all these fissures change place with the act of deep breathing. To the right of the sternum is the right auricle, behind the third costal cartilage, the third interspace, the fourth costal cartilage, and fourth interspace, and

FIG. 3.



Anterior view of the organs of the chest and abdominal cavity with reference to their relations to the skeleton and the boundaries of the stomach. 1. Larynx. 2. Thyroid gland. 3. Trachea. 4. Right lung-apex. 5. Upper lobe, 6. Middle lobe, 7. Lower lobe of right lung 8 Upper, 9. Lower interlobular boundary of the right lung. 10. Apex, 11. Upper lobe. 12. Lingual process of the left lung. 13. Cardiac boundary of the anterior border of the left lung. 14. Portion of the anterior aspect of the pericardium covered by the cardiac pleura. 15. Portion of same uncovered by diaphragm. Site for paracentesis. 16. Anterior border of right mediastinum. 17 Anterior border of the left mediastinum. 18. Upper or true border of the liver partially covered by lung. 19. Right lobe of the liver. 20. Quadrate lobe of the liver. 21. Left lobe of the liver. 22. Gall bladder. 23. Upper end of the stomach. 24. Stomach cul du sac partially covered by lung. 25. Pyloric end of stomach. 26. Larger curvature of stomach (right gastro-epiploic artery). 27. Transverse colon.—*After Luschka,* slightly modified.

extending almost to the right parasternal line, but covered by lung. The right ventricle extends at the outer inferior angle of its base very slightly, if at all, from behind the sternum into the sixth interspace.

The left mammary region is occupied almost as far as the mid-clavicular line by the heart, including portion of the right and left ventricle. The cardiac line is an oblique one beginning at or near the junction of the left parasternal line with the lower border of the second rib and thence downward and outward to the apex formed by the left ventricle in the fifth interspace an inch below and within the nipple. The upper portion of this area is covered by lung, leaving only a tongue-shaped portion of the heart uncovered between the fourth and sixth ribs. Between the fourth and fifth ribs (at 15, Fig. 3) is a spot of the pericardium uncovered by the diaphragm, which is the usual site for paracentesis of the pericardium. The remainder of the left mammary region is occupied by lung.

5. The *infra-mammary regions* differ even more on the two sides in the structures comprehended in them. The right side is, however, mainly occupied by the liver, the dome of which reaches its highest point within the mammillary line in the fourth interspace, but is covered with lung down to the sixth rib. The lower border in health just reaches the edge of the ribs at the mid-clavicular line, and then extends obliquely upward toward the left, crossing the median line usually at one-third the distance between the ensiform cartilage and the umbilicus, and reaching the left border of the

thorax at or near the left parasternal line. The lower edge of the liver varies somewhat in healthy individuals, and descends below the ribs with deep inspiration.

The left infra-mammary region includes the anterior part of the lower lobe of the left lung, the left lobe of the liver, the cardiac end of the stomach, varying degrees of distention of the latter organ producing considerable variation in the percussion boundaries of these organs.

Between the infra-mammary regions is the epigastrium in abdominal topography. In the right half of the epigastrium is the quadrate lobe of the liver, the gall bladder, the pyloric end of the stomach, at a point midway between the ensiform cartilage and the parasternal line, behind the liver and adjacent to the gall bladder. The fundus of the gall bladder can sometimes be felt at the edge of the liver. In the left half of the epigastrium is the left lobe of the liver and lower median part of the stomach.

6. The *suprasternal notch* is solely occupied by the trachea in health, but is often encroached upon by a dilated aorta, or aorta pushed up by a hypertrophied heart.

7. The *upper sternal region* under the manubrium is occupied by the trachea, which bifurcates at the junction of the first and second bone, by a part of the superior cava, the arch of the aorta, the left innominate vein, which joins its fellow to form the superior cava just below the cartilage of the first rib, close to the right edge of the sternum; also by a part of the pulmonary

artery. The upper and central part of this region is uncovered by lung.

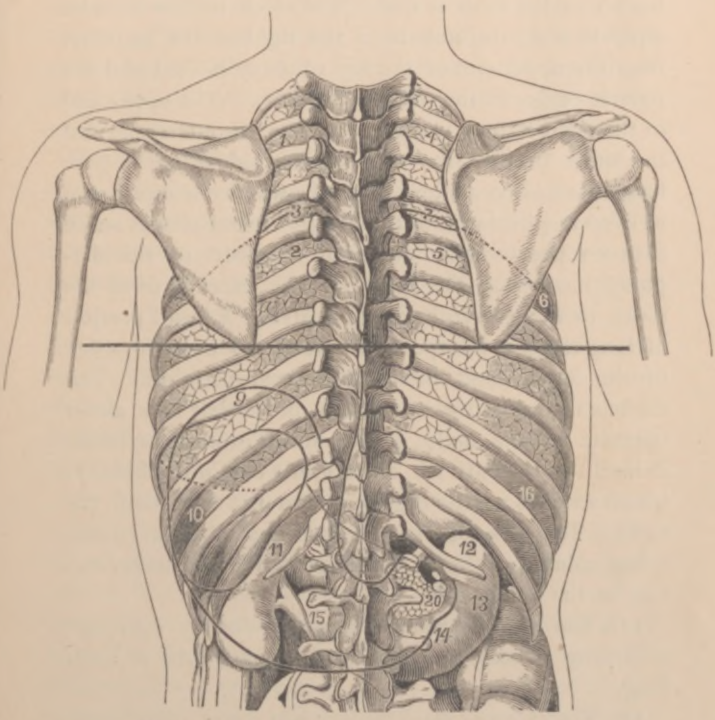
8. The *lower sternal region* contains a part of the aorta, a portion of the right auricle, much of the right ventricle, beginning opposite the fourth cartilages, and behind this the left ventricle. The edges of the two lungs unite through the upper part of this region in the middle line, the left diverging at the fourth rib where the uncovered tongue-shaped piece of the heart commences. The primary bronchi are found diverging at the upper part of this region, where they penetrate the lung. The right, larger and shorter, passes downward on the level of the fourth dorsal vertebra; the left, longer and smaller, downward and outward to the level of the fifth dorsal vertebra.

9. The *scapular regions* cover the lung, the incisure between the upper and lower lobes passing obliquely downward under the bone from the upper edge of the fifth rib behind to between the fifth and sixth ribs laterally.

10. The *interscapular region* in its central portion is occupied by dorsal vertebræ, in front of which is the trachea, bifurcating at the fourth, whence its primary bronchi extend downward and outward surrounded by lung structure.

11. The *infra-* or *subscapular regions*, extending from the angles of the scapulæ to the edge of the thorax, include on the right side lung as far as the tenth rib in the mid-scapular line. Below this is the complemental pleural space (see p. 24) filled by lung only in deep in-

FIG. 4.



Posterior view of the organs of the chest and abdominal cavity. 1. Upper lobe, 2. Lower lobe of left lung. 3. Interlobular boundary between them. 4. Upper lobe of right lung. 6. Middle lobe of the right lung. 7. Line between upper and middle lobes of the right lung. 9. Stomach demarked by a dark line. 10. Spleen in its relation to the lung in expiration, with the kidney showing behind and below it. 11. Left kidney. 12. Horizontal upper part of the duodenum. 13. Descending portion of the duodenum. 14. Horizontal lower part of the duodenum. 15. Duodeno-jejunal flexure. 16. Liver. 20. Pancreas.—*After Luschka.*

spiration, as far as the eleventh rib, where the lower border of the liver is met. The thick lumbar muscles separate the integuments to the right of the vertebræ from the upper end of the right kidney behind and the pyloric orifice of the stomach in front. The upper end of the right kidney is under the eleventh interspace and the short twelfth rib. On the left side there is pure lung tissue as far as the ninth rib, whence it dips down in deep inspiration into the complemental pleural space between the thoracic wall and that part of the diaphragm covering the spleen, which extends from the ninth to the eleventh ribs inclusive. A small portion of lung tissue is interposed between the posterior edge of the spleen and the tenth dorsal vertebra. The cardiac orifice of the stomach is on the left side about opposite to the body of the ninth dorsal vertebra. Behind the eleventh rib is the upper end of the kidney, which extends a little higher on the left side than the right. The left end of the pancreas is close to the spinal column in the eleventh interspace and under the root of the twelfth rib.

12. The *axillary regions* on both sides are occupied with lung structure, a part of the upper lobe of each lung.

13. The *infra-axillary* regions are again more complex in the structures they cover. On the right side there is lung as far as the ninth rib in the mid-axillary line; below this is liver to the eleventh rib, or edge of the thorax in this line.

On the left side there is lung as far as the ninth rib in the mid-axillary line. Below this is the spleen, which extends to the eleventh rib inclusive, or edge of the thorax at this situation. The cardiac end of the stomach, especially when dilated, is apt to protrude into the infra-axillary region and to influence the percussion note.

The Borders of the Lungs.—It is to be remembered that these anatomical boundaries are of themselves rather approximate, and furthermore, that they do not necessarily coincide with the percussion boundaries of the same organ, as in many situations portions of lung protrude between the organs and the surface and produce a modification of the note peculiar to the adjacent organ—the relative or deep-seated dulness of these organs. It is therefore useful also to know the correct anatomical boundaries of the lungs as a whole in relation to the landmarks given:—

In front the lungs extend above the clavicles from half an inch to an inch and a half or more; behind as far as a line drawn through the apex of the spinous process of the seventh cervical vertebra. Below and in front the right lung extends to the neighborhood of the sixth cartilage, the left to the fourth; in the mid-axillary line both extend to the lower border of the seventh rib, in the mid-scapular line to the tenth rib, and near the spinal column to the eleventh rib. On the left side at the inner end of the fourth cartilage the lung diverges from under the breast bone obliquely behind the fourth cartilage through the fourth intercostal space and again turns toward the sternum behind the fifth costal cartilage, but at the sixth cartilage again turns outward to form the tongue-shaped indentations into the lung boundary, by which a portion of the heart is uncovered. Behind the breast bone, from the second to the fourth cartilage, the edges of the two lungs approach each other very closely.

The summit of the dome of the liver in front reaches as far as the fourth interspace on the right side, but it is covered with a wedge-shaped extension of the lung as far as the sixth rib, where what is known as the absolute dulness of the liver begins.

It is to be remembered that in quiet breathing, during which the boundaries above traced are supposed to be noted, the anterior edge of the left lung and the inferior edges of both lungs do not reach the extreme limit of the pleural space, so that between the edges of the lungs and the boundary of the pleural sac there remains a space which is only filled at the time of deep inspiration. At other times the costal and pulmonary pleura below the lower edge of both lungs are in contact, as are also the costal and mediastinal pleura toward the median line at the anterior border of the left lung. The spaces thus formed are called **complemental spaces.**

Above the cartilage of the fourth rib the anterior border of both lungs fills the pleural space, but below these the edge of the left lung deviates from the pleural border to form the tongue-shaped cardiac indentation referred to. The inferior border of the left lung extends a little lower than that of the right, more particularly between the parasternal and the mammillary line, where it extends half an inch lower.

It is less important to know the interlobular boundaries of the lung. These begin on both sides posteriorly at the level of the spines of the scapulæ, or the second and third spinous processes of the dorsal vertebræ, and diverge downward and outward. The interlobular incisure of the left lung intersects the mid-axillary line at the level of the fifth rib, and terminates in the mammillary line at the fifth rib. The right incisure divides at about two or two and a half inches above the angle of the scapula into two branches, an upper and a lower, which separate the upper lobe from the middle, and the middle from the lower lobe of the lung. The upper branch passes nearly transversely forward to terminate in the edges of the lung at about the level of the fourth cartilage. The inferior branch passes sharply downward and slightly forward at the level of the sixth rib in the neighborhood of the mammillary line, and out at the lower edge of the lung. Hence it is that on the posterior aspect the lower lobes make up the larger part of the lung exposed to percussion; in front, on the left, only the upper lobe, on the right the upper and middle lobes. Laterally, on the left side the upper and lower lobe, and on the right side the upper, middle, and lower lobes approach the surface.

INSPECTION AND MENSURATION.

The appearances of the regions described, during and independent of the motions of breathing, are objects of **inspection,** but these are best described in connection with the conditions which modify them. In inspecting the chest from the front or behind, the patient should stand erect with the hands at his side; during lateral inspection the hands should be raised alongside of the head, or they may grasp opposite shoulders. Such relations to light should be chosen as will obviate shadows as much as possible. It will be remembered that during breathing, a woman exhibits more motion in the upper part of the chest, while in men abdominal motion is marked.

Mensuration is for the most part practised by an ordinary tape measure, and thus the circumference of the chest at different situations is determined; also differences in the circumference at the end of inspiration and of expiration, and differences in the semi-circumference as the result of abnormal states. It is to be borne in mind that in right-handed persons the semi-circumference of the right side is often a quarter of an inch to an inch greater than that of the left, owing to the greater muscular development of that side. The reverse obtains to a less degree in left-handed individuals. The transverse and antero-posterior diameters of the chest may be determined by a pair of calipers; any deviations in the shape of the chest by the cyrtometer, a simple form of which may be made out of strips of sheet lead, moulded to the chest-walls, and the outline thus produced be drawn on a large sheet of paper. More perfect appliances for chest measurement are the stethometer of Quain, the stetho-goniometer of Allison, the cyrtometer of Woillez and others, but they are not needed for the usual measurements.

THE SHAPES OF THE CHEST.

By inspection and mensuration we learn the shape of the chest.

1. The **normal shape** of the infant's chest at birth is nearly cylindrical, but as development proceeds it acquires an **oval shape** well established by the time the child has cut its milk teeth. This increases slowly until development is complete, when the outline shown in Fig. 5 is attained :—

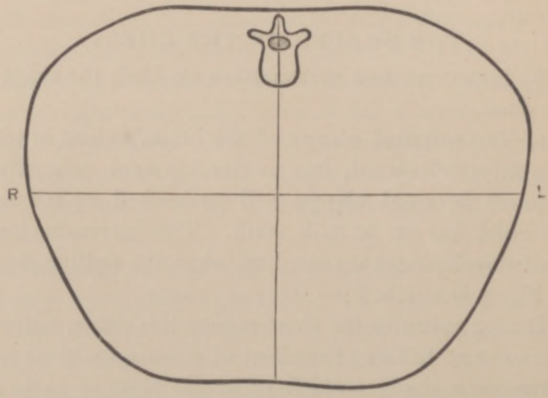
During maturity the chest retains this shape, but with the wane of life and the effect of disease incident to it there come changes which cause the chest to again approach the cylindrical shape of infancy.

The effect of various affections on the shape of the chest will be considered in connection with the separate diseases, but there are several types in those in apparent health which are important, in that they favor tendencies to special diseases or are the result of weakness in childhood.

2. Thus we have the **alar** or pterygoid chest, which is one of the forms of the so-called phthisical chest, because supposed to favor the development of this dis-

ease. Such a chest is small; the angles of the scapulæ project so as to give the appearance of wings. It is narrow, shallow, and long; but the ratio between the antero-posterior and transverse diameters is not necessarily changed. The ribs droop or are unduly oblique.

Fig. 5.



Transverse section of healthy adult chest at level of sterno-xiphoid articulation. (*After Gee.*)

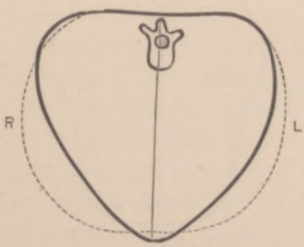
The throat is prominent, the neck long and the head bent forward.

3. Then there is the **flat chest**, also phthisical, wherein the antero-posterior diameter is disproportionately short, owing to the loss of convexity in the cartilages, which are even sometimes turned in so that the sternum is below the level of the cartilages, producing a shape of chest which on section is kidney-shaped.

In this form of chest there is not the increased degree of obliquity of the ribs characteristic of the alar chest.

4. The **transversely constricted** chest is characterized by a depression of varying depth passing outward and slightly downward on a level with the xiphoid cartilage and extending as far as the mid-axillary line. It is produced in childhood by some obstruction to the entrance of air, usually a bronchial catarrh, as the

Fig. 6.



Pigeon-breast, child of seven years.
Dotted lines indicate natural shape at same age. (*After Gee.*)

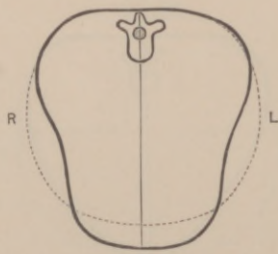
result of which the upper part of the chest is not expanded, while the lower part is held expanded by the abdominal viscera.

5. The **pigeon breast** is the result of higher degrees of obstruction than are produced by simple catarrhal conditions. Whooping-cough, with its prolonged paroxysms, is probably the most frequent cause, but any chronic pulmonary catarrh may do it, as may also enlarged tonsils. In it the shape of the transverse section

of the chest is more or less triangular, the result of a straightening of the ribs and forward protrusion of the sternum, which takes place while the ribs are plastic and yielding. The pigeon breast is usually associated with the transverse constriction above described, both being the result of different degrees of the same cause.

6. The **rickety chest** is characterized by a shallow

FIG. 7.



Rickety chest.
Dotted line indicates the shape of the chest of an infant about the same age (*After Gee.*)

longitudinal groove on each side of the chest, parallel and a little external to the sternum. It is due to external atmospheric pressure upon soft, rickety ribs before the lungs are sufficiently filled to occupy the space rendered vacant by the descent of the diaphragm. The groove takes the position it does because the softest parts of the ribs are about the costo-chondral articulations.

PALPATION.

After inspection and mensuration of the chest, palpation is usually practised. This is done by applying the palm of the hand or the fingers, as may best serve the purpose, to the chest-wall. The chief value of palpation lies in the fact that when the hand is thus closely applied, and the person "touched" speaks, a peculiar vibrating or trembling sensation is conveyed to the hand. This is known as **vocal fremitus** or **vocal tactile fremitus**. This fremitus or thrill, representing the vibrations in the air below the vocal cords, is communicated to the walls of the air passages, from the larger to the smaller, until the ultimate structure of the lung is reached, whence it is conveyed to the chest-wall and hands. In health it is felt everywhere over the chest where lung-tissue reaches, but is more distinct where the chest-walls are thinnest, and especially in the infra-clavicular spaces. It is further often more plainly felt below the right clavicle than below the left, an important fact to be remembered in recognizing delicate shades of difference. This is usually explained by the fact that the right bronchus is shorter, larger, and enters the lung higher up and more horizontally than the left, whence a larger volume of air is contained in the right lung, especially in its upper portion, and stronger vibrations are produced in speaking. For the same reason vocal fremitus is sometimes slightly more distinct posteriorly in the right half of the interscapular space, and even below the angle of the right scapula. In the axilla the same difference may exist to a less degree. Tactile fremitus is, of course, more marked in persons with thin chest-walls than in those with thick muscular walls, or walls covered with fat, while it is feebler but still easily appreciable in women. It is also greatly influenced by the pitch or tone of the voice used, being more marked in a deep, low-toned speech than in a high one. It is further influenced by words selected for utterance. My favorites are "ninety-nine," as producing a longer vibration than words like "sixty-six," for instance. But "one, two, three," or "twenty-one," "twenty-two," and "twenty-three," and the like, are useful also to bring out vocal fremitus.

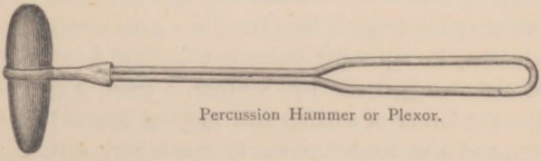
Vocal fremitus is increased in abnormal states producing consolidation of the lung, as in pneumonia and tubercular deposit, and is diminished by conditions which separate the lungs from the chest-wall, as pleuritic effusions, plastic pleuritic thickening, and even solid tumors.

Fremitus is also produced by the action of coughing, when it is called **tussile**, as distinguished from vocal; by râles, dry or moist, if the tubes are of sufficient caliber, when it is called **rhonchal**; also by pleural and pericardial frictions.

PERCUSSION.

Percussion naturally succeeds palpation, and consists in striking a part with a view to eliciting sound. In its simplest form it is probably as old as diagnosis itself, but Auenbrugger, of Vienna, was the first to publish, in 1761, results obtained from its application. Percussion is called **immediate** or **mediate**, according as the

FIG. 8.



Percussion Hammer or Plexor.

FIG. 9.

Ivory Pleximeter.

FIG. 10.

Sansom's Pleximeter.

blow is struck directly upon the part or upon some interposed medium. Immediate percussion is of limited application, but it is still sometimes very useful, and I much like to percuss the clavicular region by striking directly the bone rather than upon some interposed substance. The hammer or agent by which the stroke is practised is the **plexor**, and the interposed material is the **pleximeter.** By far the most common plexor, and for the most part the best, is the middle or index finger, or both of these, while one or the other of the same fingers of the other hand becomes the pleximeter. It is often useful, however, to have a specialized hammer, like that shown in Fig. 8, while more useful and even more indispensable at times becomes a pleximeter (Fig. 9), in situations which the fingers cannot conveniently reach, or where there is much percussing to do, when the fingers sometimes become sore and tender from the constant pounding. By far the most satisfactory pleximeter, in my experience, is the little hard-rubber pleximeter suggested by Sansom. (See Fig. 10.) Either the larger or smaller end may be applied to the chest, and the stroke given to the other, with equal efficiency.

The pleximeter was invented and first used by Piorry, of Paris, in 1828, and the hammer by Wintrich, in 1841.

The essential conditions of successful percussion are, first, the close application of the pleximeter, whether it be the finger or an artificial pleximeter, to the chest, so that it will form a part, as it were, of the area to be percussed ; and, as the two sides of the thorax are commonly compared, precisely corresponding points should be selected. Then care should be taken to strike with equal force on each side. When the fingers are used as plexors, the stroke should be made from the wrist, and vertically on the pleximeter, while the hand should be raised quickly, and one, two, three, or more blows given until the proper sound of the part is elicited. To this end the force of the stroke should be regulated, being made lighter on thin-walled chests and more forcible over thicker walls. When the proper note is brought out it should be remembered and compared with the sound elicited under the same conditions at the corresponding point on the opposite side. Practice with attention to these conditions can alone make perfect.

The sound produced by percussing the chest is a mixed one, made up of the vibrations of the pleximeter, those of the thoracic wall, and those of the air in the lungs. The first, when the finger is used as a pleximeter, is scarcely noticeable, but when a pleximeter of ivory or hard rubber is used this element may be recognized, especially when the pleximeter is accidentally struck by the nail of the finger used as a plexor. In like manner the vibrations of the thoracic wall are insignificant and unnoticeable under ordinary circumstances, in comparison with the vibrations of the air in the lungs, which are responsible for most of the sound produced in percussing the normal chest. These vibrations are set up by the blow, and it is the sound thus produced, variously modified in health and disease, which we are to study. Where the chest wall is very thick, however, the note of its percussion becomes more predominant and that of the lungs less.

Auscultatory percussion is a term applied to a method introduced by Cammann and Clark, which consists in listening, with a stethoscope applied to the chest-walls, to the sounds obtained by percussion.

Respiratory percussion is a term proposed by Da Costa for the study of a note made by percussion while the breath of the patient is held after a deep inspiration or after a prolonged expiration. Constant reference will be made to the effect of the latter on sounds elicited by percussing normal organs.

ATTRIBUTES OF PERCUSSION SOUNDS.

Percussion sounds have attributes of **quality, intensity** or **loudness, pitch,** and **duration.** No one of these attributes can, strictly speaking, be so described as to enable it to be recognized by the ear. Practice and illustration must be associated with the description in order that an adequate idea may be obtained.

Quality is the easiest indicated of the attributes of sound. Although Flint correctly says of it that "to attempt to describe the quality of sounds to one who has never heard them would be like describing colors to one who is blind," illustration happily comes to our assistance and helps greatly. Thus it is not difficult for any one who has heard it to recognize the note of a violin or piano and to name the instrument producing it. The attribute of sound, by which such recognition is made is quality, and each quality is produced by certain conditions peculiar to the instrument producing the sound. It varies therefore with those conditions.

Now the qualities of sound produced by percussing the normal chest are mainly two: First, *the normal vesicular resonance or clear sound;* second, *the dull sound or* *dulness.* There are modifications of both of these. A third quality, not strictly speaking a normal thoracic sound, but so conspicuous in adjacent organs in health as to often influence the thoracic sounds, will also be described in this connection. I allude to *tympany.* Each of these is produced by conditions peculiar to itself.

Vesicular resonance, or lung-clearness, as applied to the healthy chest, is produced by percussion over normal air-distended lung tissue, a structure containing air in minutely divided spaces. Such structure is its condition, and the sound produced is as much *sui generis* as is the violin's sound. It is of the nature of a reverberation, and is reverberation modified by minute subdivision of air spaces. It is not inaptly compared by Flint to the sound produced by percussing a loaf of bread over which a towel has been spread, the upper crust of the bread corresponding to the chest-wall; but, as a rule, normal resonance is characterized by less hollowness than the percussion of a loaf of bread. It differs in different parts of the chest of the same individual and in different individuals. Its typical quality may always be found in the left infra-clavicular space or below the angle of either scapula in healthy persons with chest-walls of moderate thickness.

The chief cause which operates to produce the differences alluded to in health is the varying thickness of the chest-walls; but the state of tension of the air in the air vesicles has to do with it, as has also the position of adjacent viscera and the mode of percussion, according as it is forcibly or lightly practised, according as it is well or faultily done. The differences themselves consist in variations in the other three attributes named—intensity, pitch, and duration.

Intensity means simply loudness and increases *pari passu* with the thinness of the chest-wall and the force of the percussion blow. The effect of the attributes of pitch and duration are best studied after the other qualities mentioned, dulness and tympany, are considered.

Dulness in general may be defined as diminished resonance, but the term is not used by all authors with a single meaning. Thus Da Costa says,* "a dull sound denotes the absence of air. It is the sound both of fluids and solids. It is, thus, the sound sent forth by the airless viscera; from the liver, spleen and heart." Others, however, would use the term "flatness" to indicate this condition, exhibiting its typical note in percussing the thigh. R. C. M. Page † applies the term flatness to the quality obtained by percussing over fluids contained in thin walls, and presumably, also, over pure solids. To retain the word flatness for the sound produced by percussing an absolutely airless organ or fluid, and dulness for resonance diminished in positive degree, gives a desirable latitude in the use of terms, further increased by the application of the adjective terms slight, moderate, considerable, or marked. I shall therefore use the term in this sense. Dulness and flatness are both

* "Medical Diagnosis," 7th ed.; 1890, p. 264.

† "Physical Diagnosis," 3d ed.; p. 23.

associated with increased resistance to the percussing finger, a sign also more or less valuable in diagnosis.

Tympany or **tympanitic resonance** is the sound elicited by percussing over a large cavity filled with air —a cavity whose walls are rather thin, and neither very tense nor very yielding. The stomach and intestines furnish such a cavity, and it is in this region that we seek the tympanitic quality of resonance. Tympany also has variations in pitch due to variations in the size of cavities which will be better understood after this attribute of sound is considered.

We are now ready to discuss and illustrate the attributes of **pitch** and **duration**, neither of which are so easily described as quality and intensity. They can, indeed, only be learned by practice and with varying facility by different ears, the musical ear having a decided advantage. Perseverance, however, will enable any one to appreciate them sufficiently for practical purposes.

First as to **pitch.** We speak of it as high or low and of intermediate degree. Pitch is higher the more rapid is the succession of the vibrations of the sounding body and of the sound waves which emanate from it, while intensity depends on the amplitude of the vibrations.* Shrillness is the acme of pitch, loudness of intensity.

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* Amplitude is the length of the excursion of the particles which at any time form the sonorous wave, and the motion of the particles or their width of swing must not be confounded with the motion of the sonorous wave itself.

The higher the tension of a percussed cavity containing air the more numerous the vibrations and the higher the pitch, but the shorter the amplitude of the vibrations the less the intensity. *Vice versâ*, a high-pitched tympanitic resonance would indicate a smaller cavity with tenser walls than low-pitched tympany. The normal vesicular resonance is characterized by its low pitch, because the air vesicles, from their elasticity, are not in a state of high tension. If, however, the lungs be forcibly dilated, the air vesicles are placed in a state of higher tension and of diminished elasticity, a situation akin to that of a distended stomach, and if percussion be now practised over such areas the pitch will be raised, but there will be added not only a higher pitch, but also a tympanitic quality, and a note will be produced which was named by the late Dr. Flint **vesiculo-tympanitic resonance.** It is a mixed note, therefore, and its conditions are produced by any cause which over-distends the air vesicles, as prolonged crying in a child. It is also the note of the over-distended air vesicles in emphysema of the lung or of portions of a lung, supplementally active in consequence of impairment of function in other parts. A tendency to vesiculo-tympanitic resonance also exists at the right apex of the lung as compared with other situations of typical resonance, and is recognized by the shadowy higher pitch sometimes noticeable in that locality.

Tympanitic sounds, although generally high-pitched, also vary in pitch, the latter increasing inversely as the size of the cavity and directly with the degree of tension.

Thus the stomach, being a large cavity, gives on percussion a lower pitch than the small intestine distended to an equal degree. On the other hand, tension may be made so great by forcible distention, say of the stomach, that the tympanitic sound may be destroyed. Skoda explained these phenomena as follows: In the moderate distention which gives us good tympany, the stomach wall is not tense enough to be thrown into vibrations, the air within the cavity alone vibrates and true tympany results. If, however, the distention is excessive, percussion throws both walls and contained air into vibration, and the two sets of vibrations interfering with each other, a non-tympanitic muffled sound results. This explanation cannot, however, be accepted, in fact, as stated by Adolf Weil,* is refuted by the instrument whence tympany takes its name, the drum, in the tapping of which both the membrane and the contained air are thrown into vibration, and yet a resonant sound results. So, too, human speech and human song are produced by the simultaneous vibration of membrane in the shape of the vocal cords and of circumscribed air masses. Both elements must therefore be admitted to enter into the production of the tympanitic sound, and it is easy to show that, given a membrane of equal tension, the larger the air space the deeper the tone or lower the pitch, as for example the bass drum; while, given the

* "Handbuch der topographischen Percussion." Zweite Auflage, Berlin, 1880.

same volume of air and membrane of different tension, the pitch is higher the greater the tension.

Now when a bladder or stomach is so forcibly distended that its percussion produces a dull sound instead of a tympanitic one, and such distention is only possible when the air space is tightly closed on all sides, it is as though the air space were surrounded by unyielding walls. Percussion under these circumstances—a thoroughly closed cavity and firm walls—produces no tympany, because the waves of the contained air are reflected back from the smooth walls and the sound fails to be produced. The observer hears for the most part only the sound produced by the vibrations of the bladder walls, influenced in part by the convex shape of the bladder and in part by the condensed air within it. The pressure of this air resists the inward vibration of the bladder wall, and by shortening the amplitude of the air vibrations diminishes the intensity and resonance of the sound. In a word, it is shorter, duller, non-tympanitic.

If, however, the mass of air thus surrounded by a tense wall communicates with the exterior by an opening, the tympanitic note responds to percussion.

Dull and flat percussion are high pitched in their note, and the pitch increases with the dulness and the area of the dulness, while the first suggestion of impaired resonance is a slight heightening of pitch which the practiced ear readily recognizes, and attaches to it great importance. The tendency to a higher pitched note just below the right clavicle in health as compared with the left is also to be remembered in weighing slight differences in the percussion note of the two sides. It is associated with the tendency to increased vocal fremitus in the same situation, already referred to.

The explanations of this tendency to slightly higher pitched resonance and slight dulness at the right apex are not uniform, and are therefore best considered in a footnote.*

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* First is the explanation of Flint, who, in ascribing it to a special character of vesiculo-tympany, implies some change in the elasticity of the air-vesicles. How this is brought about except by some greater functional activity of the right apex I do not know.

The second explanation of this slight impairment of the resonance is based on the different arrangement of the bronchial tubes on the right side as compared with the left. The former are larger, extend higher up than the latter, and thus give us more tubular tissue, including a larger proportion of connective and muscular tissue to deal with in percussing, which would give us slightly less resonance.

A third explanation, which certainly must be allowed to apply in some instances, is the greater muscular development of the right side of the body, and in consequence greater thickness of the pectoral muscles of that side. This would also cause a slightly higher pitch. The opposite state of affairs in left-handed persons would go far to confirm this, but I am not aware of any systematic observations intended to settle this question.

Still another explanation of this difference is based on the fact that the right lung rests, through the diaphragm, upon the right lobe of the liver, which is a dense organ, and percussion of the lung would be modified, by such relation, toward a slight impairment of resonance. It is not impossible that any one or more of the first three causes might operate to produce the difference on the two sides, the last cause more particularly in explaining any slightly raised pitch in the lower right lobe as compared with the left.

Duration is the attribute of least importance, or at least comes little into play in the percussion of the human body. It varies inversely with the pitch, that is, the higher the pitch the shorter the duration, and vice versâ.

We are now ready to study the percussion sounds as heard in the different regions of the chest as already mapped out.

PERCUSSION OF THE NORMAL CHEST—TOPOGRAPHICAL PERCUSSION.

First, in the **supra-clavicular spaces.**

Satisfactory percussion here is difficult and results are not to be too much relied upon. The nearest approach to normal clear percussion or vesicular resonance is found above the center of the clavicles where the lungs rise from half an inch to an inch and a half or even two inches above the clavicle, being usually higher in women than in men. Toward the inner end of the clavicle the percussion may acquire a more tympanitic quality, on account of the proximity of the trachea, while toward the outer end a duller note obtains.

On the **clavicles** themselves percussion is clear, almost typically so, over the middle of the bone, but becomes duller as the outer end is approached, while on the inner end it may be higher pitched.

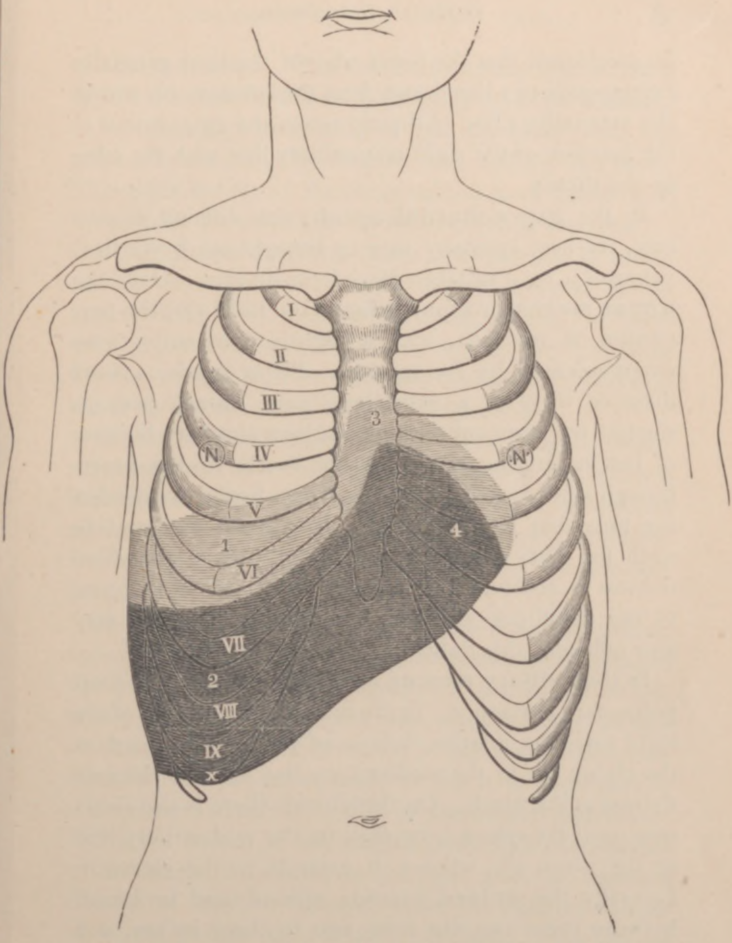
The **infra-clavicular spaces** furnish in health the typical clear percussion-note or vesicular resonance as far as the upper edge of the fourth rib. On the right side is to be looked for the shadowy higher pitch, the vesiculo-tympany of Flint, so that Page selects the left subclavicular as the typically normal. This difference is not invariable, but the fact is to be remembered in weighing shades of difference with a view to diagnosis.

In the **mammary region** percussing down the right mammillary line, the clearness continues, possibly a trifle less on account of the greater thickness of the pectoral muscle, until the fourth interspace or the fifth rib is reached, when there is a raised pitch and diminished intensity, which passes at the sixth interspace or seventh rib into a positive dulness which continues in health to the edge of the ribs. This impairment of the resonance on the right side is due to the liver, the lesser degree being known as the deep or *relative* dulness, and below this the *absolute dulness.* The upper border of the absolute dulness corresponds with the lower edge of the right lung. Close to the sternum on the right side there may be slight impairment of resonance from the third to the fifth rib, due to the relative dulness of the right auricle, passing at the fifth rib into the relative dulness of the liver, and at the sixth into the flatness of that organ. On forced inspiration the liver is pushed downward an inch or more, and on forced expiration there is a corresponding rise.

On the left side, close to the sternum, normal vesicular resonance begins to lessen at the third interspace, owing to the deep or relative dulness of the heart, and at the fourth costal cartilage is replaced by the absolute dulness of this organ, which continues down along the left edge of the sternum until it passes into the left lobe of the liver, from which it cannot be demarked ; but in general terms the cardiac dulness may be said to extend from the fourth to the sixth rib, and from the sternum to a curved line extending a short distance along the fourth cartilage and thence down within the nipple line to the seat of the apex beat. The cardiac area of dulness is also diminished on deep inspiration, because the organ becomes more fully covered by the distended lungs. Without the nipple on both sides there is, in health, resonance to the anterior axillary line, slightly lessened by the mammary gland and pectoral muscle.

The **infra-mammary** or **hypochondriac** region on the right side is wholly occupied by the liver and furnishes flat percussion, beginning in the mammillary line at the sixth rib, and at the edge of the sternum a little higher, and extending to the edge of the thorax in this line. The width of the area of absolute dulness of the liver is three to four inches. On the left side the percussion in this region varies greatly in different persons and in the same person at different times. Toward the sternum the left lobe of the liver for the most part maintains its dulness, but even this is sometimes replaced by the tympany of a dilated stomach, while to the outside of this, the stomach as normally distended with gases quite frequently imparts a tympanitic note. On the other hand, the presence of solids and fluids in the stomach in varying amounts contributes dulness. A spleen of normal size does not extend into the infra-mammary region. In this connection it may

FIG. 11.



Showing Absolute and Relative Percussion Dulness of Liver and Heart.

1. Relative dulness of liver. 2. Absolute dulness. 3. Relative dulness of heart. 4. Absolute dulness.

be mentioned that the lower edge of the liver generally corresponds to a line drawn from the left sixth rib within the mammillary line obliquely across the epigastrium to the junction of the right mammillary line with the edge of the thorax.

In the **supra-sternal notch,** also difficult to percuss, tracheal tympany may be brought out by vertical percussion on a suitably placed pleximeter. Over the **upper sternal** region, as far as the third rib, the percussion is resonant, with a slightly tympanitic note communicated by the trachea. Below this for a short distance there is a purer lung note, though perhaps slightly less resonant than typical lung structure because of the underlying heart. At the fourth rib the heart, though still covered in by the lungs, begins to deaden the note, but it is still fairly clear in the median line until the liver is reached opposite the sixth rib, where dulness is absolute and extends one-third to half-way to the umbilicus, although a tympanitic stomach may also influence this dulness.

In the **axillary spaces** on both sides there is good pulmonary resonance. In the infra-axillary region of the right side, the relative dulness of the liver is noted at the eighth rib in the mid-axillary line and the absolute dulness at the ninth. On the left side there is also clearness until the spleen is reached in the mid-axillary line at the ninth rib, whence it extends to the eleventh. Laterally the **spleen** extends upward and backward between these two ribs from two to three inches, and sometimes it is so covered in as to escape recognition by careful percussion. The left infra-axillary region is also apt to be encroached upon by the tympany of the stomach.

Posteriorly, percussion is best practised with the patient leaning slightly forward and folding his arms. The upper border of the lungs behind is on a level with the spinous process of the seventh cervical vertebra.

In the **supra-spinous fossa** the percussion resonance is markedly less than the typical, because of the bone and the thick muscles overlying it, and the same may be said of the infra-spinous region. At the same time percussion here is important because differences on the two sides are usually easily recognizable.

In the **interscapular** region there is again better resonance than over the scapulæ themselves, but still less intense than below the angles of the scapulæ, on account of the tolerably thick muscles and the spinal column. In the upper portion the tympany of the trachea may influence the note.

In the **infra-scapular** regions we have the nearest approach behind to the typical resonance as represented by the left infra-clavicular space. The information obtained here by percussion is most valuable, only second in importance to that obtained by percussing below the clavicles, and in consequence of this it is important to remember the inferior border of the normal resonance. The lower border of the lung on both sides corresponds to the tenth rib, where, on the right side, the absolute dulness of the liver is found, while the relative dulness on strong percussion is found a rib higher. On the left side resonance extends in the line of the angle of the scapula fully to the tenth rib, though sometimes a tympanitic quality may be imparted by a dilated stomach or the colon, or a slightly dull sound if the spleen extends a little farther back than usual. Here as elsewhere on the thorax there may be slightly less intensity, and slightly higher pitch on the right side, on account of the greater muscular development in right-handed persons, and the effect of a deep inspiration in lowering the resonance, and in expiration of raising it an inch or more, is also to be remembered. In ordinary breathing the normal resonance posteriorly passes at the tenth rib into the absolute flatness of the lumbar region.

The upper border of the **kidneys** under the eleventh rib, the left being a little higher than the right, cannot ordinarily be separated by percussion from the dulness of the spleen and liver, nor can the inner border be separated from the spinal column. The outer edge can, however, be defined, by percussion, from the colon on the right and the stomach and colon on the left, by percussing outward from the median line behind. The outer border of the kidney is about three or four inches beyond the median line. The lower border can sometimes be defined by a line of tympany just above the crest of the ilium, produced in the colon. Forcible percussion is required, and it is desirable to place a pillow under the abdomen of the patient lying prone upon his face.

ABNORMAL PERCUSSION LUNG SOUNDS.

It goes without saying that a sound which is normal in one situation becomes abnormal when heard in a position unnatural to it in health, as dulness or tympany below the clavicles or below the angles of the scapulæ, where vesicular resonance is ordinarily found. But in addition there are certain positive modifications of normal sounds not heard anywhere in health, or at least under such exceptional conditions as do not permit them to be included among normal sounds.

These are **vesiculo-tympanitic resonance, amphoric resonance,** and **cracked-pot sound.**

Vesiculo - tympanitic Resonance.—The vesiculo-tympanitic resonance of Flint has already been alluded to, but requires to be further considered because it is not generally recognized by either American, English, or German authors as something distinct and different from tympany, and it requires to be conformed to their treatment of conditions supposed to cause it. In the language of its describer, "the resonance increased in intensity; the quality a combination of the vesicular with a tympanitic, and the pitch higher in proportion as the tympanitic quality predominates over the vesicular." According to him, also, the morbid condition which especially illustrates this form of resonance is the over-dilatation of the air vesicles which constitutes vesicular emphysema of the lungs, but it is also present in interstitial or interlobular emphysema. Also, over the upper lobe of a lung when the lower lobe is solidified in the second stage of pneumonia, and over the lower lobe when the upper is solidified. So, also, if the lower part of a pleural sac contains fluid, even though the volume of the lung is diminished, the upper part of the same lung may give the same vesiculo-tympanitic note. Attention was first called to this by Skoda, and it is known as Skoda's sign. Too much of the intra-thoracic space must not be occupied, as the lung is thus compressed and rendered airless, but the resonance is vesiculo-tympanitic above the liquid when the latter is sufficient to fill a third, a half, or even two-thirds of the intra-thoracic space.

Now these are essentially the conditions named by Da Costa, Paul Niemeyer, and Graham Brown as producing *tympanitic* resonance of lung tissue. Says Brown:* "Just as when the lung is removed from the body and allowed to collapse it gives a tympanitic note, so when a similar retraction and relaxation of the pulmonic tissue takes place within the thorax, that variety of percussion note may be heard. This is best marked in cases of pleuritic effusion which, gravitating to the lower portion of the cavity, floats up the lung and causes relaxation of the upper portion. When the effusion is small in amount the tympanitic note can only be detected over that portion of the lung which lies immediately above the upper limit of the fluid, but when the effusion is considerable the whole upper lobe may be tympanitic on percussion. This is also called tympany by mediate relaxation. Similarly, effusion into the alveoli in pneumonia or edema may produce a like result."† This is

* "Medical Diagnosis," 3d edition, Edinburgh, 1887, page 207.

† This can occur only in the first and third stages of pneumonia when the air vesicles contain air, the second stage being one of absolute airlessness and dulness.

tympany by **immediate** relaxation. Niemeyer* adds, occasionally gangrene and infarct, also disseminated tubercular infiltration, emphysema, and nervous asthma, and that portion of the lung not inflamed but immediately adjacent to a hepatized part. In like manner phthisical consolidations of the apices may also occasion an obscurely tympanitic note over neighboring portions of the lung (mediate relaxation). Finally, Da Costa, who with Flint may be regarded as representing the American School, says: "But generally a tympanitic sound over the seat of the lungs is expressive of emphysema or of pneumothorax, or sometimes of a cavity or of edema of the lungs. Again, as Skoda has taught us, it occurs in moderate pleuritic effusions above the level of the liquid."†

It has seemed to me important to contrast these statements, both in order to give a better idea of what Flint intends to convey by vesiculo-tympanitic resonance and to avoid confusion in the minds of those who might with reason be confused by statements apparently so diverse. That there should be something different from typical tympany in the percussion note produced under the circumstances named seems likely, yet I am by no means certain that the words *exaggerated resonance* or *hyper-resonance* would not convey the idea sufficiently well.

Pure Tympanitic Resonance.—Tympanitic re-

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* Grundriss der Percussion und Auscultation. Zweite Auflage. Erlangen, 1873, pages 38, 39.

† "Medical Diagnosis," 7th edition, 1890, page 265.

sonance is found in normal thoracic states only over the larynx and trachea and in the left infra-axillary region from encroachment of a tympanitic stomach. Elsewhere it becomes a sign of an abnormal state.

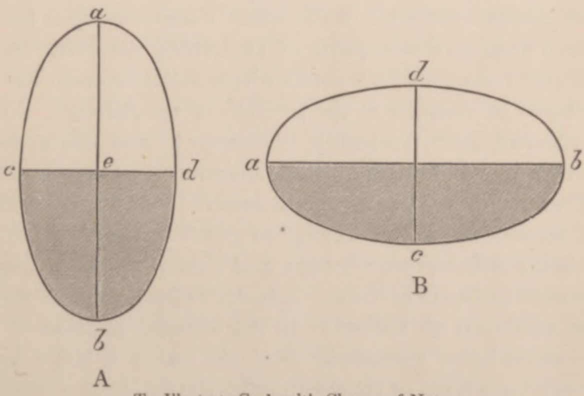
The fundamental principle to be remembered in connection with tympanitic sounds is that their pitch depends inversely on the volume of circumscribed air and the transverse section of an opening communicating with the exterior.

In the chest, tympany is produced by percussing over air-containing cavities in the lung tissue, sufficiently near the surface and sufficiently large, and whose walls are not too tense. Bearing in mind the above principle, approximate estimates as to size and shape of cavities may be even made by observations as to pitch. Thus a cavity of small size will give a higher-pitched tympanitic note than one of a large size.

As these cavities usually communicate with a bronchus they are further characterized by differences in the pitch when percussed with the mouth open or closed. This is Wintrich's change of note, according to which percussion over a given cavity gives a higher-pitched tympanitic sound with the mouth open than when it is closed. This may be illustrated by percussing over the thyroid cartilage under the two conditions, when the difference will be very evident. It occurs in connection with superficially placed cavities in communication with a bronchus. If this change of sound is observed on lying down, but is not on sitting up, or vice versâ, it means that the bronchus leading to the cavity is obstructed in the position in which the Wintrich change of note does not occur. This is the interrupted change of note of Wintrich.

By what is known as Gerhardt's change of note we learn something about the shape of cavities. Cavities which have unequal diameters, or are oval in shape and are partially filled with fluid, alter their note on chang-

FIG. 12.



To Illustrate Gerhardt's Change of Note.

ing the position of the patient from sitting to horizontal. Thus suppose A to represent an oval cavity in the vertical position with the contained fluid at the line *c d*. If the patient lies down the long diameter will become horizontal, as in B, and the level of the fluid will fall to *a b*. The percussion note is lower when the longer diameter is horizontal, higher when it is vertical. If, therefore, the percussion note is lower when the patient is sitting up, the direction of the longer diameter is antero-posterior ; if it is higher while sitting up, the long diameter is vertical.

Every cavity does not, of course, furnish the conditions of tympanitic percussion. Recent experiments also shed some doubt as to the correctness of the law originally announced by Wintrich, that the pitch of oval cavities partially filled with fluid depends on the direction of the greater diameter, while other conditions, too, have been suggested as capable of explaining the differences in pitch observed in cavities whose relations have been altered by changes in the position of the patient.

Second, pure tympanitic resonance is also characteristic of pneumothorax if the distention is not too great. There being no free communication of such a space with a bronchial tube, no change of pitch occurs when percussing with the mouth open and closed. If there happens to be liquid in the sac, Biermer's change of note may be produced as follows: In the vertical position of a pneumothorax containing fluid the cavity is larger because the weight of the fluid pushes the diaphragm downward. Hence in this position the pitch is lower. If the position of the patient is now changed from the vertical to the horizontal the cavity becomes smaller by reason of the changed position of the fluid and the pitch becomes higher.

Third, a pure tympanitic resonance may be produced in pneumonia and pleurisy when the hepatization is so complete or the pleuritic exudation is in such close relation with the lung that percussion throws into vibration the air in the trachea and bronchi.

Amphoric Resonance.—Amphoric resonance, a variety of tympanitic resonance, is a high-pitched metallic resonance, so called from its resemblance to the sound produced by striking the side of a jar, either empty or containing a small quantity of fluid. It may also be imitated by filliping the cheeks when the mouth is distended with air. It is an echoing sound, the waves being reflected from side to side of the closed vessel, as is speech in a vaulted chamber. Amphoric resonance is said to be produced or intensified by what is known as the **bell-metal** test of Gairdner, in which a coin of sufficient size is percussed by means of another on the anterior surface of the chest, while the auscultator listens posteriorly or *vice versâ*.

Amphoric resonance is not very often met; the conditions of its production in the human body are an air-filled cavity of considerable size, with firm and *smooth* walls, completely closed or communicating with the air by a small opening only. When thus communicating it is louder when the mouth is kept open. These conditions are fulfilled by certain phthisical cavities, and especially by pneumothorax or pyopneumothorax, sometimes also by a distended stomach. If with such a pyopneumothorax the body be shaken, the splashing or **succussion** will sometimes have the same ringing character. The same conditions are sometimes fulfilled by a distended stomach containing fluid.

The Cracked-pot Sound.—This sound is well-named because it quite resembles that produced by tapping a cracked jar, and is therefore one of the most distinctive and easily recognized of the abnormal percussion sounds. It is, too, a modification of tympany, and is caused by the expulsion of air from a cavity through a small opening by a sudden forcible blow. It is also imitated in mechanism as well as character by suddenly striking the back of the two palm-apposed hands against the knee, after the method used by the boys to imitate the clinking of coins.

It may also be made by striking the pleximeter when the latter is not closely applied to the skin, an accident favored by a hairy skin. The cracked-pot sound may also be produced in the normal chest by percussing it sharply while the patient is in the act of speaking or crying out, the narrow glottis affording the condition of a small opening. This may more readily be done under these conditions in children who have thin, elastic chest-walls.

The cracked-pot sound is produced in disease by percussing over a cavity which affords the conditions named, viz., a somewhat superficial position, sufficiently yielding walls, and communicating by a small opening with a bronchial tube and thence with the outside air. It is the most infallible sign of a cavity known. In producing it, the mouth of the patient is kept open and a sudden forcible blow of the plexor given. Often it cannot be heard unless the ear is attentively turned near the chest to catch the sound. The same conditions exist in a pneumothorax, with a thoracic fistula into the lung, and under these circumstances a cracked-pot sound may be produced by percussing such a chest in the manner described.

AUSCULTATION.

Auscultation is the act of listening to sounds, more particularly those produced in the chest by the act of breathing or speaking, or in the course of the heart's action, or in the blood-vessels, to these sounds as modified by disease, or to certain new sounds produced by disease. In so doing the ear is applied either directly to the chest or through the intermediation of an instrument known as a stethoscope. According as this instrument is employed or not, the auscultation is **mediate** or **immediate.** Both have their advantages. When it is desired to isolate or circumscribe a sound, especially in the study of the heart, the stethoscope helps us greatly, while in the study of more diffuse sounds, as many of those produced in the lungs, the direct application of the ear to the chest is generally to be preferred. The stethoscope becomes also desirable in the examination of patients not especially clean. In inexperienced hands, also, the patient is rendered uncomfortable by undue pressure by the head on the instrument.

The stethoscope was invented and used by Laennec, of Paris, in 1816, in its single shape. Through the labors of Laennec, by the aid of the stethoscope the diagnosis of diseases of the chest developed in a comparatively short space of time to an accuracy scarcely equaled with any other set of organs. The binaural instrument was devised by Cammann, of New York city, in 1840. There can be no doubt that, with the latter, sounds are more loudly heard. On the other hand, all noises, as that of the rubbing of linen or clothing, are so much exaggerated that the beginner is often confused. The double instrument is becoming more popular of late, but preference depends on training. A man who has been brought up to use the double stethoscope soon grows to prefer it, while he who is trained to the single instrument would not have the double. When either form of the instrument is used, better results are obtained when the chest-end is applied directly to the bare skin, whereas in immediate auscultation it is desirable that there should be a thin, soft towel, or some thin garment, interposed between the ear and the skin. The ear or stethoscope should also be applied closely to the chest-wall, so as to become a part of it or continuous with it; and yet, as stated, the stethoscope may be applied too strongly, so as to give pain to the patient. Successful auscultation requires that the attention should be closely concentrated on the matter in hand.

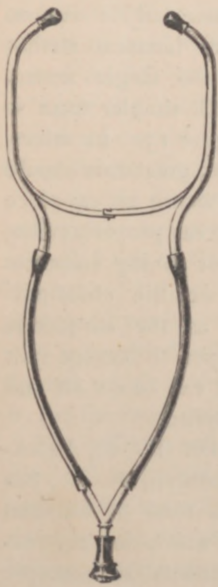
FIG. 13.

Hawksley's Stethoscope.

The single stethoscope is made of wood or metal.

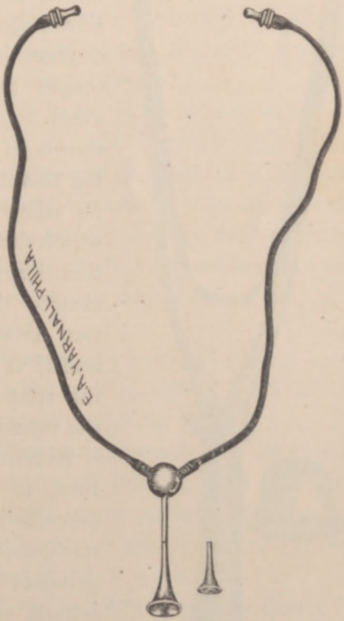
That originally made by Hawksley, of London, out of gun-metal, and provided with a detachable hard rubber ear-piece, shown in Figure 13, is the most convenient

Fig. 14.



Sansom's Binaural Stethoscope.

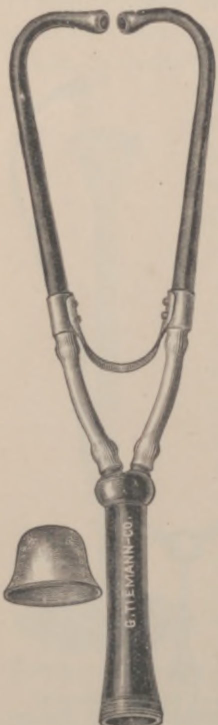
Fig. 15.



Simpler Form of Sansom's Binaural Stethoscope.

and neatest. A large variety of double stethoscopes have been suggested. The double instrument, Figure 14 in the text, partly metal and partly rubber tubing, was devised by Sansom, and is very conveniently carried when folded at the joint. It is especially suitable when the patient is inaccessibly placed in relation to the examiner, an advantage possessed in various degrees by all binaural stethoscopes over the single instrument. A still simpler form is shown in Figure 15. In selecting this shape, great care should be taken to secure an ear-piece which fits the ear properly; also, that the rubber tubing embraces closely the metallic chest-portion as well as the ear-pieces, and if it happen to become split the split end can be cut off and the tube reapplied.

Fig. 16.



Recently Dr. H. K. Valentine, of Brooklyn, N. Y., has described* a form of binaural stethoscope which in my experience conducts stethoscopic sounds more loudly to the ear than any I have ever used. The instrument (Fig. 16) is composed of hard rubber, the bell and ear-pieces being

* N. Y. *Med. Record*, July 16, 1892.

united by two pieces of ordinary soft-rubber tubing, each about three and a half inches in length.

The bell is a cylinder five inches long, having an internal diameter at the mouth of seven-eighths of an inch. At the top of the cylinder there are two openings, each one-quarter of an inch in diameter, separated by a sharp septum of hard rubber, and the same diameter is continued the full length of the ear-pieces.

When the instrument is in use, the divided waves of sound are carried from the cylinder in two straight lines along the ear-pieces to the curved ends, which lead them directly into the ears of the operator. The expense of making the stethoscope is largely due to the perfectly smooth finish of the interior of the hard-rubber tubing, throughout its entire length, by which means only are such good results obtained.

It is provided with an accessory soft-rubber bell, also figured, which intensifies the sounds, but the instrument is, for the most part, best used without it.

The ordinary soft-rubber tubing connecting the cylinder and ear-pieces permits of folding, and thus the stethoscope is readily carried in the pocket. It is better dropped into the pocket with the sharply flexed rubber tubing uppermost, so that it will not crease.

When the interior of the bell becomes very dusty, it may be easily cleaned by allowing cold-water to run through it.

AUSCULTATION OF THE NORMAL LUNG.

The breathing sounds in health are separable into two distinct orders: first, the **vesicular breathing** or

respiratory murmur; second, **bronchial breathing.** Both are normal sounds, constantly produced in the act of breathing, but in certain parts of the chest one is heard more or less to the exclusion of the other. Thus the vesicular breathing is heard in its most typical character under the left clavicle, where it is best studied by immediate auscultation.

Bronchial respiration is the easiest of description. It is blowing or tubal in quality, both in inspiration and expiration, and the two parts are nearly equal in length, the expiratory being often slightly the longer. It is heard in its purest form over the larynx and trachea, but also quite pronouncedly between the scapulæ at the root of the lungs, where, however, it is more or less admixed with vesicular breathing. The pitch is high in both in- and out-breathing, and somewhat higher in the latter.

Vesicular breathing is the sound produced by the movement of the air in the smallest bronchial tubes and air vesicles. It is also divided into two portions—the inspiratory and expiratory, the **in-** and **out**-murmur, the former being much the longer. Perhaps no language can give a correct notion of the vesicular murmur, but it is a soft, low-pitched sound, said to resemble the sighing of a gentle breeze through the leaves of a tree. It is the sound of the movement of the air in the finest bronchial tubes and air vesicles. As stated, when typical the inspiratory murmur is much longer than the expiratory. The ratio is, however, not fixed. The expiration may be one-fourth as long, or it may be a mere whiff, as it were. It represents the recoil of the air vesicles and the backward movement of the air. The precise mechanism of the production of the sound in question will be left to the physiologist, our present purpose being to consider the sound and its modifications in disease.

The vesicular murmur is not everywhere the same, even in health. As a rule, it is slightly louder, more purely vesicular below the left clavicle, and, assuming it to be typical in this situation, is nearest maintained in the axillæ and below the scapulæ. Under the right clavicle the slightest rise in pitch and a distinct prolongation of the expiratory portion is often noted, and to be remembered as of great importance in diagnosis in doubtful cases. This is usually ascribed to an admixture of the bronchial element due to the larger size of the right bronchus, and of its branches sent up toward the right clavicle. Over the scapular regions posteriorly the vesicular murmur is less intense, because of the thickness of the bones and muscles, but the same difference between the two sides may sometimes be noted in the supraspinous fossæ, as below the clavicles in front. For the same reason it is less intense in the mammary regions, and in all fat and muscular persons as compared with the thin and emaciated. Between the angles of the scapulæ still more of the bronchial element is added than below the right clavicle, and the sound is decidedly more blowing and the expiration longer. It is to be remembered that both vesicular and bronchial breathing are being constantly produced in the lungs, but that in certain situations one overshadows the other, partly because of its proximity immediately under the point where the ear is applied, and partly because the normal lung is a poor conductor of sounds.

ABNORMAL MODIFICATIONS OF BREATHING SOUNDS.

Changes in the Vesicular Murmur.—The vesicular murmur is modified by diseased states as follows:—

1. It is jerking or interrupted.
2. It is increased in intensity or loudness.
3. It is diminished in intensity, more indistinct.
4. It is altogether absent.
5. It is commingled with bronchial breathing, by which it is rendered harsh and its rhythm altered.
6. It is substituted by bronchial breathing.

1. Interrupted or *jerking* breathing is the least important of the alterations in the vesicular murmur, being generally of no significance whatever. Such is its value in persons who are nervous or slightly alarmed during examination. The interruption affects most frequently the inspiratory act, but it may occur in either or both, and the act may be broken into two or three parts. More serious is its cause when it occurs in connection with severe pleurisy or pleurodynia, where the pain of the act of breathing causes the latter to be interrupted. It has here, however, no more significance than in nervousness. Finally, it may be present in incipient tuberculosis or emphysema, but even here its diagnostic value is merely confirmatory, and that only when it persists.

2. Vesicular breathing is *exaggerated* or *supplemental*, or increased in intensity by any cause which compels the lung or a part of it to assume increased function. This happens in one lung or a part when the other or the remainder is deprived of its use by compression or destruction. In this change both the inspiratory and expiratory factors are proportionally increased in loudness and in length, the accentuation of increase being in the inspiratory sound rather than the expiratory. Its pitch is unaltered. From the resemblance of this exaggerated breathing, as it is also called, to the normal breathing in children it is often called **puerile** breathing.

3. The vesicular murmur is *feeble* or diminished in intensity by various causes. Such feebleness affects the inspiratory murmur rather more than the expiratory, so that the latter may be relatively prolonged, but it is, at the same time, even feebler than in health. Such diminution may be due to feebleness in the inspiratory act from debility, or to obstruction in the bronchus leading to the ausculted area; or to a loss of elasticity in the air vesicles, as in emphysema of the lungs or the very early stage of tubercular deposit. More commonly, in actual practice, it is due to the interposition of a liquid or a solid medium between the lungs and the ear, such as a pleuritic effusion or the plastic exudation of a pleurisy. Or it is due to the filling up of the air vesicles by an exudate, as in pneumonia, or tubercular infiltration in phthisis. More frequently it is obliterated by these causes.

4. The vesicular murmur is *absent* or altogether removed by the higher degrees of the last-named conditions, viz., pleuritic effusion, pneumonic and tubercular infiltrations.

5. The vesicular murmur is altered by the addition of a bronchial element, the first effect of which is to lengthen the expiratory factor of the breathing sound, to alter, in a word, its rhythm. Coincidently with, or immediately succeeding upon this, is a roughening of both inspiration and expiration, at first slight and then positive. As long as this degree is maintained there is still a vesicular factor in the breathing, whence it was named by Flint **broncho-vesicular breathing.** Expressive terms are also harsh respiration, rude respiration, or rough respiration. Such modifications of normal breathing are brought about by an infiltration of a certain number of air vesicles with solid material, while others still maintain their function. The effect of this is also to improve the conducting power of the portion of the lung involved, so that it becomes a better conductor of the bronchial sounds elsewhere produced, which are thus brought to the ear. It means, therefore, that a certain small extent of consolidation has taken place.

How shall we distinguish between puerile breathing and broncho-vesicular breathing, a most important requirement, since they indicate opposite conditions? Yet there is a certain similarity between them which inexperienced observers may mistake for identity, and which even an experienced man may sometimes have occasion to dwell on before deciding. Both are louder and rougher as to inspiration, but vastly different is the manner in which expiration is influenced. In puerile breathing it may be slightly longer and more distinct than in health, but it maintains its ratio to the length of the inspiratory murmur. Not so is it with the rude inspiration. Here the expiratory sound is roughened and prolonged out of all proportion to the inspiratory. And in catching slight degrees of difference the attention must be concentrated on the expiratory murmur. If it is greatly prolonged in proportion to the inspiratory, so as to nearly or quite equal it, and at the same time harsher than in health, not simply louder, then we have broncho-vesicular breathing and the conditions which produce it. And if to this is added a slight rise of pitch on percussion, a slight dulness, the condition is confirmed. Sometimes, however, these conditions do not go entirely *pari passu.* Then we must wait and watch. We must not forget, too, the physiological differences on the two sides, that there is the slightest higher pitch on the right in both percussion note and breathing sound, and that the expiratory murmur is slightly longer on the right. It must be remembered, too, that in simple feebleness of the respiratory vesicular murmur the expiratory element is less affected in its duration, but that here both inspiratory and expiratory sounds are less loud rather than more loud.

6. Finally, the vesicular murmur *may be altogether substituted by bronchial breathing.* This means that a considerable area of lung has become obliterated as to

its vesicular structure, and in this change has also become an excellent conductor of the distant normal bronchial breathing, which is heard with a blowing tubal quality as though produced directly under the ear. Again, it is to be remembered, that there is no more bronchial breathing produced under these circumstances than there was before the consolidation took place. It is simply that the vesicular murmur has altogether vanished, for the reason named, and therefore cannot longer mask the bronchial breathing, while the latter also is better conducted to the ear. Acute croupous pneumonia furnishes the most characterestic bronchial breathing. Between this and broncho-vesicular breathing there is every degree, depending upon the degree of destruction of vesicular tissue and the extent of consolidation. When the consolidation is very intense the bronchial breathing is rendered more intense, more metallic even than the tracheal breathing sound, which may be regarded as the type of bronchial breathing in disease, of which Da Costa truly says it resembles more the sound heard in health over the trachea than over the bronchial tubes.*

Changes in Bronchial Breathing.—The more usual modifications of bronchial breathing are **cavernous** breathing and **amphoric** breathing.

1. **Cavernous Breathing.**—The beginner will not be discouraged at any difficulty he may have in distinguishing between bronchial breathing and cavernous breathing when he learns that at the present day the

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* Op. citat., p. 277.

German clinicians do not attempt to distinguish between them. English and American observers have, however, usually separated them; both Flint and Da Costa, for example, say that the sign is more likely to be confounded with the normal vesicular murmur than with bronchial breathing, differing, says Flint,* "from the former only in the absence in the inspiratory sound of the vesicular quality."

In the first place the cavernous breathing is represented as more hollow in character, less diffused, less tubal, and therefore of much lower pitch than bronchial breathing. The expiration is also commonly lower pitched than the inspiration, reversing, in this respect, the bronchial breathing, although this is not constant enough to be made a rule of difference.

The conditions of its production are a cavity with yielding and resilient walls, by the collapse of which the air can be forced out, since the sound depends upon the entrance and exit of air. It is also often associated with gurgling, or may alternate with it. It may disappear to reappear after copious expectoration. Cavities at the apex of the lung in tubercular consumption are the most common causes, but whatever produces an excavation of the kind may cause it. A dilated bronchus, an abscess, and even gangrene of the lung may be such a cause.

2. **Amphoric Breathing.**—Amphoric breathing is

* "Manual of Auscultation and Percussion," 5th Ed., Phila., 1890, p. 107.

more easily recognized from its ringing metallic character, like that of the amphoric percussion note, resembling also the sound produced by blowing upon the mouth of a bottle. It is produced by the same conditions, a cavity with firm walls—a large cavity. It is likewise a blowing sound, of high or low pitch, inspiratory or expiratory, or both. It is an echoing sound. Clinically its presence most frequently means pneumothorax, but a phthisical cavity may rarely furnish the same conditions. Every case of pneumothorax does not, however, produce it, since there must be a perforation of the pleura above the level of the fluid and free communication with a bronchial tube.

There are other modifications of cavernous breathing more or less accidental and therefore of less importance. Thus it sometimes happens that either the inspiratory or the expiratory portion is absent, when the peculiar breathing may be still recognized by the pitch and quality of the portion remaining cavernous. Again, we may have a vesicular inspiration with a cavernous expiration, or there may be an admixture of cavernous and pure bronchial breathing, brought about by a combination of conditions which need not be mentioned here. Another variety of modification is the **Seitz-metamorphosing respiration,** in which the inspiratory sound is heard for about one-third of its time as harsh tubal and the remainder is of ordinary blowing, cavernous, or amphoric quality. It is said to be caused by air entering a cavity through a narrow opening. Again, there is the *broncho-cavernous* respiration and the *vesiculo-cavernous* breathing of Flint. In the former, the sound of expiration is bronchial, high pitched, and is said to indicate a cavity situated near consolidated lung. In the *vesiculo-cavernous* breathing the cavity is surrounded by a comparatively intact pulmonary tissue which produces an admixture of sound.

AUSCULTATION OF THE NORMAL VOICE.

Normal Vocal Resonance.—When the ear is applied below the clavicle of a person speaking, a confused monotonous humming sound is produced, of slight intensity, and low pitch. In the aged, it is apt to be tremulous or somewhat bleating. This is normal vocal resonance. It varies, however, in intensity and pitch in different persons, being almost inaudible in some. It depends also somewhat upon the manner in which the person speaks and the words he utters. It is increased not so much by loud speaking as speaking "from the chest." It is better noted also if the patient counts "one, two, three," or speaks the word "ninety-nine." It is also feebler in women than in men. It is accompanied by a fremitus which is the same as that described under palpation. It is a tactile fremitus in which the ear is the touching part instead of the palm of the hand.

Vocal resonance varies in different parts of the chest, being more marked where the walls are thin. Hence below the clavicles it is relatively loud, and more so below the right, just as is tactile fremitus, an important fact to be remembered in diagnosis, as well that every-

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where on the right side it may be more marked. Toward the sternal portion of the clavicular region it is louder, the tracheal voice influencing it. Below the clavicles it diminishes with the greater thickness of the chest walls of the mammary region, it is again more marked in the axillæ, less intense over the scapulæ and louder below them. Between the scapulæ it is also intense.

The **whispering voice** also requires some allusion. It being borne in mind that whispering in most persons is an act of expiration, if the ear is applied to a thin-walled portion of the chest, as below the clavicle, and the patient asked to count in a whisper, there is heard a feeble, low-pitched blowing sound, *unaccompanied by fremitus,* with a pitch and quality the same as those of the expiratory vesicular sound in breathing. All that has been said of vocal resonance, as to its audibleness and the degree thereof in different persons and on the different parts of the chest, is true of the "normal bronchial whisper," as it is called by Flint, because "the conduction of the sound produced by the whispered voice must be chiefly by the air contained in the bronchial tubes."

Normal Bronchophony.—When the stethoscope is placed over the thyroid cartilage of the larynx of a person speaking, a much louder resounding sound is heard directly under the ear, accompanied also by a thrill or fremitus conveyed to the ear. But it is still confused and no articulate words are heard. It corresponds to bronchial respiration, as normal vocal resonance accords with vesicular breathing.

If the person thus ausculted over the larynx or trachea whispers instead of speaks audibly, a high-pitch tubal sound accompanied by feeble fremitus is heard. It is, in fact, the expiratory breathing sound, as heard in these air tubes, interrupted by the act of speech.

Abnormal Modifications of the Ausculted Voice.—The correspondence of vocal resonance and normal bronchophony with normal vesicular breathing and normal bronchial breathing has been referred to. The same relation exists in pathological conditions. Thus any increase in the intensity of the normal vocal resonance implies a corresponding condensation of lung tissue, culminating in typical bronchophony when the consolidation is complete, just as the normal-vesicular breathing passing through broncho-vesicular terminates in bronchial breathing. *Pari passu* with increased vocal resonance and broncho-vesicular breaching goes increased bronchial whisper, the usual rule of health, of slightly greater intensity on the left, a higher pitch on the right being remembered.

Pectoriloquy.—In addition there are certain special modifications of the normal vocal resonance corresponding more or less to certain morbid states. Thus there is the cavernous voice or pectoriloquy, in which articulate speech is heard as though coming directly from the chest into the ear. While this is sometimes the sign of a cavity, it is not always so, the voice being similarly transmitted by solidified lung. Whispering pectoriloquy, in which whispered articulate speech is conveyed to the ear, is a much more reliable sign of a cavity.

Amphoric voice is ringing and metallic, like the other amphoric sounds, and like them indicates the same conditions—a large cavity with firm walls.

Ægophony is another very distinctive modification of the normal voice when ausculted. It is admirably likened to the bleating of a goat, and is produced during speech when there is a thin layer of liquid between the chest wall and the lung, in pleuritic effusions, or when there is liquid in the chest cavity from other causes.

Diminished Vocal Resonance.—Finally, speech sounds may be diminished in intensity by the same causes which diminish the tactile fremitus; pleuritic effusions, pleuritic thickening, compression of the lung by fluid or air, and by over-distention of the lung.

NEW OR ADVENTITIOUS SOUNDS.

These sounds are not a modification of preëxisting sounds, but something altogether new or additional. They include **râles**, or **rhonchi**, the **friction sound**, and **metallic tinkling.**

Râles are new sounds produced in the trachea, bronchial tubes or in cavities, concurrent with the movement of air inward or outward in the act of breathing. They are the direct result of some partial obstruction to the onward movement of the air, for the most part within the tube, but the narrowing may also be the result of extra-tubal pressure. They are divided into moist or dry râles, according as the obstructing substance is liquid or the reverse. Both are influenced by coughing and may often be completely removed, for the time being, by this act. When not thus influenced by coughing they are probably due to pressure from without.

Dry râles are due to the vibration produced in thickened adherent mucus or the swollen mucous membrane of the bronchi, by air moving over them. Sounds produced in the tubes of large lumen, like the trachea, are musical, low-pitched, and are called **sonorous** râles. Those produced in the small tubes are high-pitched and hissing, and therefore called **sibilant** râles.

Moist râles are caused by the passage of air through liquid, which may be blood, mucus, or serum. They are therefore of the nature of bubbling sounds and are spoken of as large and small bubbling sounds, according as the bubbles are large or small, and as large bubbles can only form in tubes of large size or cavities, they indicate these conditions, while the small râles indicate smaller tubes. The bubbling sounds are further subdivided, according to size, into gurgling, mucous, submucous, subcrepitant, and crepitant râles, and crackling.

Gurgling is a term applied to the largest bubbling sounds, and is produced in cavities containing fluid. It is also known as the cavernous râle, and has sometimes a metallic character when it becomes associated with the other metallic physical signs already mentioned as characteristic of a cavity with firm walls.

The mucous râle is a bubbling sound smaller than the cavernous, but still of large size, produced in the trachea and larger bronchi. The death-rattle is a tracheal mucous râle. The **sub-mucous** râle is a smaller bubbling sound produced in tubes of smaller size, and the **sub-crepitant** in still smaller. The **crepitant** râle is formed in tubes of smaller size and in the air vesicles. It may be a true bubbling sound, or it may be due to the separation of agglutinated air vesicles by entering air. From its extreme importance in the diagnosis of pneumonia, although it occurs also in edema of the lungs, it requires some further illustration. It is aptly compared to the crackling produced by throwing salt on the fire, or rolling the hair between the fingers alongside of the ear; also to the noise made by separating near the ear the moistened thumb and index finger. The first appears to me the best imitation. It is heard only in inspiration and is thus distinguished from the sub-crepitant râle, which is heard in expiration as well.

Crackling literally means the same as crepitation, and, in fact, the mechanism of the two signs is nearly the same. Both are inspiratory sounds, and both may be small bubbles. The main difference is really in the number of crackles which go to make up the râle, the crepitant consisting of several of these, while the crackling consists of but one, two, or three. "Crackling" is heard at the apices of the lungs, and the crepitant râle for the most part at the base. The interpretation of crackling is almost invariably tubercular consumption, and it means that the tubercle is beginning to break down. Yet we may have pneumonia of the apex.

What is known as "moist crackling" is a little larger râle than crackling, a pure bubbling sound produced in the smallest bronchial tubes, and is really a sub-crepitation.

The **friction sound** is a noise produced by the rubbing of two slightly roughened serous surfaces upon each other. The pulmonary and costal pleuræ and the cardiac and pericardiac serous membranes move over each other smoothly and noiselessly in health, but let them be roughened in any way by an inflammatory exudate, an eruption of tubercles, or other morbid growth, and at once the friction sound is produced. In its simplest and most frequent form, representing the first stage of pleurisy, it also resembles somewhat the crepitant râle, and it is sometimes not easy to distinguish from it. In addition, however, to being more superficial in situation, the friction sound is not influenced by coughing, while the crepitant râle is. The friction sound is heard more loudly if the stethoscope is pressed closely to the chest-wall and is localized, while the crepitant râle is heard over a large area of lung. It is also often a to-and-fro sound, being heard with expiration as well as with inspiration, while the crepitant râle is confined to the latter. The friction sound disappears with pleuritic or pericardial effusion, to return for a time with the subsidence of the effusion.

In addition to its typical crepitant-like character, as heard in pleurisy, the friction sound assumes also at times greater roughness, which is more conspicuous in pericardial friction. Where organization has taken place in an exudate there is sometimes a leather-like creaking produced under the same circumstances as the friction sound, and it is regarded as a friction sound. It is sometimes so loud as to be heard by the patient himself, and may also be recognized by palpation. Pleural friction may be found anywhere in the chest, but is more frequent in the sides.

Metallic tinkling is the last of the adventitious sounds to be considered. It is another one of the amphoric sounds, requiring a space with firm, tense walls as its condition. A pneumothorax will furnish such condition, as also do certain pulmonary cavities. Under these circumstances a drop of liquid falling into such a space will produce metallic tinkling. This sometimes happens in a pneumothorax when a drop of secretion will sometimes fall from a bronchial tube into a cavity.

Allied to the metallic tinkling is the Hippocratic succussion produced in pyo-pneumothorax and very rarely in a cavity, when the patient is shaken.

PHYSICAL SIGNS OF ABNORMAL STATES, OR DISEASES OF THE LUNGS.

ACUTE BRONCHITIS.

Acute bronchitis of the larger tubes is essentially a symmetrical disease, the bronchi of both lungs being generally more or less equally invaded. There may be absolutely no physical signs, inspection, palpation, percussion, and auscultation being alike negative. In other cases *inspection* may discover increased frequency of respiratory movement, and possibly increased frequency in the cardiac apex beat if there be fever. *Palpation* may appreciate a rhonchal fremitus if there be sufficient narrowing of the breathing tubes. It may be found anywhere or on either side and may be very transient. *Percussion* continues invariably clear so long as the bronchitis is uncomplicated.

Auscultation furnishes the most distinctive and constant physical sign, the presence of dry râles, the sonorous and sibilant, which may invade either or both lungs, and may also be transient. To these may be added harshness of breath sounds. In the resolution of bronchitis, bubbling râles may substitute the sonorous and sibilant, in consequence of the presence of liquid secretion.

Capillary bronchitis involves the finer and finest tubules, into which it generally extends from the larger. The frequent breathing is more evident and constant ;

so the frequent heart-beat with fever. Rhonchus may be felt, and there may be slight impairment of resonance in the affected area. *Auscultation* gives constant results in the shape, first, of dry râles of the finest kind, followed very soon by small bubbling râles, submucous and sub-crepitant, but dry râles are often absent. These signs are most frequent in the bases of the lungs posteriorly, but may extend all over.

CHRONIC BRONCHITIS.

Physical signs more constantly attend chronic bronchitis, yet they afford no unchanging picture. To *inspection* there may be nothing apparent, or the frequently associated complication of emphysema of the lungs may be the cause of a diminished excursion of respiratory motion, and the roundness or barrel shape of the chest characteristic of this disease ; to *palpation* of a diminution of the normal vocal fremitus, and to *percussion* a hyper-resonance, unless in the vicinity of a superficial dilated bronchus filled with secretion, where there may be impairment of resonance. If such a dilated bronchus be emptied of its contents by expectoration, the percussion signs of a cavity may be present, but in the middle or lower part of a lung instead of the apex. Vesiculo-tympanitic or even tympanitic resonance may be present from relaxation of lung tissue, especially in the lower posterior part of the lungs.

Auscultation may also be negative, but much more frequently recognizes an alternation or combination of harsh and feeble breathing, sonorous and sibilant râles, with moist râles of all sizes, variously modified by different distances from the ear and varying consistence of the secretion.

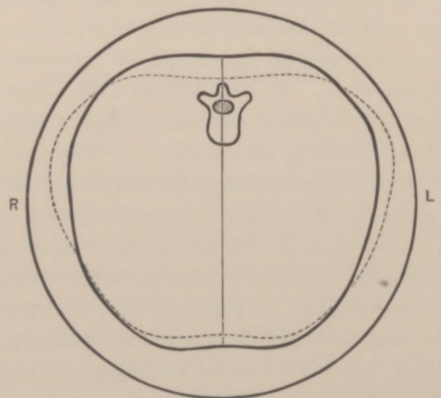
EMPHYSEMA OF THE LUNGS.

This condition, an over-distention and destruction of air vesicles with a like destruction of their covering of capillaries, is invariably the result of bronchitis and a complication of it. It also affects both lungs at the same time, but involves different lungs and different parts of the same lung unequally.

The physical signs are more or less distinctive. *Inspection* discovers a rounded chest anteriorly and posteriorly, with increased circumference, and wide intercostal spaces, the highest degree of which is known as the "barrel-shaped chest." Fig. 17. But the emphysema may be so circumscribed as to produce local bulgings, by preference in the upper lobe of the right and lower lobe of the left lung. The excursion of expansion of the chest walls is diminished, while the scaleni and sterno-cleido-mastoid muscles stand out distinctly. The apex of the heart is displaced downward and to the right, but it is often difficult to find, because covered up by the enlarged lung. To *palpation* vocal fremitus is diminished, while the natural resiliency of the chest walls is substituted by increased resistance.

Percussion recognizes resonance exaggerated in various degrees, sometimes amounting almost to tympany, the vesiculo-tympany of Flint. The cardiac dulness is extended to the right and downward, partly from displacement by the distended lungs, and partly from hypertrophy of the right ventricle. At the same time the cardiac area is more thoroughly covered by the lungs, and pretty strong percussion is often necessary

FIG. 17.



Bilateral Enlargement in Emphysema. (*After Gee.*)

to bring it out. The hepatic area of dulness is also lowered by reason of the encroachment of the lungs.

The distinctive *auscultatory* sign of the emphysematous area is the feeble inspiratory murmur due to the fact that the air vesicles are already distended with air and there is little further distention possible with the inspiratory act. The prolonged expiratory murmur is the result of the lost elasticity of the air vesicles, in consequence of which they recoil but slowly on their contents. Vocal resonance is diminished because of the diminished motion in the air columns. Feeble crackling is said to be sometimes heard. If bronchitis is present its sounds are associated and often obscure all else. The pulmonary second sound at the second left interspace is accentuated on account of the hypertrophy of the right ventricle, but the heart sounds are usually obscured by the extra covering of the lung. With dilatation of the right ventricle, which sooner or later succeeds, the increased accentuation disappears.

Interlobular emphysema, in which the connective tissue between the lobules is infiltrated with air as the result of rupture of air vesicles from violent acts of coughing, or of wounds of the lung; the physical signs, except to inspection, are the same as those of vesicular emphysema, except that the crackling sound referred to is more common. The configuration of the chest in such cases is not usually altered. Suddenness of onset is characteristic of this form of emphysema, and it is apt to be associated with a similar infiltration of the tissues of the neck, which gives rise to a very distinctive crepitation to palpation.

SPASMODIC ASTHMA.

The physical signs of this peculiar neurosis reveal themselves to all the methods of physical diagnosis employed. Thus *inspection* observes the most labored effort in breathing, while the chest moves but slightly, because the lungs cannot be inflated. The spaces above and below the clavicle and above the sternum, the intercostal spaces, and the pit of the stomach are drawn in, for the same cause,—that is, the thoracic cavity not being filled from within, the external atmospheric pressure forces the yielding portions inward.

Rhonchal fremitus is recognized by *palpation*, while vocal fremitus, obscured by the rhonchus, is otherwise diminished by a frequently associated emphysema. *Percussion* is negative in uncomplicated asthma, but if asthma is associated with emphysema it may produce abnormal resonance.

Auscultation furnishes the most striking and easiest recognized of the physical signs. All over the chest are heard sonorous and sibilant râles, inspiratory and expiratory, but more commonly the latter. In fact, for the most part, they do not require the ear to be placed close to the chest for recognition. The vesicular murmur, on the other hand, is inaudible.

It is to be remembered that chronic bronchitis, emphysema, and asthma may also complicate each other, and render correspondingly complex the physical signs.

TUBERCULAR PHTHISIS OR CONSUMPTION.

Accepting the modern doctrine, that all phthisis is tubercular, there are three ways in which it invades the lungs :—

1. As catarrhal or broncho-pneumonic phthisis.

2. As fibroid phthisis.

3. As miliary tuberculosis of the lungs.

Catarrhal Phthisis.—This, the most common form of consumption, presents two varieties, differing mainly in the rapidity of their course,—whence acute and chronic phthisis. The former is also known as *phthisis florida*, or galloping consumption. Perhaps there should be added, as a distinctive feature of the latter, the diffuseness as well as the rapidity of the process.

Catarrhal phthisis resolves itself, with more or less definiteness, into three separate stages, of which the physical signs, commonly sought at the apices of the lungs, are also more or less distinctive :—

1. The incipient stage, or beginning deposit.

2. Stage of complete consolidation.

3. Stage of softening and cavity-formation.

1. *Inspection*, in the *incipient stage*, is as often negative as not. A slight impairment of motion in the infra-clavicular space may be present, and more rarely a slight flattening of the same region. The clavicle becomes correspondingly conspicuous. The body may continue well nourished or slightly emaciated, or the heart-beat in the normal position may be somewhat accelerated, while the respirations are likely to be more frequent than in health.

Palpation recognizes increased vocal fremitus in the same situation, although this may not always be noticeable in the first stage, while the physiological difference in favor of the right side is to be remembered. Percussion in this stage gives slightly higher pitch and impairment of resonance, which may be noted above, on, or below the clavicle. Dulness may sometimes be brought out by directing the patient to hold his mouth open during percussion, or to hold his breath at expiration.

To *auscultation* above or below the clavicle, we have the first evidence of abnormality in a prolongation of the expiratory murmur and harshness in the inspiratory sound — the broncho-vesicular breathing described. Theoretically, this should be preceded by a diminished intensity in the inspiratory sound, owing to the interference of the newly-deposited tubercles with the movement of the air into the air vesicles, but practically this is scarcely encountered, and if encountered, is of such indistinctive significance as to be of little value.

Increased vocal resonance is a constant accompaniment of these modifications in the normal breathing sounds, but it, as well as the vocal fremitus, may be masked by a pleuritic thickening, and the physiological difference so often referred to must be remembered. Da Costa also calls attention to the fact that in a certain number of cases, at this stage, there is a blowing sound in the subclavian or pulmonary artery, and that a murmur is sometimes present in the subclavian or pulmonary artery before any other physical sign is present. There are frequently concurrent with these signs those of a bronchitis more or less acute.

2. In the *second stage* the changes discoverable by *inspection* are more easily recognized. There is evident loss of flesh, depression of surface, and impaired range

of respiratory movement. The hectic flush is intermittingly present. *Palpation* may also discover an increased warmth of skin. The increased vocal fremitus should be plainly recognized unless obscured by a thickened pleural membrane. Dulness on *percussion* is positive.

To *auscultation* there is increased vocal resonance. The bronchial factor in the breathing now becomes conspicuous, showing itself by the harshness and relative shortening of the inspiratory element, with the decidedly rough and blowing expiration; also a gradual diminution of the vesicular factor, until the latter disappears entirely, when we have the typical bronchial breathing of extended areas of tubercular infiltration. This sign will now be found in the supra-spinous fossa as well. The high degree of vocal resonance, known as bronchophony, is also superadded as a valuable confirmation of the presence of complete consolidation. The auscultation signs of a concurrent bronchitis may also be present in this and the next stage.

3. In the *third stage* the information furnished by *inspection* is still more decided. Emaciation is extreme, and breathing and the pulse are rapid, the face often flushed. There is flattening over the affected area, and the excursion of respiratory movement is still more limited. In this stage the superficial veins over the involved area may be prominent, partly from emaciation and partly from obstructed circulation. To *palpation* the vocal fremitus is still more marked, and even remains distinct over cavities, because of the consolida-

tion around them, unless there be some obstruction to the entrance of air in the bronchus leading to the involved area. Rhonchal fremitus may be added if adventitious sounds are present. The skin is hot and dry, unless succeeding one of the sweats which characterize this stage, when it may be moist and clammy.

Dulness on *percussion* is always to be found in the third stage, but to it is constantly added some one of the varieties of tympanitic note referred to, viz., pure tympany, the "cracked-pot" sound or amphoric resonance, due to cavities. These require sufficient size and superficial situation on the part of the cavity, and the other conditions described on pages 54, 55, 56 and 57. On the other hand, resonance may even be normal over a cavity some distance from the surface, especially if the percussion be lightly made.

Auscultation in this stage may continue to recognize the bronchial breathing of the second, but to it may be superadded the distinctive signs of a cavity, which may also supplant those of the bronchial breathing. These signs are cavernous breathing, cavernous voice, or pectoriloquy, either whispering or with the ordinary voice, amphoric breathing, and amphoric voice, the full import and conditions of all of which have been described. To these are often added the large bubbling sounds known as gurgling, caused by the air bubbling through the fluid in a cavity. Metallic tinkling may be added to these phenomena, caused by the bursting of bubbles in a cavity with the amphoric conditions.

Fibroid Phthisis or Cirrhosis of the Lung.—Fibroid phthisis does not admit of the same sharp divisions into stages which characterize catarrhal phthisis. Frequently traceable in its initial symptoms to the inhalation of irritating substances, and much more chronic in its course even than the chronic form of catarrhal phthisis, the general clinical history is of great value in distinguishing it from the latter. It is constantly associated in its beginning with pleurisy, and it may be a sequel of it.

The degree of retraction as noted by *inspection* is greater and more easily recognized, and not confined to the apices of the lungs. The heart is frequently dislocated and its apex correspondingly displaced, sometimes to an extreme degree. The intercostal spaces are often narrowed, the diaphragm may be drawn up. The modifications of vocal fremitus as revealed to *palpation* are not nearly as constant, being masked by the retraction and pleuritic complications, and may be absent. There is little or no elevation of temperature.

Percussion is more constant in its phenomena, there being marked dulness and a wooden-like resistance. There is sometimes hypertrophy of the right ventricle due to the extra effort of the right heart to propel the blood through the obstructing lungs. *Auscultation* most frequently notes bronchial breathing and exaggerated voice, but both of these may be lessened in intensity by thickened pleuræ.

A dilated bronchus is a frequent result furnishing the signs of a cavity, which may be in the middle or even at the base of the lung, and furnishes a copious expectoration characterized by a peculiar fetor, in which the microscope sometimes discovers fat-crystals.

To the signs of the fibroid state in one part of a lung are frequently added those of emphysema in the remainder or in the other lung.

The rarity with which the bacillus tuberculosis is found in the sputum in this condition is not regarded as sufficient to exclude it from the category of tubercular diseases.

Acute **miliary tuberculosis** is not accompanied by any distinctive physical signs, and the diagnosis is made from the clinical and hereditary history rather than from such signs. A tympanitic or hyper-resonant *percussion* note is sometimes present throughout the lung in disseminated miliary tuberculosis due to the relaxed state of the air vesicles which such an infiltration favors.

Not every case of tuberculosis of the lungs begins in the apex, nor even when it does thus begin are the physical signs always first discovered anteriorly. Examination of every case should therefore include the posterior portion of the lung, and especially the supraspinous fossæ. Tuberculosis not very rarely succeeds upon a pneumonia as well as upon a pleurisy, and especially a catarrhal pneumonia, when the signs first make their appearance in the area which has been made vulnerable by the previous state.

PNEUMONIA.

Acute croupous or lobar pneumonia, more common in the right lower lobe, presents three easily separated sets of physical signs corresponding to as many stages in the morbid process itself.

The *first*, or *stage of congestion*, in which the air vesicles are still open, is of short duration, terminating within the first twenty-four hours, and may therefore be overlooked. *Inspection* notes the face flushed, increased frequency of respiration, with restricted movement upon the involved side and exaggerated motion on the sound side. The patient lies by preference on the affected side because of the greater comfort it gives him. This posture not only diminishes the pain by hindering the motion of the affected side, but also lessens the dyspnea by permitting unrestrained expansion of the other side which is doing the work.

Palpation at first may even find vocal fremitus diminished on account of the relaxation of the air vesicles, but vocal fremitus becomes decidedly increased as the air vesicles fill up. The skin is hot and the pulse is frequent. *Percussion* obtains but slight if any impairment of resonance. In fact, tympany or the vesiculo-tympany of Flint is frequently present in this stage as the result of the relaxation of the partially filled air vesicles, giving resonance by immediate relaxation. See p. 52.

Auscultation in the very earliest stage may find the vesicular murmur feeble, but very soon is heard the distinctive physical sign of pneumonia, the crepitant râle at the end of inspiration, or if there be coincident pleurisy—pleuropneumonia—the closely simulating friction sound may be added. Over the normal part of the lung there is exaggerated vesicular breathing.

But all of these physical signs, even if carefully sought for, may be wanting if the pneumonia is deep-seated, as is not infrequently the case. They appear as the surface is reached, or they may not be recognized at all if it remains central.

The second stage, or *stage of red hepatization* or solidification, lasting four or five days, furnishes unmistakable signs. All the signs pneumonia reveals to *inspection* in the first stage are intensified in the second, and the breathing is markedly abdominal. To *palpation*, vocal fremitus is now intense, the skin is hot and dry, and the pulse continues frequent.

Percussion gives absolute flatness over the solidified area, with high pitch and short duration, except in those very rare instances alluded to on p. 56, where the extreme consolidation throws the column of air in the trachea and bronchi into vibration, producing tympany. This explanation is perhaps the only one when it occurs in the upper lobe. In a lower lobe, tympany may result in the same way, from the proximity of a dilated stomach. Over the adjacent normal areas, also, resonance is exaggerated in consequence of the supplemental action of these parts. There may even be here tympany or vesiculo-tympany due to the relaxation of the adjacent air-vesicles, an instance of resonance by mediate relaxation. Even cracked-pot sound may be produced by percussion over the solidified lung as the result of the sudden expulsion of air from a large bronchus leading to the solidified area.

Auscultation discerns high-pitched bronchial breathing over the solidified lung. Indeed, these are the circumstances which give the typical bronchial or tubal breathing. The air vesicles are obliterated, and the resulting excellent conducting medium brings the tracheo-bronchial blowing to the ear. The ausculted voice gives us typical bronchophony and occasionally even pectoriloquy, as well as whispering bronchophony and pectoriloquy. The heart sounds are also heard with great distinctness over the consolidated lung, owing to the improved conduction, while the sounds of a concurrent bronchitis are similarly intensified. A lingering crepitant râle may also be heard.

The third stage, or *stage of gray hepatization* or resolution, occupies six to ten days. It repeats largely, to inspection, palpation, and auscultation, the phenomena of the first. Resonance continues impaired for some time. The normal manner of breathing gradually returns, the temperature of the skin is noticeably less, the crepitant râle returns, technically known as the "crepitans redux," and is finally replaced by the normal vesicular breathing sound, by which time the dulness has disappeared.

Croupous pneumonia may rarely terminate in abscess or gangrene, when the signs of the second stage continue, the temperature does not fall, in a word, the crisis does not occur. The signs of a cavity which might naturally be expected are rarely present, and it is rather by the general symptoms, the failure to recover, the continued high temperature, the expectoration of pus, and, in the case of gangrene, the intensely disagreeable odor, that informs us of the issue. These issues probably represent on a large scale what takes place in every instance in minute areas in the third stage of all pneumonias which terminate favorably. The occasional termination in tubercular phthisis exhibits a similar arrest of the resolving process in the second stage, and the phenomena of the catarrhal or fibroid phthisis supervene.

The obscuring effect of a thickened pleura upon all of these signs is to be remembered, and too much stress cannot be laid upon the fact that we may have a central deep-seated pneumonia which may give no physical signs, also that in old persons the physical signs of a pneumonia are very apt to be delayed from one to three days.

Catarrhal or Lobular Pneumonia or Broncho-Pneumonia.—The physical signs of this form of pneumonia are not nearly so distinctive as those of croupous. A circumscribed affection involving a few lobules, the physical signs are necessarily more obscure. Occurring most frequently in the course of a bronchitis in children and in old persons, as well as *de novo* in the former, the physician should be on the watch for it under these circumstances. It also occurs in adults, though more rarely, especially in those suffering from tuberculosis, as the result of insufflation of broken-down tubercular matter, which produces by inoculation and irritation a tubercular broncho-pneumonia. When superadded to a bronchitis under any of these conditions, there ensues increase of fever, embarrassed breathing, and associated increased inspiratory effort. *Palpation* should recognize increased vocal fremitus if the area involved be sufficiently large, *percussion* should reveal dulness and *tympanicity* of *adjacent supplementally acting areas. Auscultation* will also discover in the inflamed area the crepitant râle, the bronchial breathing, increased vocal resonance, and bronchophony, in addition to the physical signs of the concurrent bronchitis.

Embolic Pneumonia and Hemorrhagic Infarct.—Pulmonary Apoplexy.—The effect of the lodgment of an embolus from any source in a branch of the pulmonary artery is to produce an extravasation of blood in the conical area formerly supplied by the vessel. Such an extravasation is called a hemorrhagic infarct. It is, in fact, a circumscribed apoplexy, but the term apoplexy of the lung is better retained for such extravasations of blood, circumscribed or diffuse, as are due to rupture of branches of the pulmonary artery from other causes than embolism. Such is over-distention of blood-vessels in valvular disease of the heart, disease of the blood-vessel wall, or traumatism.

Small infarcts of the lungs may give rise to no symptoms whatever. When large enough they cause sudden embarrassed breathing, rusty expectoration, and circumscribed dulness, all of which increase with the size of the infarcted areas. *Palpation* reveals increased vocal fremitus, and *auscultation* crepitant and sub-crepitant râles, bronchial breathing, and bronchophony. These are the signs of a croupous pneumonia, which is indeed present, the consequence of the infarct, which acts as an irritant. The circumscribed area covered by these signs would exclude an ordinary croupous lobar pneumonia, while the absence of fever, the suddenness of onset, and the presence of cardiac disease aid in the diagnosis.

Similar symptoms may be caused by massive hemorrhage of the lungs or pulmonary apoplexy, caused by the rupture of a large branch of the pulmonary artery, whose wall is weakened by tuberculous infiltration or the engorgement due to valvular heart disease. Such a vessel may suffer a further strain in consequence of some transitory congestion, and rupture occurs. A great mass of blood is poured out, which, besides entering the bronchial tubes and producing hæmoptysis and mucous râles, also infiltrates the lungs, coagulates, and produces consolidation. If the patient lives, the blood in the bronchi may be insufflated into the vessels and there act as an irritant, producing intense inflammation followed by gangrene or abscess.

Pulmonary œdema furnishes many of the signs of the first stage of croupous pneumonia, and is sometimes accompanied by a frothy, pinkish expectoration ; but the absence of fever, and the presence of dropsy elsewhere, or its causes, account for the condition.

Collapse of the Lung.—In the course of a capillary bronchitis there sometimes occurs a collapse of a portion of the lung, owing to a valvular plugging of a bronchus, as the result of which air may pass out during expiration but cannot enter with inspiration, or it may occur as the result of a want of strength to fill the air-cells. The area of collapse often corresponds in size with that of lobular pneumonia.

When such collapse occurs there is sudden difficult breathing noticed on *inspection*, but *palpation* gives no information. *Percussion* reveals dulness, but it is much less marked than in lobular pneumonia, while *auscultation* finds no bronchial breathing, or if present it is very feeble; no bronchophony, but rather diminished intensity of breathing sounds and diminished voice. Collapse of the lung is apt to be symmetrical.

Compressed lung, most frequently due to pleural effusion, generally furnishes flattening, increased vocal fremitus, impaired resonance, increased vocal resonance, and bronchial or broncho-vesicular breathing.

Cancer of the lung furnishes signs of consolidation very similar to those of the second stage of tubercular consumption. Flattening, increased fremitus, dulness, increased vocal resonance, bronchial breathing, all except elevation of temperature, may be present, and it is the history of the case and special symptoms that determine the diagnosis rather than the physical signs. History of heredity, cancer elsewhere, cachexia, more constant and severe pain, are symptoms of importance in the diagnosis. A peculiar currant-jelly-like sputum is much mentioned as characteristic.

PLEURISY.

Acute pleurisy is also resolvable into three stages, each of which is characterized by physical signs more or less distinctive. They include a **dry stage**, a stage of **effusion**, and a stage of **resolution** or **absorption.**

The *first or dry stage* is characterized anatomically by the presence of the so-called lymph or exudate on the pleural surfaces. During this is revealed to *inspection* a restrained expansion of the affected side, often thrown into jerks or catches because of the pain suffered in a continuous inspiration. The expansion on the opposite side, on the other hand, is full and unhampered. The patient is apt to lie on the affected side. Very rarely does *palpation* recognize a fremitus corresponding to the friction of the two pleural surfaces. *Percussion* in this stage is negative, but *auscultation* recognizes the friction sound already described. It may be at a single spot in the infra-mammary or infra-axillary space, and hence be overlooked. At other times it may be noted over a considerable area.

The inflammatory process may stop here and resolution take place, or it may continue into the *second* or *stage of effusion.* The signs of this stage vary with the amount of liquid in the sac. With a small amount, the lungs are slightly floated up, and there may be no signs unless there be a vesiculo-tympany above the line of the fluid, a Skodaic resonance by mediate relaxation of the air vesicles.

The effusion, however, rarely remains so trifling, but commonly rises to the mid-chest. In the upright position of the patient, *inspection* discovers in a spare person shallowness and perhaps obliteration of the lower intercostal spaces. The motion of the chest wall is lessened both in the vertical and transverse directions.

To *palpation* vocal fremitus is diminished over the area of effusion, but may be increased in the lung above it. To *percussion* there is absolute flatness over the area of effusion, but the line of demarcation is not everywhere at the same level, being higher behind than in front. The late Dr. Calvin Ellis first called attention to an S-like curve in the line of demarcation which is said to be diagnostic. Very important in the diagnosis is the fact that the fluid changes its level, and with it the line of dulness, when the position of the patient is changed. There is also an abnormal sense of resistance to the finger in percussing over the area of effusion. Above the effusion, especially anteriorly, there is again Skodaic resonance by mediate relaxation, and even sometimes a cracked-pot sound. Tympany may also be present, due to the proximity of a distended stomach.

To *auscultation*, the breathing sounds are inaudible or very feeble, as compared to the corresponding portion of the opposite side, but vocal resonance, though diminished, is still well heard where the collection of fluid is moderate. Above the line of dulness there is occasionally a friction sound, and close to the root of the lung bronchial breathing may be heard. This is, however, more apt to be the case when the effusion is larger and the lung is further compressed. Egophony is also sometimes heard.

When the effusion is larger, filling up two-thirds or three-fourths of the pleural sac, the effects described are increased, while new ones are added. *Inspection* notes that respiratory movement is still more hampered, the intercostal spaces are widened and even bulging, while fluctuation may sometimes be recognized through them. The heart is displaced by the accumulated fluid, and if it be in the left sac, the apex is often found far over to the right of the median line, and if on the right, the apex is pushed further to the left. Its sounds are not, however, altered further than to be heard more intensely in the situation where they are not usually so heard, because sound is transmitted more readily through a single uniform medium than through two or more of different densities. On the opposite side, the breathing movements are supplementally increased. There is complete absence of vocal fremitus on the affected side.

Percussion is absolutely flat all over the effusion, and Skodaic resonance is not now obtainable because the lung is too thoroughly compressed up into the apex of the sac. Resistance to pressure is marked. On *auscultation* bronchial breathing may be heard at the upper posterior of the lung, because the large tubes are still pervious to air, and the compressed lung intensifies the sound. Sometimes bronchial breathing is heard in more peripheral parts of the chest, probably conducted hither along a band of adhesion or along a rib. Elsewhere there is absence of breath-sounds. Vocal resonance and whispering voice are alike absent, or the former is very feeble. In certain situations, too, high up, where there is but a thin film between the chest-wall and the lung, there may be egophony, but this is more apt to be present as the fluid is being absorbed.

In the *third stage*, if resolution takes place with a gradual retrocession of the fluid and the reëxpansion of the lung, we have a return to normal physical signs. There may be, too, a **friction redux.** A considerable time is, however, required for absorption, and it is often many days before the normal breathing sounds are heard with their usual intensity or the natural fremitus is felt. Often resolution is not complete, and there then remain the symptoms and sequelæ of a chronic pleurisy.

Chronic Pleurisy.—Its symptoms and sequelæ are not uniform. The simplest and most harmless expression is a thickened pleural membrane. In this there is no adhesion between the opposite pleural surfaces, and the motion of the lung is not interfered with. There is, however, a general interference with the conduction of sound, and all the normal physical signs, including vocal fremitus, vocal resonance, normal percussion sounds, and normal breathing sounds are diminished in intensity. For the same reason many abnormal physical signs, as already more than once instanced, are also less plainly heard.

The harmful symptoms of chronic pleurisy are more frequently manifested in the results of delayed absorption of effusion, and in a change of its character from serous to purulent. The resulting accumulation of fluid in the pleural cavity is not always a continuation of acute disease. A chronic pleurisy may originate *de novo*, and often without the consciousness of the patient, although a careful analysis of the case will not fail to find symptoms of ill-health which are explained by the state of affairs ultimately found. Such pleurisies are known as **latent.** With the discovery of the effusion, which may depend more or less on the acumen of the physician, the latency disappears.

Such fluid furnishes the physical signs which have already been detailed on p. 100. Its further effects vary very much according as it is serum or pus. In either event its speedy removal is desirable, because the longer it remains compressing the lung, the longer will the latter be in returning to its natural state. Hence, it is better done by aspiration than by the slower method of medication. If the fluid be serous, and if it has not been too long retained, the lung gradually resumes its normal state, and a thickened pleura is all that remains, with the physical signs referred to as associated with it. Not infrequently, however, the two pleural surfaces, costal and pulmonary, remain permanently agglutinated, and then, although the lung slowly resumes its natural function, there still remains some flattening over the lower part of the thorax, while the signs of a compressed lung may be found at the apex.

If the liquid be pus, we have an **empyema**, and the consequences are much more serious. The occurrence of a chill and continued high temperature will suggest a purulent collection. Baccelli's test may be tried.*

Medical treatment almost never removes it, and aspiration is as invariably followed by reaccumulation. Hence, permanent measures, as the introduction of a drainage tube or exsection of a rib, must be used. Even here, if the drainage tube be inserted early, the lung may resume its natural office, and there may be no more permanent damage than the agglutination referred to, and subsequently a retracted thorax. More frequently, however, we have to do with a lung partly bound by adhesions into its new and unnatural position, while the pleural surface may be looked upon as an extensive ulcer. The restrained lung is unable to expand to refill its natural space, while the huge ulcer referred to must heal slowly with a resulting cicatrix. This cicatrix has the property of all cicatricial tissue. It must contract, and with this contraction drags with irresistible force whatever is attached to it, including the ribs and even the spinal column, which is sometimes drawn out of line. Thus there results distortion, in various degrees, of the shape of the thorax, associated with a

* Baccelli, of Rome, in 1875, suggested a method of distinguishing purulent accumulations from serous. He found that the whispered voice was often audible over these serous accumulations, while it was inaudible over pus collections. Douglas Powell, Transactions of International Medical Congress, 1881, failed to confirm this observation. I have sometimes noted the sign under the circumstances described by Baccelli, but not always.

shortness of breath which is permanent, but which may, nevertheless, grow less as time rolls on.

A result of empyema which remains to be alluded to is a circumscription of pus into two or more separate or communicating spaces. It is not always easy to recognize such a state of affairs. Most frequently it is ascertained by the attempt at removal by tapping, the withdrawal of a certain amount of fluid giving partial relief and leaving areas with physical signs unchanged. Da Costa gives us from Jaccoud* some points to assist toward such recognition. Given, in the area of dulness, a zone along which vocal vibrations are preserved, as from the spinal column toward the sternum, a separation between two portions of fluid probably exists along such line. Again, if voice and fremitus continue, though feebly, except in a zone of a few finger-breadths behind, and at the lower border of the chest, while no tympanitic sound can be elicited under the clavicle, it may be concluded that the effusion is multilocular. When diaphragmatic adhesions exist, the normal movements at the epigastrium and hypochondrium are reversed, and the inspiration is accompanied by depression in the lower intercostal spaces instead of a filling out.

One other feature must be pointed out as associated with such collections, and that is, pulsation sometimes communicated to them by the heart. Hence the term **pulsating empyema.** Such a one recently occurred

* Da Costa, op. citat., p. 366, from Bulletin de l'Académie de Médecine, 1879.

to the writer. It was below the left clavicle, and so striking that he hesitated to puncture it lest it be a pulsating auricle or an aneurism. The knowledge that there was pus elsewhere in the pleural sac, the elevation of temperature, and the absence of sound or murmur or thrill seemed to justify operation, and a large quantity of fetid pus was drawn through a communication made with a pus cavity lower down. The tumor and pulsation and fever disappeared, and the patient, who was a girl, recovered.

PNEUMOTHORAX.

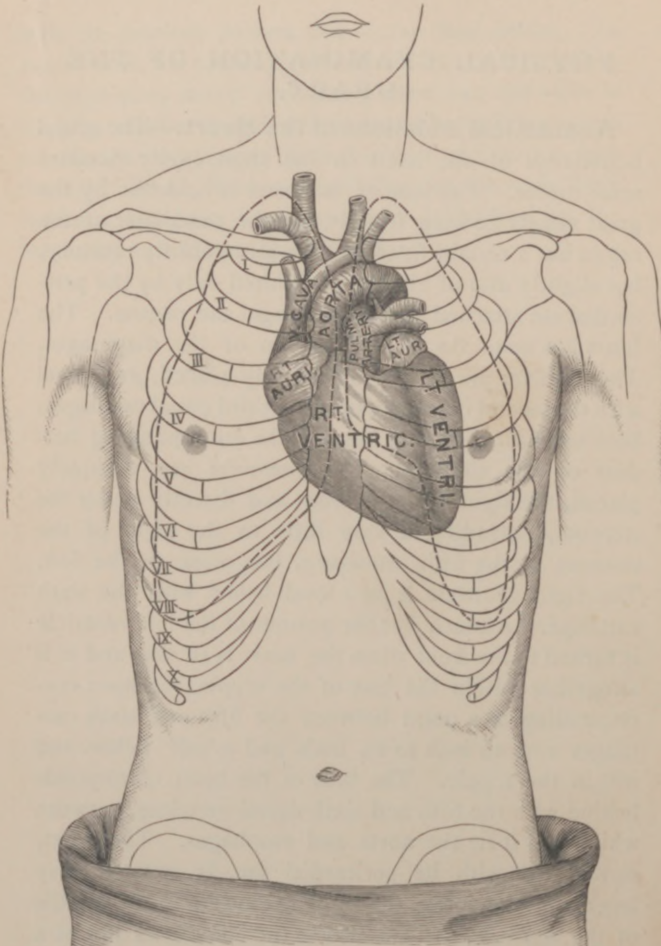
This comparatively frequent complication of tubercular consumption commonly results from the rupture into the pleural sac of a cavity in the lung, an accident usually brought about by a fit of coughing. This results in a rapid filling of the pleural cavity with air, which is soon followed by an effusion of liquid, generally purulent. The result is a distended air sac occupied to a certain height with liquid, compressing somewhat the lung and displacing the heart, while the physical conditions are those of a resounding cavity.

The effect on the physical signs is as follows: To *inspection* a bulging chest, a filling out of the intercostal spaces. The thoracic wall on the affected side diminishes its excursion of respiratory movement, or it appears at a standstill. *Palpation* appreciates no vocal fremitus. *Percussion* furnishes over most of the half of the thorax involved the most striking of the percussion notes, the ringing, amphoric resonance, which contrasts strongly with the absolute dulness due to the fluid below. To *auscultation* the breathing sounds are distant and feeble, the expiratory sound continuing short, but the voice is ringing, amphoric, and an unmistakable tinkling sound attends the dropping of fluid from the perforation into the fluid below. To a sudden shaking of the body there results a splashing sound similarly intensified by the reëchoing to which it is subjected.

PHYSICAL EXAMINATION OF THE HEART.

Anatomical Relations of the Heart.—The actual boundaries of the heart in the chest cavity demand some notice. The base of the heart is held fast by the great vessels coming from it, but the remainder of the organ has a certain freedom of motion chiefly rotatory, but slightly also of elongation limited only by the pericardial sac attached to the diaphragm and pleuræ. The heart lies upon the central tendon of the diaphragm. The *auricles* are nearly transversely placed, on a level with the second interspaces and the third costal cartilages, both extending slightly beyond the corresponding borders of the sternum. The *ventricles* are obliquely placed, the right being in front and directly under the sternum, extending a very little to the right of the sternum at the fifth interspace, but more to the left. The right ventricle is on a level below with the sixth cartilage. A much smaller portion of the left ventricle is turned to the front when the heart is *in situ*, and it is altogether within the line of the nipple, the apex corresponding to a point between the fifth and sixth cartilages and an inch to an inch and a-half below and within the nipple. The base of the heart corresponds behind with the fifth and sixth dorsal vertebræ, between which and it lie the aorta and esophagus. The heart, surrounded with its pericardial sac, is covered very largely by the lungs, the right extending to the middle of the sternum, the left also to the middle as low as a

Fig. 18.



Position of Heart in Relation to Ribs and Sternum.

line continuous with the lower edge of the fourth cartilage, along which it passes, thence obliquely across the fourth interspace and the fifth rib, the lung covering the whole of the left ventricle, except the apex.

The **size** of the heart approximates that of the fist of its owner. I am inclined to think it is frequently a little larger. Its weight in adults is for males 311⅔ grams (11 ozs.); for females 255 grams (9 ozs).

The Præcordium.—By the **præcordial region** or **præcordium** is meant that portion of the thorax covering the heart, and it may be said to be bounded above by a line drawn through the junction of the manubrium with the blade of the sternum, below by a line drawn along the upper edge of the sixth cartilage, and laterally by a vertical line drawn through the seat of the apex-beat, and another three-fourths of an inch to the right of the sternum. In this region inspection and palpation recognize the apex-beat between the fifth and sixth ribs and an inch and a half below and within the nipple. In children it may be found an interspace higher, and in the aged and persons with long and narrow thoraxes it may be an interspace lower. Occasionally, in the second interspace to the left of the sternum in thin persons, a feeble impulse can be seen produced by the dilatation of the left auricle. The situation of the apex is slightly altered by changes of position or by distention of the stomach from any cause. The act of breathing, however, influences it most. With a deep breath the heart descends and is pushed inward by the inflated lung, and the impulse approaches the epigastrium. On a deep expiration it rises slightly, and while the breath is held remains higher. The apex-beat is rendered more distinct by exercise or emotion. This is still more the case in pathological states where there is enlargement. Emphysema of the lungs and effusion into the pericardial sac render it more or less indistinct. Its position is also variously changed by morbid conditions, and a thrill or fremitus is sometimes communicated to the hand in valvular diseases.

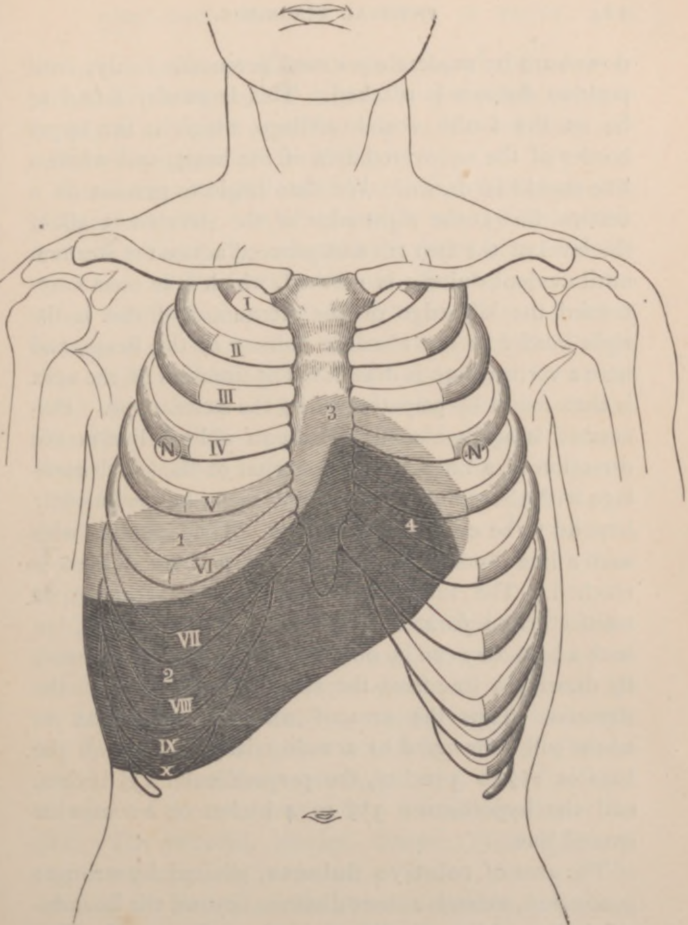
Fremitus is also sometimes noticeable as the result of pericardial friction. The whole præcordial region is sometimes abnormally prominent in hypertrophy and pericardial effusions, especially in the young, while retraction due to adhesion is also seen. In the neighborhood of the præcordium, at the root of the neck, pulsations, arterial and venous, are noted, also epigastric pulsations, which will be explained under the head of the conditions that produce them.

PERCUSSION AND AUSCULTATION OF NORMAL HEART.

The **percussion boundaries** of the heart have been already mapped out on page 45, but it may not be amiss to review them at this point somewhat more in detail.

The Percussion Borders of the Heart.—To map out the percussion borders of the heart, we begin percussing on a horizontal line at the left edge of the sternum, at about the second interspace, proceeding

Fig. 19.



Showing Absolute and Relative Percussion Dulness of Liver and Heart. 1. Relative Percussion Dulness of Liver. 2. Absolute Percussion Dulness of Liver. 3. Relative Percussion Dulness of Heart. 4. Absolute Percussion Dulness of Heart.

downward by moderately strong percussion, only, until positive dulness is reached. This is usually found to be on the fourth costal cartilage, which is the upper border of the uncovered area of the heart, and where a line should be drawn. We then begin to percuss on a vertical line at the right edge of the sternum at about the level of the fifth rib and proceed across the sternum until evident dulness is reached, which is in most cases toward the left edge of the sternum, and this is the right border of the absolute dulness of the heart, and here a vertical line is drawn. The situation of the apex is then found by palpation or by the stethoscope. Percussion is again commenced on an oblique line in the direction of a line from the junction of the fourth cartilage with the sternum toward the apex, but sufficiently beyond to be certain of clearness. Then parallel with such a line proceed downward until positive dulness is reached. The lower border of the heart cannot be satisfactorily separated by percussion from the liver, but such a boundary can be obtained with sufficient accuracy by drawing a line from the apex perpendicular to the sternum. Thus the area of **absolute dulness** in adults will correspond to a rude triangle of which the base is 2½ to 3 inches, the perpendicular 2½ inches, and the hypothenuse 3½ to 4 inches on a somewhat curved line.

The area of **relative dulness**, elicited by stronger percussion, extends a short distance beyond the boundaries indicated in every direction except downward. The exact measure of this must depend somewhat on the delicacy of the ear of the examiner and the mode in which he percusses, but it may be put down approximately as a finger's breadth, and on the left side still within the nipple line in adults.

Various causes influence the area of cardiac percussion dulness in health. In children, the area of the cardiac dulness is decidedly reduced on account of the intense resonance of the child's thorax. In old age, on the other hand, the area of absolute cardiac dulness is increased on account of the shrinkage of the lungs. The upper border of absolute dulness may be at the third rib, and the apex may be in the sixth interspace. The effect of a deep inspiration is materially to diminish the area of dulness, while that of expiration enlarges it.

Pathologically the normal area is increased downward to the left in hypertrophy of the left ventricle, downward toward the epigastrium and to the right in hypertrophy of the right ventricle.

The **Auscultation** of the **normal heart** is very simple. It consists in the recognition of the normal heart-sounds, known as first and second. Both sounds are audible over the whole precordial region in health, but the **first sound**, characterized by its longer, booming character and lower pitch, is heard most loudly at the seat of the *apex beat*, where it is the louder of the two. The **second**, shorter, sharper, higher-pitched, and more snapping in character, is most intense at the base of the heart, *on the sternum opposite the second interspace*. Both sounds are heard at both situations, but each has its situation of greatest loudness. Hence, at the apex the rhythm may be said to be represented by the trochaic foot — ⌣, while at the base it is represented by the iambus ⌣ —. The two sounds have also been long compared to the word *lub-tup*, the first syllable corresponding to the first sound, and the second to the second part. While this word cannot be said to resemble the heart-sounds very closely, there seems to be no other that resembles them more.

As to the **mechanism** of the sounds, while that of the first is probably somewhat complex, including the shutting down of the auricular ventricular valves, the apex beat, the rush of the blood through the aorta and pulmonary artery, and the noise of the muscular contraction, it is sufficient for clinical purposes to consider it produced, as it undoubtedly is for the most part, by the shutting down of the auriculo-ventricular valves, the mitral or bicuspid on the left side, and the tricuspid on the right. Both sets of valves shut down simultaneously, both contribute to the production of the sound, while the greater muscular power of the left side gives to it a distinct predominance.

The second sound is of simpler mechanism, and is caused solely by the shutting down of the semilunar valves of the aorta and pulmonary artery with the recoil of the blood upon them. On account of the more powerful recoil in the aorta, the aortic is the predominating sound.

We may isolate the part played by each set of valves by carrying the stethoscope to certain situations, and in diagnosis constant advantage is taken of this. Thus, in order to pick out the mitral part of the first sound,

FIG. 20.

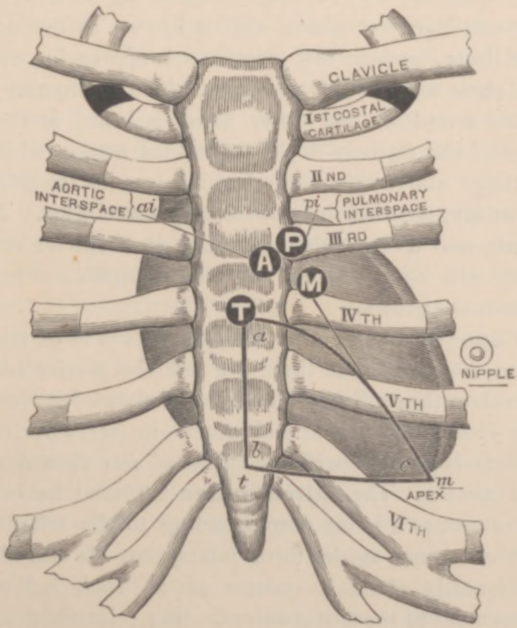


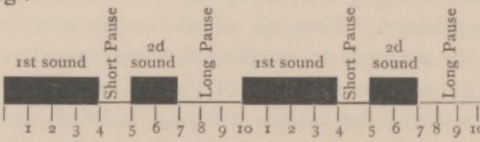
Diagram showing the Location ot Cardiac Valves and Points of Maximum Intensity connected with them. The triangle, *a b c*, is the area of superficial or absolute dulness. A corresponds to the anatomical *seat* of the aortic valves, P to the pulmonary, M to the mitral, T to the tricuspid. The points of greatest *intensity* of the sounds are *ai* for the aortic, *pi* for the pulmonary, *m* for the mitral, *t* for the tricuspid.

the stethoscope is placed at the seat of the apex beat, while the tricuspid factor is best heard at the left sternal border, between the fifth and sixth cartilages. So with the second sound, the aortic factor is best heard at the second interspace to the *right* edge of the sternum; and the cartilage just above this is known as the **aortic cartilage,** because this great vessel approaches next to the chest-wall in this situation. The pulmonary part of the sound, on the other hand, is heard at the *left* edge of the sternum at the second interspace, while the cartilage above this, behind which ascends the pulmonary artery, is called the **pulmonary cartilage.** These points, and a circle about an inch in diameter around them, are known as the mitral, tricuspid, aortic, and pulmonary **areas.**

Topography of the Valves.—It is to be remembered, however, that these are not the *precise seats* of the valves themselves. These are all situated in wonderfully close proximity to each other—in fact, a portion of each is contained within a space of *less than half an inch square.* The **mitral valve** is placed behind all the others, at a point corresponding to the left border of the sternum at the third interspace. It lies almost horizontally about a quarter of an inch below the attachment of the aortic valves. The **tricuspid valve** corresponds to a line drawn obliquely across the sternum from the third left interspace to the fifth costal cartilage of the opposite side. The **aortic valve** lies nearly horizontally behind a line joining the middle of the sternum and the end of the third left costal cartilage. The **pulmonary valve,** a little higher and to the left of the aortic, runs quite horizontally, corresponding to a line drawn along the upper border of the third left costal cartilage. Thus all of the valve attachments except the tricuspid are horizontal or very near horizontal. The want of identity of the auditory valve area, or place where the sounds are best isolated, with the actual sites of the valves, is due to the fact that the sounds are best heard at points on the chest-walls nearest the cavity or channel in which vibrating blood is flowing.

The normal heart-sounds are heard less loudly over the normal areas during deep inspiration, when they are more completely covered by the fully expanded lungs, and the first sound is heard more loudly at a new point toward the median line, to which the apex is pushed by the inflated lungs. On the other hand forced expiration increases the area over which the sounds are heard.

The **time** of the normal heart-sounds requires some further study because on a thorough understanding of this depends largely skill in diagnosis. The first sound begins with the systole of the ventricles and is coincident with the apex-beat, the second occurs in the diastole, immediately after the first, with a short pause between. The second sound is succeeded by a longer pause occupied with the diastole of the ventricles, during the latter part of which occurs the systole of the auricles, terminating the diastole of the ventricles. Thus if a revolution of the heart's sounds and pauses be represented by a dash and interspaces we will have the following :—



of which the first sound will occupy four-tenths, the short pause one-tenth, the second sound two-tenths, and the long pause three-tenths.

It is to be remembered that each one of these sounds is double, two systolic occurring at the ventricular orifices, and two diastolic at the aortic and pulmonary orifices. It may be further conceded that the first sound is heard at the base of the heart and the second sound as heard at the apex are simply conducted from the seat of their production, and that they are in no part produced at the situation where they are less loud.

ABNORMAL MODIFICATIONS OF HEART-SOUNDS.

It is not impossible, even in health, to have these paired sounds separated, and thus is produced what is known as **reduplications** of the heart-sounds, a phenomenon more common in diseases of the heart. Thus, as the effect of running there may result such an engorgement of the lesser circulation and high tension in the pulmonary artery, that the pulmonary valve closes a little sooner than the aortic, and reduplication of the second sound occurs. In like manner the closure of the triscupid valve may be retarded, the synchronism destroyed, and reduplication of the first sound thus produced. The first sound is reduplicated at the end of expiration and beginning of inspiration, the second at the end of inspiration and the beginning of expiration. The same and similar conditions operate to produce reduplication of the heart-sounds in disease.

The **intensity** of the heart-sounds is greater in persons with thin chest-walls and under the influence of excitement. Abnormally the feverish state and general hypertrophy have the same effect, but the latter is more apt to influence the sound of the particular cavity which is hypertrophied. The heart-sounds are often heard with unusual distinctness at points distant from their normal areas because of consolidation of adjacent lung, and sometimes inexplicably. Intensification or accentuation, as it is called, of the aortic or pulmonary element of the second sound is caused by whatever produces increased tension in the arterial or pulmonary circulations. Heart-sounds are also sometimes made ringing by their proximity to a cavity with firm walls or even a tensely distended stomach.

Abnormally, heart-sounds are rendered less intense by general and cardiac weakness, fatty degeneration of the myocardium, pericardial and pleural effusions, and emphysematous lungs, which cover up the heart more completely.

Abnormal Heart-Sounds or Murmurs are modifications of the normal sounds, either superadded to them or altogether substituting them. These are produced within the cavity of the heart, and are accordingly known as endocardial. In addition an altogether new sound is engendered external to the heart, and therefore called exocardial or pericardial. To this the term murmur is also applied, although the mechanism of its production is so widely different it does not seem to me desirable to perpetuate the practice.

The **endocardial sounds** or heart **murmurs** are sounds produced by an alteration in the conditions of normal blood currents either by structural changes in the heart or its valves, or in the composition of the blood.

The former are called **organic** murmurs, the latter **functional** or **accidental.*** Both are the result of vibrations or oscillations in the blood stream produced by the causes referred to, and not of a friction between the blood current and the narrowed orifices or inequalities on them. Hydraulic laws teach us that when a fluid passes through a tube the inner surface of which it wets, a thin film of fluid becomes attached to this surface, over which the remainder of the fluid moves without friction. So it is with the cardiac cavity and its valves over which the blood moves. Further, while a fluid is passing along a tube of uniform diameter at a moderate

* The term inorganic is sometimes applied to the functional murmurs, but this word has another meaning so definite, that of mineral, that it seems almost misleading to apply it in the sense referred to in the text.

speed, no murmur results, whether the inner wall of the tube be smooth or rough. A murmur is only produced when the tube becomes suddenly narrower and then widens again, and the greater the narrowing the less speed of current required to produce the murmur. Thus the vibrations arise, and thus the sound is produced.

In the case of functional murmurs which apparently occur without the intermediation of sudden narrowing, we must suppose such a change in the composition of the blood, either as to its density or viscidity, which permits it to be more readily thrown into vibration. In either event there is a derangement of that normal adaptation of the column of blood to the orifices and cavities through which it has to pass, which, under ordinary circumstances, permits the function of the heart to be performed noiselessly except so far as its normal sounds are concerned. In the case of the organic murmurs the alteration is produced by the various valvular defects to which the heart is subject, in that of the functional murmurs by the various anæmias which are principally associated with such murmurs. The true valvular murmurs may be intensified by conditions of the blood.

It should be mentioned that Ernest Sansom considers that the vibration of solids is by far the most important in the generation of murmurs, the influence of fluids being intermediate, and not immediate.*

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* "Diagnosis of Diseases of Heart and Aorta." Philadelphia 1892, p. 236.

ORGANIC MURMURS.

An organic murmur may be produced at any one of the four cardiac orifices, mitral, tricuspid, aortic, or pulmonary. They are far more common at the mitral and aortic.

Murmurs are also classified as systolic and diastolic. **Systolic** murmurs occur during the systole of the ventricles, **diastolic** murmurs during their diastole, and these alternate with the apex beat. A diastolic murmur which immediately precedes the systole is called a **presystolic** murmur. Murmurs are further classified as direct and indirect. **Direct** murmurs are those which arise in the blood current as it is flowing in the normal direction; **indirect** are those which arise in a current flowing opposite to the natural direction. The order in which murmurs are considered is of little importance. Their great frequency seems a sufficient reason for taking up mitral murmurs first.

Mitral Murmurs.—*The mitral systolic or mitral indirect murmur.*—During the systole of the ventricles the auriculo-ventricular orifices in a perfect heart are closed in order to prevent the return of the blood to the auricles, while the aortic and pulmonary orifices are wide open to carry the blood into these great vessels, and the ear placed at the apex hears mainly the first sound. If, however, there be a defect in the mitral valve as the result of which it closes imperfectly, then, during the systole a stream of blood will flow backward into the left auricle accompanied by a murmur.

This is the mitral systolic murmur, and it means **incompetency** or **insufficiency** of the valve with consequent **regurgitation** of blood. The mitral systolic murmurs are almost invariably best heard in the mitral area at the apex, and are conducted into the left axilla and under the angle of the left scapula. Rarely, however, they are heard just to the left of the pulmonary area, probably because the vibrations are conducted into the appendage of the auricle and are best heard where this approaches nearest the surface, namely, an inch and a-half to the left of the pulmonary area. This occurs more frequently, too, with functional murmurs.

Mitral diastolic and *presystolic murmurs, or mitral direct murmurs.*—During the diastole of the ventricles the aortic orifice is closed and the mitral orifice open, and the blood flows noiselessly into the left ventricle, the filling of which is finally completed by the systole of the auricle. If, however, the mitral orifice be narrowed from any cause, the blood column is thrown into vibration and a murmur results—a diastolic murmur. When, as frequently happens, the narrowing or stenosis is not sufficient to cause a murmur throughout the entire diastole, but only when the additional momentum is given to the blood by the systole of the auricle, a murmur occurs only at this time—that is, just before the systole commences. It is then called *presystolic*. These murmurs mean, therefore, **mitral stenosis**, which is, however, generally associated with incompetency of the mitral valve. The systolic mitral murmur is, for the most part, soft, but may have every variety of character and be high pitched or low pitched, but the presystolic is always rough, and is variously characterized as rattling, rolling, churning, grinding, blubbering, and bubbling, being compared to the vibration by the lips caused by blowing the breath through them. The sound is further characterized by its *abrupt* termination, although this is not invariable. It may also disappear for a time or even altogether. A presystolic thrill, felt at the apex of the heart, often accompanies the murmur. These murmurs are best heard in the mitral area, and are *not*, as a rule, *conducted* thence in any direction. In Dr. Sansom's experience the murmur is heard rather to the right of the apex.

A diastolic murmur heard in the mitral area may also be due to aortic regurgitation, the sound being conducted from the seat of its production to the apex; but the greatest difficulty in the recognition of the presystolic murmur is its separation from a systolic mitral murmur, a difficulty which is increased in mitral stenosis because in this condition the first sound is usually short, resembling the second. The point, therefore, is to get the exact time of the murmur by noting carefully in association with it the apex beat or the carotid pulse, not the radial, because the latter is often not synchronous with the systole of the ventricles.

Aortic Murmurs.—*Aortic systolic or aortic direct murmur.*—During the systole of the ventricles in health, the aortic orifice is wide open, and the blood flows noiselessly through it. If any interference with the complete opening of the orifice, or roughness or inequalities exist, the stream of blood is thrown into vibration, and the aortic systolic murmur results, heard at the base of the heart. Such a murmur, therefore, means narrowing or **stenosis** of the **aortic orifice** or **roughening** only of the beginning of the aorta. It is generally loud and harsh, sometimes musical, heard most loudly in the aortic area—second *right* interspace—but generally all over the præcordium. It is conducted into the great vessels of the neck with great intensity.

Aortic diastolic or aortic indirect murmur.—During diastole the aortic orifice should be closed and impermeable to blood. If, however, as the result of disease, perfect closure be impossible, a stream of blood will flow backward into the left ventricle, accompanied by a murmur at the base of the heart which is the aortic diastolic, and means always **insufficiency** or **incompetency** of the **aortic** valve. This murmur is generally soft, long, and blowing, and varies more in the seat of its intensity than any other cardiac murmur. Generally loudest in the aortic area, but often louder than this over the midsternum, it is even well heard as low as the ensiform cartilage, or at the apex itself. It has been mistaken in this situation for a presystolic mitral murmur. It is also transmitted downward along the sternum and toward the apex, because it is in this direction that the column of regurgitant blood is moving. It is accompanied by a powerful heaving impulse, and the characteristic trip-hammer or Corrigan pulse, characterized by its rapid rise and sudden fall. It also occurs alone, but is frequently associated with the aortic systolic murmur, indicating stenosis as well as incompetency.

Murmurs in the Right Side of the Heart.—The same conditions at the valve orifices on the right side of the heart produce similar murmurs, but they are very much rarer. Thus **tricuspid regurgitation** produces the tricuspid systolic murmur, and **tricuspid stenosis** produces the tricuspid presystolic murmur. These are heard in the tricuspid area at the lower part of the sternum, at its junction with the fifth and sixth cartilage. Tricuspid regurgitation is apt to occur sooner or later in connection with mitral disease, but independent of mitral diseases it is very rare, being generally congenital. See, however, p. 157. **Pulmonary stenosis** scarcely occurring, except congenitally, produces the pulmonary systolic murmur, and **pulmonary regurgitation**, the rarest of all, would produce a diastolic murmur. Both are heard in the pulmonary area at the second interspace, at the left edge of the sternum.

Impurity of Heart-Sounds.—In addition to the easily recognizable abnormal sounds described, there occur more or less marked modifications of the normal sounds due to slight defects of the valves, which render them less typical, whence the term impurity of heart-sound. They may be caused by slight thickenings or other changes which modify the normal closure of the valves, and are of uncertain significance. On the other hand, very decided alterations in the valves and orifices are sometimes found at the necropsy when no modifications of the normal sounds were detectable during life.

The Exocardial or Friction Sound.—The only true exocardial murmur is the **pericardial friction** sound caused by rubbing of the two surfaces of the pericardium upon each other, in health a noiseless act like that of the pleural surfaces. When roughened, however, by disease a to-and-fro sound of varying loudness and harshness is heard. The most frequent cause is pericarditis, but any cause which roughens the two opposite surfaces, such as tubercular and other morbid growths, will produce a friction sound.

The friction sound sometimes resembles the intracardial murmur, but a little experience enables one to distinguish them. The friction sound is a superficial to-and-fro sound heard directly under the ear, commonly loud and rasping, never blowing, sometimes creaking. It is most loud over the middle of the heart, not synchronous with the normal heart-sounds and not conducted in the direction of the blood-current. It is often influenced by changes of position or by breathing. It may sometimes be felt by the hand placed over the heart. It is generally of short duration and disappears with the filling of the pericardium by effusion.

A friction may be *pleuro-pericardial,* that is, given a local pleurisy, the pericardium in its motion over the rough surface of the pleura may produce a friction sound simulating pericardial, but such friction ceases with the complete holding of the breath.

Cardio-respiratory murmurs are systolic murmurs heard at the end of a full inspiration, and are caused by the heart's impulse forcing with its contraction the air out of some adjacent air vesicles, or possibly even a cavity. The sound resembles a soft systolic murmur, but ceases when the breath is held in expiration. Similarly caused are *pulsating crepitations.*

FUNCTIONAL, OR ACCIDENTAL, OR HÆMIC MURMURS.

These are murmurs usually supposed to arise independently of any abnormality in the state of the cardiac valves or orifices. They have certain characters by which they are commonly distinguished from organic murmurs, although such distinction is not always easy. 1. They are invariably systolic. 2. They are almost always soft and blowing, and greatly influenced by posture, being more pronounced in the recumbent position than in the upright, although this relation is sometimes reversed. 3. They are most frequently basic, and far more commonly pulmonary than aortic, but occasionally they are heard at the apex. 4. Functional murmurs are unattended by the unequal distribution of blood and the alteration in the size of the heart and its cavities, which always, sooner or later, accompany the organic murmurs.

They have heretofore been regarded as due to some condition of the blood, as the result of which its particles are thrown into vibration more readily than in health. Hence they are also called hæmic murmurs. Such condition is generally accompanied by a watery state of the blood; for this reason they are also called anæmic murmurs, being especially frequent in anæmia and chlorosis, and in women immediately after child-birth. Whether it be this thinness of the blood which is responsible for the murmur, or some accompaniment of such a state is not known. These murmurs also occur in connection with various morbid states of the blood, such as that of the infectious fevers, leucocythæmia, chlorosis, and the various anæmias; also in certain neuroses, especially Graves' disease and allied affections. In these latter there are also arterial murmurs, which are ascribed to vaso-motor influences producing inequalities of caliber, which engender murmurs. From these facts Sansom reasons to a similar origin of the murmurs in the great vessels in neuroses and anæmia. The ventricle, weakened by impaired nerve force, toils to overcome an unusual resistance in the great vessels due to tension, and the muscular fibrillæ of the conus just below the valves are thrown into tremor. The valves themselves may vibrate, and these vibrations are communicated to the area of the thorax adjacent to these vessels through the portions of the vessels immediately above the valves. The right ventricle and its conus are more superficial, its muscular walls are thinner, and in the conditions named it has to contend against relatively greater obstruction, hence murmurs at its site are more frequent.

Certain systolic murmurs at the *apex*, associated with anæmia and neuroses, but unaccompanied by valve lesions, Sansom ascribes to an actual mitral regurgitation, the result of weakness of the muscles concerned in closure of the mitral orifice. Other explanations than theseare as signed by various authors, for information as to which the student is referred to Sansom's recent work on "Diseases of the Heart and Thoracic Aorta." I will only add that Balfour, for one, holds that the pulmonary murmur is not an arterial, but an auricular murmur.

VASCULAR MURMURS.

In the examination of arteries the stethoscope is applied—for the carotid, at the insertion of the sterno-cleido mastoid muscle into the clavicle and sternum, and carried upward along the anterior edge of the muscle; for the subclavian, *behind* the clavicular insertion of the sterno-cleido mastoid muscle, the arm being dependent; for the brachial, on the inner border of the biceps at the bend of the elbow, with the arm partially flexed, and for the crural, in the popliteal space. Care should be taken to apply the stethoscope very lightly, as the pressure itself will engender a sound which is called the acoustic pressure murmur. This may be made self-audible at almost any time with sufficiently quiet surroundings by pressing upon the artery in front of the ear.

Normal Arterial Murmurs.—Considering the apparent simplicity of the matter, there is a singular discrepancy in the statements concerning the so-called normal arterial murmurs. I am inclined to agree with W. Russell, who says no murmur **originates** in the great vessels of the neck in health, unless it be as the result of undue pressure with the stethoscope. On the other hand, there can be no doubt that two sounds are commonly heard on such auscultation. My own observations go to show the following: If a stethoscope be thus lightly placed over the carotid or subclavian arteries, so as not to compress the vessels, two sounds are heard with each movement of the heart—one corresponding to the systole of the ventricles and the expansion of the arteries, the other to the diastole of the heart and the contracting recoil of the arteries. The longer and louder is the second or aortic heart sound, conducted from the site of its production, the aortic valves. The second, shorter and fainter, is the first sound of the heart, similarly conducted. The first of these sounds is occasionally heard in the abdominal aorta, more rarely in the brachial and femoral. The second sound is not thus conducted.

Abnormal Arterial Murmurs.—Abnormal sounds are conducted into the arteries in valvular disease of the heart, particularly aortic disease, both obstructive and regurgitant, and rarely also in mitral disease. The systolic murmur of aortic stenosis is that pre-eminently conducted into the great vessels of the neck.

Finally, murmurs may arise in the arteries themselves from any causes which produce a change in the diameter of the vessel, such as aneurismal dilatation, congenital narrowing, or narrowing due to thrombi or to compression caused by adhesions, contraction of cicatricial tissue, morbid growths or inflammatory infiltration, or the pregnant uterus. Thus a murmur may occur in a branch of the pulmonary artery from pressure by a tubercular deposit or pneumonic infiltration or enlarged bronchial gland, and a murmur may even be produced in the subclavian artery by a tubercular deposit at the left apex. A murmur in a branch of the pulmonary artery from such cause is intensified during expiration, while a murmur in the left subclavian from the same cause is said to be intensified by holding the breath at inspiration. Thyroid tumors in the neck also produce arterial murmurs by pressure. The **placental murmur** is a mixed venous and arterial murmur.

Venous murmurs are distinguished from arterial murmurs by their continuousness as contrasted with the intermittent arterial murmur. An acoustic pressure murmur may be produced in any vein which is large enough, as the jugular and femoral, by pressing slightly upon it with the stethoscope, without, however, pressing so hard as to obliterate the blood current.

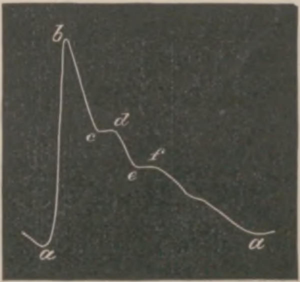
Murmurs independent of such pressure are sometimes heard in these large veins, including the femoral, as the result of tricuspid regurgitation, but the principal pathological venous murmur is the **venous hum** or **bruit de diable.** It is compared to the sound heard on placing a sea shell of moderately large size against the ear. It is frequently heard in chlorotic females over the bulb or dilatation of the internal jugular vein ; also sometimes in the large intra-thoracic trunks, the superior cava, and the innominata. It is best heard on the right side by turning the head as far as possible to the left and then placing the stethoscope above the right clavicle behind the sterno-cleido mastoid muscie. It is a **continuous** soft murmur resembling the humming of a top, and by its continuousness can be readily distinguished from an intermittent arterial murmur. This murmur cannot be regarded as always abnormal, since it is often heard in healthy individuals. Thus Winterich found it in 80 per cent. of the Bavarian cuirassiers whom he examined. It is much more frequent in women than men in the proportion of 7 to 1, according to Aran. Extreme loudness may be regarded as an indication of abnormality. Its presence may especially be regarded as corroborative.

THE SPHYGMOGRAPH IN DIAGNOSIS.

Whatever the diagnostic value of the sphygmographic tracing in valvular heart disease, and it is sometimes considerable, no study of a case of such disease is complete without it. While the original sphygmograph of Marey probably furnishes as good a tracing as any of the modern instruments, the latter have the advantage of cheapness. That of Dudgeon is the most popular at the present day, especially Richardson's modification with sphygmometric attachment. Directions for its use and the preparation of suitable paper always accompany the instrument. Space need not therefore be occupied by them. By means of the sphygmometer varying degrees of tension may be measured before the tracing is made. In the pulse of low tension the maximum movement of the lever is attained with slight degrees of pressure, and small increase of the same tends to extinguish the tracing. In pulses of high tension the maximum excursion of the lever is brought only by rather strong pressure, and the strongest pressure will not extinguish the tracing.

The Normal Pulse Tracing.—This is shown in the drawing. It consists, first, of a vertical or almost vertical upstroke, *a b*, a sudden oblique fall, soon interrupted by a notch, *c*, followed by a short rise to *d*, another fall, a second notch, *e*, and another rise to *f*,

FIG. 21.



Normal Sphygmogram Enlarged. *a b*. Percussion upstroke. *a b c*. Percussion wave. *c d e*. Tidal or predicrotic wave. *e f a*. Dicrotic wave. *d e f*. Aortic notch. *f a*. Diastolic notch. (*Sansom*.)

followed by an undulating fall to the base line of the sphygmogram. The anacrotic or upstroke, or *percussion stroke*, as it is also called, is the effect of the sudden dilatation* of the artery upon the lever, which, having

* It is held by Broadbent that no actual increase of the lumen of the artery takes place in the formation of the pulse, but that with the filling of the vessel it simply changes from the oval to the circular shape. This seems, however, to be an error, as an actual increase in diameter is easily demonstrable by suitable instruments.

reached its maximum height, falls to rise again and form the so-called *tidal* or *predicrotic wave*, *c d e*. This wave is still a part of the effect of the distending force of the vessel on the lever, which through its inertia is carried too high, then falls, and is again caught by the still dilating vessel and carried to *d*. Thus these two waves are really but one. The vessel now begins to collapse and the lever to fall with it, but soon rises again to form the curve, *e f a*, called the *normal dicrotic wave*, while the notch immediately before it is the *aortic* or *predicrotic* notch. The dicrotic wave is the result of a second rise of the vessel wall due to the elastic recoil of the over-dilated aorta on the contained blood, which, being prevented from going backward by the closed aortic valves, moves forward, producing the dicrotic wave. The second sound of the heart is found to coincide exactly with the predicrotic notch, *d e f*. Subsequent slight waves, which may or may not be present, are ascribed to vibrations due to the elasticity of the vessel. The further the vessel tested is from the heart, the greater is the distance as a rule between the dicrotic and the predicrotic wave. The pulse wave reaches the more distant parts of the arterial system at successive intervals.

The effect of increased pressure of the button of the sphygmograph on the artery is to shorten the first or percussion wave, and to render the dicrotic wave more distinct, also the smaller vibrations in the down stroke. Apart from this, the altitude of the percussion stroke depends upon the quantity of blood thrown from the ventricle, but is more or less peculiar to the individual, and its smallness in one as compared with another does not necessarily imply that such person has an abnormality in his circulatory apparatus, while the tracings, even in the two radials, of a person perfectly healthy may not be identical, because of difficulty in applying the instrument in precisely the same manner, or of anatomical differences on the two sides, making such application impossible. The special features of the sphygmogram in different cardiac affections will be given in connection with these.

FIG. 22.

Sphygmogram showing Prolonged Arterial Tension. (*Sansom.*)

Two modifications of the normal sphygmogram require, however, special allusion, since they are the consequences of a variety of morbid states. They are the sphygmogram of *high arterial* tension, or, as Dr. Sansom prefers to call it, *prolonged arterial tension*, and *low arterial tension*.

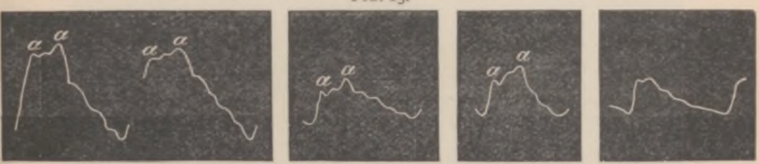
Prolonged arterial tension is a condition in which the pressure in the interior of a blood-vessel is unduly prolonged. The effect on the tracing is, in a word, to broaden the top of the primary curve, as shown in the accompanying sphygmogram.

In some instances the ascending limb of the sphygmogram is broken into two, as shown in Fig. 22.

Such a pulse is called an *anacrotic* pulse.

The pulse of prolonged arterial tension is produced by any cause of resistance to the motion of the blood through the capillaries and arterioles, and such causes are numerous. Chronic renal disease, especially interstitial nephritis, is one of them ; so are gout, lead poisoning, constipation, atheroma of the arterial walls, and even anæmia. The anacrotic pulse is also produced in aortic stenosis, where it has diagnostic value.

FIG. 23.



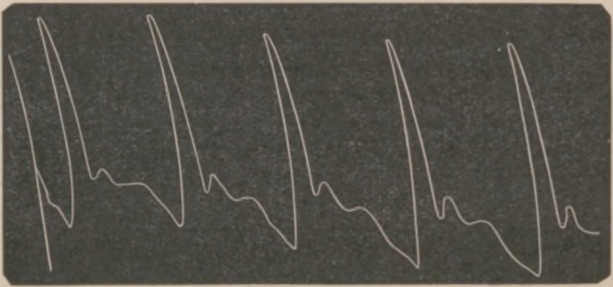
Anacrotic Pulse-curves from the Radial Artery. (*Landois and Stirling.*)

Low arterial tension is the reverse of prolonged arterial tension. Instead of the filled state of the vessel being maintained, the fulness is of short duration and the wall drops away at once. Such a pulse is easily obliterated by pressure, while the pulse of high tension is difficult to obliterate. As to the sphygmographic tracing, the up stroke is vertical, the apex angle is acute, the tidal wave is insignificant, while the dicrotic wave is the most conspicuous feature of the tracing. Fig. 24 furnishes a marked example of such a tracing, in which the first wave of the down stroke is the dicrotic wave, the tidal wave being wanting.

Dicrotism in pulse of low tension may even exceed that indicated in the sphygmogram. Thus it may spring from the level of the base line, when it is called *full dicrotic*, or it may start from below the base line, when it is called *hyperdicrotic*, or even be in the ascending line of the succeeding trace, when it is called *monocrotic*.

The pulse of low tension may be produced artificially by the administration of nitroglycerin or the applica-

FIG. 24.

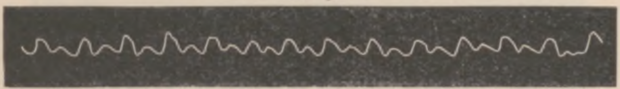


Tracing of Pulse of Aortic Regurgitation. (*Strümpell.*)

tion of heat to the surface of the body, as by the warm bath, the conditions being suddenness of cardiac impulse and absence of resistance to the onward movement of the blood; it is very characteristic of aortic regurgitation, of collapsed conditions, such as are the result of depressing emotions and colliquative discharges like diarrhea and copious diuresis. It is also found in fever of which the dicrotic pulse is more or less characteristic. Abnormal dicrotism is not, however, confined to low tension. It varies within the limits of health, and occurs at times in connection with high tension, as shown by Roy and Adami, where there is a sharp, sudden systole of the ventricle leading to a corresponding sharp and energetic rebound or reactionary wave, as shown in Fig. 25.

Erroneous interpretations of such dicrotism may be avoided by increasing the pressure of the sphygmograph when, if the tension is low, the tracing is obliterated,

FIG. 25.



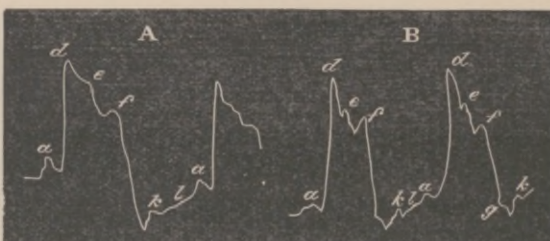
Tracing from Case of Prolonged Arterial Tension, showing Dicrotic Wave. (*Sansom.*)

while if it is high the first wave becomes broadened and the dicrotism less.

THE CARDIOGRAPH IN DIAGNOSIS.

The cardiograph does not furnish as valuable assistance to diagnosis as the sphygmograph, chiefly because of the difficulty in getting typical tracings. Tracings are usually taken from the site of the apex, although they may also be obtained from the various chambers of the heart in a large animal like the horse by introducing an elastic bag and attached tube into the right cavities through an opening in the jugular vein, and into the left cavities through an incision in the carotid artery, connecting each bag and tube with a Marey's tambour and thence to a revolving drum. Any pulsating part of the heart, as the left auricle, may be brought into connection with the cardiograph and a tracing therefrom secured, while without an appreciable impulse a tracing is impossible even at the apex. Appended are a number of normal apex tracings in which *a* represents the auricular systole, the ascent, *a d*, the contraction of the ventricle, *d e f* the continued systole, *k* the effect of the first

FIG. 26.



Normal Cardiac Apex Tracing. (*Galabin.*)

sudden entrance of blood into the ventricles, *l* the gradual ascent from the gradually increasing flow of blood into the ventricles during diastole, and *a d* again the systole of the ventricles. The notch, *d e f*, is constant, the height of the primary elevation being exaggerated by the velocity of the needle in the instrument employed.

Considerable variation takes place in the apex cardiogram as the result of varying pressure, while partial and even complete inversion of the tracing may occur, whence another source of difficulty in the way of clinical availability of the cardiograph, for it cannot be relied upon to express accurately the direction of the different events of the cardiac action.

The position of the sounds of the heart in relation to points in the apex trace have, however, been determined with some approach to accuracy. Thus the first sound, as determined by its *muscular* element, is regarded as commencing with the first ascent of the lever, and continuing until the *termination* of the rounded shoulder, *f*, at which the muscle of the ventricular wall relaxes. So far as concerns the factor of valvular tension, the position of the first sound must be assigned to a point near the summit of the up stroke, where the sudden contraction of the *papillary* muscles begins, continuing to the *beginning* of the rounded shoulder *f*, where this contraction ceases, the muscle of the ventricular *wall* remaining still contracted.

The second sound occurs somewhere between the shoulder, *f*, and the lower extremity of the descending line succeeding it.

In the apex cardiogram of the normal heart-beat the systole is decidedly shorter than the diastole, occupying two-fifths as compared with three-fifths. As the rate of the pulse increases the diastolic interval shortens, until the systole and diastole become equal, although precise measurement of the absolute deviations of these phases by the cardiograph is as yet impossible. Their relative duration may, however, be thus measured, as may also be the force of the ventricular contraction by the height of the upstroke. The breadth of the summit of the trace measures the duration of the systole and increases with hypertrophy of the ventricles.

In abnormal states the diastolic portion of the tracing is (1) *relatively diminished* or (2) *relatively increased.*

1. It is relatively *diminished*—

(*a*.) In hypertrophy.

(*b*.) Where in addition to hypertrophy conditions exist in which the ventricle becomes too rapidly filled. This occurs in aortic regurgitation and in mitral regurgitation when there is hypertrophy of the left auricle; also in the two conditions combined.

2. The diastolic portion of the tracing is relatively *increased*—

(*a*.) When the heart's action becomes slow, the difference between a frequent pulse and a slow pulse being chiefly in the length of the diastole.

(*b*.) Dilatation of the left ventricle, the conditions being the opposite of those of hypertrophy. Herein we have one of the most valuable diagnostic uses of the cardiograph. It is not always easy by other clinical means to inform ourselves when this serious change has taken place which involves a loss of compensations. The cardiograph enables us to do so.

(*c*.) In mitral stenosis, where the diastolic interval is often markedly prolonged, while at other times it is found to vary greatly in duration, two systoles occurring without an appreciable diastolic interval, while between two others there may be a prolonged interval. Much more characteristic, according to Sansom, who has devoted much study to this subject, are the number of vibrations in the diastolic part of the trace. "In fact," says Sansom, * "the vibrations which are heard by the ear as murmurs, or felt by the finger as thrills, may be written on the smoked paper by the needle of the cardiograph." Many other clinical facts of interest and importance may be studied to advantage by the cardiograph, but I must refer the student to the larger works for their consideration.

* Lettsomian Lectures on "Valvular Diseases of the Heart," 1886.

PHYSICAL SIGNS OF THE DIFFERENT FORMS OF VALVULAR DISEASE.

MITRAL INSUFFICIENCY.

This is the most frequent of the uncombined forms of valvular disease. The valve leaks, the blood flows backward during systole from the left ventricle to the left auricle. The auricle first attempting to resist the backward flow hypertrophies slightly, but eventually dilates, and the blood is crowded backward into the lungs, which become engorged. The right ventricle, in its efforts to push the blood through the engorged lungs, hypertrophies, and the pulmonary factor of the second becomes louder and sharply accentuated. The compensating effect of the hypertrophied right ventricle for a time arrests the mischief. At this stage, perhaps, begins the hypertrophy of the left ventricle, which in all cases of mitral insufficiency presents itself sooner or later, although at first the double outlet for the blood from the ventricle would seem to demand less strength of the left ventricle. The right ventricle, however, in its hypertrophied state, delivers more blood to the left ventricle, which demands more power to drive it on, hypertrophy results, and thus compensation is a while longer maintained. Sooner or later the tricuspid valve becomes insufficient, the blood regurgitates into the right auricle, and thence into the great veins of the neck. The valves of these ultimately yield, the jugular pulse appears, and the general venous system is engorged.

In this engorgement the liver, stomach, and kidneys share. Then comes transudation, dropsy, albuminuria. Among the later phenomena in extreme cases are an enlarged, tender, and pulsating liver, a symptom which is pathognomonic of tricuspid regurgitation, but a liver lifted by some pulsating agency behind it must not be confounded with the true pulsating liver. More frequently the liver is visibly enlarged and tender without visible pulsation. Such enlargement disappears in part after death, and is not noticeable at the necropsy.

Inspection discovers the apex-beat to the left of its normal position and perhaps a little lower down. It may be in the line of the nipple or even beyond it, and more forcible and diffuse than in health. The outward dislocation of the apex-beat is due to the enlargement of the two ventricles. An auricular impulse may be present to the left of the pulmonic area in the second interspace, and may be presystolic and active for the auricle, or systolic and passive for the auricle. A bulging præcordium may be looked for in young persons, and in advanced stages also a jugular pulse.

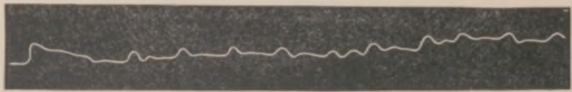
On *palpation* the apex-beat is found more forcible than normal, and there may be a pulsation near the ensiform cartilage caused by the systole of the enlarged right ventricle. Sometimes an intermittent *systolic thrill* is felt in the fourth interspace in the left mammillary line.

The radial pulse in the early stages is comparatively unaltered. Later it becomes frequent and irregular in volume. Appended, Fig. 27, is a sphygmogram of the pulse in advanced mitral insufficiency. It is of the type of the *pulsus parvus irregularis*.

Percussion discovers enlargement of both the relative and absolute areas of dulness, upward in the direction of the left auricle, downward to the left and also to the right, the right border of the heart reaching at times the right border of the sternum.

Auscultation recognizes a systolic murmur in the mitral area, conducted with various degrees of loudness into the left axilla and under the angle of the scapula. This direction of its conduction is the distinctive feature

FIG. 27.



Tracing of Pulse of Mitral Insufficiency. (*Da Costa.*)

of this murmur. It is usually soft, but occasionally rough, more rarely musical. It is also sometimes well heard to the left of the pulmonary cartilage, and rarely over the entire præcordium. Not always loud enough to be easily heard, it may be brought out by exertion on the part of the patient.

The second sound of the heart is sharply accentuated at the pulmonary interspace until the tricuspid valve fails, when the accentuation vanishes. The aortic second sound is less strong, corresponding with the less degree of hypertrophy of the left ventricle.

MITRAL STENOSIS.

This lesion occurs as an uncombined or simple form of valvular disease in young persons, especially women, but is very much more commonly combined with regurgitation. The orifice is stenosed and the blood is restrained from passing freely into the left ventricle. The same backward effect is produced upon the left auricle, the lungs, the right ventricle, and general venous circulation, as in mitral regurgitation, but the left ventricle is not hypertrophied in simple mitral obstruction, because no extra muscular effort is called for, while hypertrophy of the left auricle is one of the most characteristic signs of mitral stenosis. Theoretically, the left ventricle should even atrophy, but the absence of the enlargement is of great diagnostic value.

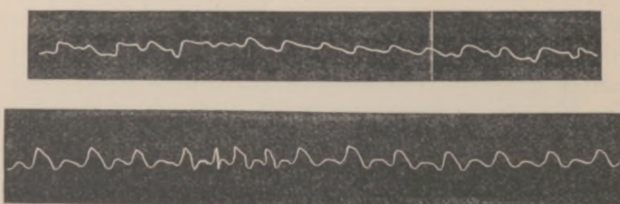
Inspection, consistently with what would be expected in absence of hypertrophy of the left ventricle, recognizes little or no displacement of the apex. If there is any it is due to the hypertrophy of the right ventricle. Nor is the apex-beat increased in force. A left auricular impulse, pre-systolic, may be noted for the same reason as in mitral regurgitation, as may also a jugular impulse. The bulging præcordium occurs under like conditions as in mitral regurgitation, but is not often seen.

Palpation discerns that the apex-beat is without undue force, but it may be diffuse, and an impulse may be felt in the situation of the apex of the right ventricle. The most marked feature of palpation when present is the *presystolic thrill* at the apex. It is similar in rhythm to the presystolic murmur, but may be present without it, and is not always present.

In moderate degrees of stenosis the pulse is not altered; in high degrees it is very small, from want of left ventricular power; also irregular, like that of mitral regurgitations. Two tracings from cases of mitral stenosis are introduced in the text.

Percussion recognizes cardiac enlargement in the

FIG. 28.



Tracings of Pulse in Mitral Stenosis.

direction of the left auricle and right ventricle, but not of the left ventricle.

Auscultation does not discover a murmur in every case of mitral stenosis, because of the feebleness of the auricular contraction, especially at the beginning. Most characteristic is the abruptly terminating *presystolic* murmur described on p. 125, confined for the most part to the mitral area, though it may be conveyed upward, and it is even heard posteriorly, though rarely. Dr. Sansom places it rather at the right of the apex.

Accentuation of the second sound is marked, but confined to the pulmonary area, because there is no hypertrophy of the left ventricle. The second sound may also be duplicated, because of the want of synchronousness in the closure of the aorta and the pulmonary valves. Dr. Sansom regards this reduplication as a seeming one only of the second sound. He regards it rather as the normal second sound followed by another sound due to a sudden tension of the mitral valve itself. He also says it occurs in at least a third of all cases of mitral stenosis, and is rare in other cardiac conditions.

The murmur of mitral stenosis is sometimes difficult to distinguish from that of aortic regurgitation, but in the latter there is enormous hypertrophy of the left ventricle, which is wanting in mitral stenosis. The time of tricuspid stenosis is identical with that of aortic regurgitation, but it is heard in a different part of the præcordium,—in the epigastrium. On account of these difficulties, while the presystolic murmur is a valuable sign of mitral stenosis, it should not be alone relied upon for diagnosis, but should be taken in connection with other signs. Tricuspid stenosis may be associated with mitral stenosis, or insufficiency, or both. See p. 125 for further characterization of the presystolic murmur.

Dr. Sansom lays great stress in the evidence of the cardiograph in the diagnosis of mitral stenosis, which enables one to judge of the relative length of systole and diastole. In stenosis the interval between the systoles may be greatly prolonged or the diastolic intervals vary greatly in duration. In mitral regurgitation, on the other hand, a short interval only separates the systoles.

MITRAL INSUFFICIENCY AND STENOSIS.

More frequently stenosis is associated with insufficiency when we have the double mitral murmur, sometimes with difficulty divisible into its two parts. Extreme irregularity of rhythm and pulse, with frequency and smallness of the latter, conspicuous thrill, marked right-sided hypertrophy, and sharply accentuated pulmonic sound are characteristic.

AORTIC STENOSIS.

This is a frequent form of valvular disease, and when uncombined with regurgitation the least dangerous. The aortic orifice is narrowed and prevents the free discharge of blood from the left ventricle into the aorta. The ventricle attempts to overcome this, and its walls hypertrophy in proportion to the degree of resistance, and often for a long time compensate for the obstruction—until dilatation occurs, when the danger really begins.

Inspection and *palpation* recognize a forcible apex-beat beyond the normal situation and at varying distances in accordance with the degree of hypertrophy, while palpation adds occasionally a purring basic thrill with each beat of the heart when dilated hypertrophy is established. A bulging of the præcordium is also present.

The pulse is the *pulsus tardus*, slow in reaching its maximum volume, which is small. It is frequent but regular, contracting in the latter respect with the pulse of mitral disease. Fig. 29 is a sphygmogram.

Percussion elicits dulness downward and laterally toward the left, since, as a rule, the enlargement is confined to the left ventricle. There may, however, be enlargement upward to the left of the sternum.

Auscultation discloses a systolic basic murmur, loudest at the aortic area—second interspace at the right of the sternum—which is conducted distinctly into the carotids, and even sometimes along the course of the aorta, behind and to the left of the vertebral column, into the popliteals and dorsal arteries of the feet. It is not, however, confined to this area, but may be heard over the entire præcordium. It is usually rough, but may be soft and musical. It is made louder by exercise. The aortic factor of the second sound is weak if the constriction be at all decided, because of the feeble recoil, a necessary result of the small amount of blood in the aorta. The first sound is normal and somewhat louder and more prolonged than natural, because of the powerful contraction of the left ventricle.

Fig. 29.

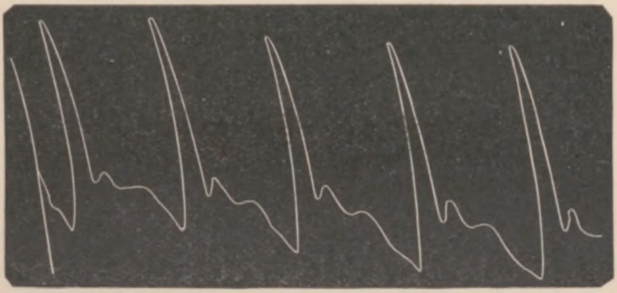
Pulse Tracing of Aortic Stenosis.

Roughness of the aorta due to atheroma, dilatation, or narrowing of the vessels by pressure or otherwise, may also cause a systolic murmur, and so may roughness within the ventricle in the course of the outgoing column of blood ; but these causes have generally a less positive effect upon the substance of the heart. At the same time, one of the most important points to be remembered in diagnosis is that an aortic systolic murmur by no means always indicates aortic stenosis. In like manner anæmic or hæmic murmurs, which are always systolic and for the most part basic, may simulate aortic systolic murmurs, but these occur in young, delicate persons, of both sexes, and are often intermittent and without other effect on the circulation. There may be roughness, too, in the pulmonary artery which can be localized to the left of the sternum.

AORTIC INSUFFICIENCY.

The most serious and irremediable of the valvular diseases of the heart commonly met with ; less frequent than aortic stenosis, with which it often exists in combination, it is still not uncommon even uncombined. It is the lesion most frequently followed by sudden death. The aortic valves are incompetent and the blood flows backward into the left ventricle during diastole. The ventricle, seeking to restore the balance, redoubles its energy, hypertrophies. The blood is thus driven into the aorta with great force, swelling the arteries to extreme fulness, which, however, falls away promptly, because of the backward flow into the ventricle at the same time with the forward movement into arteries and capillaries. This sudden falling away of the pulse, from extreme distention to collapse, is very characteristic of this form of valvular disease, and is called the "trip-hammer" or "water-hammer pulse," also Corrigan pulse. It may even be visible to the casual observer in the exposed arteries, such as the carotid, temporal, and radial, while the aortic beat,

Fig. 30.



Tracing of Pulse of Aortic Regurgitation. (*Strümpell.*)

ordinarily beyond reach in the supra-sternal notch, may sometimes be felt in this situation. The abrupt jerking impulse with sudden recoil is easily recognized by the finger, which, however, fails to find the pulse as strong and hard as would be expected from the appearance. On the other hand, it is soft and receding. A tracing of this pulse is found in Fig. 30. It is the typical *pulsus celer*.

The tremendous systole of the ventricle may ultimately force the mitral valve to yield, and compensation to be gradually lost *pari passu* with a growing dilatation. To this succeed the phenomena of mitral regurgitation, including hypertrophy of the right ventricle, which again comes for a time to the rescue, but weakens with the giving away of the tricuspid valve.

Inspection often discerns the præcordium prominent, with the apex-beat lowered and to the left, and the visible pulsation far beyond the normal situation of the apex, all confirmed by palpation, to which is also evident at times a systolic thrill over the carotids and subclavians, and sometimes in the aorta at the suprasternal notch. A *capillary pulse* is also sometimes demonstrable in the skin and mucous membrane. This may be brought out by drawing a pencil lightly across the skin of the cheek or forehead, and on the mucous membrane of the averted lower lip, by pressing a glass microscopic slide against it, as suggested by F. C. Shattuck.

Percussion discloses increased dulness to the left and downward, and also, sometimes, in advanced cases, upward to the left of the sternum, not from hypertrophy of the left auricle, but to enlargement of the ventricle upward.

Auscultation recognizes a diastolic murmur, long and various in quality, but usually blowing and harsher than the aortic obstructive murmur. Its area of maximum intensity is commonly at the aortic interspace or midsternum, sometimes as low as the fourth left costal cartilage, and even at the ensiform cartilage. Hence it may be mistaken for the mitral obstructive murmur and for the murmur of tricuspid disease, but both of these, be it remembered, is unaccompanied by hypertrophy of the left ventricle. The murmur is naturally transmitted downward toward the ensiform cartilage or along the left edge of the sternum, and toward the apex in the direction of the regurgitating column, but it is also heard in the direction of the great vessels of the neck, though less loudly than the aortic systolic murmur.

AORTIC STENOSIS AND REGURGITATION.

This double lesion is a comparatively frequent one, indeed, commonly regarded as the next in frequency after mitral obstruction, and therefore more frequent than either aortic stenosis or aortic insufficiency alone. It occasions a double basic murmur, systolic and diastolic, and is also a grave condition giving rise to the same dangers as aortic regurgitation, and the same enormous hypertrophy of the left ventricle.

TRICUSPID REGURGITATION.

Tricuspid regurgitation as a primary condition is extremely rare, and when present is probably the result of an endocarditis during fœtal life, endocarditis at this period being more prone to attack the right than the left side. Endocarditis involving the tricuspid may, however, occur in children also, according to Byrom Bramwell,* more commonly than has been supposed.

Amer. Jour. Med. Sci., Apr., 1886, p. 419.

Infectious or mycotic endocarditis also affects the tricuspid valve, according to Osler, in 19 out of 238 cases. More frequently tricuspid regurgitation is one of the terminal events of mitral disease, the tricuspid orifice yielding to the tension upon the right ventricle, consequent upon the resistance to the movement of the blood through the engorged lungs. It is associated with the dilatation of the right ventricle which succeeds upon its hypertrophy if the patient live long enough. It is also one of the possible sequelæ of emphysema of the lungs and long-standing fibroid phthisis. Its effects, depending upon the venous circulation, have already been detailed, p. 146.

In primary tricuspid disease with regurgitation, *inspection* and *palpation* note an apex beat diffused about the normal area toward the epigastrium, and *percussion* detects enlargement toward the right end of the sternum.

To *auscultation* the systolic murmur thus engendered is invariably feeble and is heard almost solely in the tricuspid area, just above and to the left of the ensiform cartilage. Occasionally only is the second pulmonic sound accentuated. There should be no confounding of this murmur with that of aortic regurgitation conducted toward the same situation nor with that of mitral regurgitation heard at no great distance, for the reasons named. To these must be added a difference in quality and pitch between the tricuspid and the mitral murmur. The jugular pulse is also more or less constantly associated with tricuspid regurgitation. The presence of the pulsating liver is almost pathognomonic. The jugular pulse is systolic in time and does not appear until the valves situated at the opening of the internal jugulars into the innominate veins yield. These give way first on the right side because the communication is more direct. It is sometimes not easy to distinguish a true jugular pulse from a false one, but pressure on the vein above the valves will cause the false pulse to disappear while the true pulse, coming from the right ventricle, will remain.

TRICUSPID STENOSIS.

Tricuspid stenosis is a still more rare condition, but it may occur in connection with left-sided heart disease as the result of rheumatic endocarditis and unknown causes. As in endocarditis of the right side, there is thickening, adhesion, narrowing. These cases are regarded as most frequently acquired, not congenital, although the diagnosis is seldom made because the murmur is masked by the coincident mitral systolic murmur.

Tricuspid obstruction without coincident mitral disease is exceedingly rare. A presystolic tricuspid murmur pointing to such a condition in a case observed by Gardner was found due to a growth from the endocardium of the right auricle, so placed as to fall over the tricuspid orifice in the manner of a ball valve.

Congenital defects would include other cases.

Shattuck has met one instance of tricuspid stenosis with mitral stenosis and regurgitation, along with adherent pericardium, hepatic cirrhosis, and slightly granular kidney, confirmed by autopsy. In this case there was a presystolic tricuspid murmur observed for three years before death.

A presystolic murmur at the right edge of the sternum from the fourth costal cartilage to the ensiform cartilage and thence to the sixth left cartilage at its junction with the sternum would be the murmur diagnostic of the condition, but frequently there is no murmur audible in connection with such a lesion found at necropsy. There should also be enlargement of the right auricle. A presystolic thrill may accompany the murmur.

PULMONARY STENOSIS.

The great majority of systolic murmurs heard at the pulmonary orifice are functional. Pulmonary stenosis may, however, be present, and where it exists it is far more likely to be congenital from arrested development, although intra-uterine endocarditis may also cause it. So, also, may infectious endocarditis, and in rare instances atheroma.

Pulmonary stenosis should furnish a systolic murmur in the pulmonary area, to the left of the sternum. The murmur may even be heard behind, between the shoulders, and it may be rough. It is accompanied by hypertrophy of the right ventricle. There may be a basic thrill, as in aortic obstruction, but the pulse is uninfluenced. Compensation may be set up by means of a patulous foramen ovale, an open ductus arteriosus, or interventricular communication. The invariable association of cyanosis due to venous obstruction and of attacks of dyspnœa complete the picture and aid greatly in the diagnosis. Anæmic murmurs at the same time and place are unaccompanied by cyanosis.

Walshe has described a case of death from thrombosis of the pulmonary artery in which he heard a pulmonary systolic murmur before the end came.

PULMONARY REGURGITATION.

Simple pulmonary regurgitation is scarcely known, but it is easy from what has gone before to deduce the physical signs which are to be expected—a diastolic murmur heard in the pulmonic area, hypertrophy of the right ventricle, jugular pulse, venous congestion, and cyanosis. A few cases are related in which a diastolic murmur has been found associated with defects in the pulmonary valves, in one warty, which might have been the result of infectious endocarditis. All others are congenital. Among them is aneurismal dilatation. Such was a case reported to the Pathological Society of Philadelphia by Edward T. Bruen. (See Transactions for 1883.)

CONGENITAL DEFECTS.

Congenital defects in the cardiac valves and orifices deserve a passing notice. They may be the result of endocarditis during fœtal life or of arrest of development. Their most frequent seat is the right heart and the most frequent form is stenosis of the pulmonary orifice, the effects and signs of which have already been considered. Another is a permanently patulous foramen ovale; or there may be a defect of the septum of the ventricles, or a communication between the aorta and pulmonary artery—a persistent ductus arteriosus—or between the aorta and the vena cava or right auricle. All of these intercommunications produce murmurs difficult to separate, and it is, after all, by attention to the general condition that the defect is recognized. The patient, a child of arrested development, more or less permanently cyanosed, with continued embarrassed breathing, all of these are conditions which point to the congenital defect. If there be added to these a persistent loud murmur at the base of the heart without other signs or symptoms of valvular disease, this may be due to congenital defect.

RELATIVE FREQUENCY AND RELATIVE DANGER OF VALVULAR DEFECTS.

The order of frequency of the various valvular defects is not entirely agreed upon. As to one, however, there seems to be universal concurrence, and that is that mitral regurgitation is the most frequent. After this, however, statistics differ. Thus of the older authors Walshe presents the following order of frequency for the single or individual murmurs:—

1. Mitral regurgitation.
2. Aortic stenosis.

3. Aortic regurgitation.
4. Mitral stenosis.
5. Tricuspid regurgitation.
6. Pulmonary stenosis.
7. Tricuspid stenosis.
8. Pulmonary regurgitation.

As already stated, all agree that the mitral systolic murmur indicating mitral regurgitation is the most frequent. Dr. Frederick J. Smith, analyzing the registers and post-mortem records of the London hospitals for eleven years—1877–1887—and taking the fatal cases only, arrived at the following order:—

1. Mitral regurgitation.
2. Mitral stenosis.
3. Aortic regurgitation.
4. Aortic stenosis.
5. Tricuspid stenosis.

Out of the 705 cases Smith found 26, or 3.38 per cent., of mitral stenosis, and 25, or 3.25 per cent., of aortic regurgitation. So it cannot be said there is any practical difference in the relative frequency of these two lesions. Smith's statistics, being recent and based, as they are, upon the examination of registers and autopsy records, might be reasonably regarded as correct. Yet it is not easy to disprove the presence of a coincident regurgitation in many cases of anatomical stenosis, which would, therefore, have to be deducted from the cases of simple lesion and added to those of combined.

Two murmurs at one orifice are usually characterized as "double" murmurs, but Sansom suggests that the term "combined" be applied to these murmurs, and the term "associated" retained for murmurs at more than one orifice.

F. J. Smith's results as to associated murmurs are as follows:—

1. Aortic regurgitation and stenosis; mitral regurgitation.

2. Mitral stenosis and regurgitation.

3. Aortic stenosis and mitral regurgitation.

4. Aortic regurgitation and mitral stenosis.

5. Aortic regurgitation and stenosis.

6. Aortic regurgitation and stenosis; mitral stenosis and regurgitation.

7. Mitral regurgitation and tricuspid regurgitation.

8. Aortic regurgitation and stenosis; mitral regurgitation; tricuspid regurgitation.

9. Mitral stenosis and regurgitation; tricuspid regurgitation.

10. Aortic stenosis; mitral stenosis and regurgitation.

11. Aortic regurgitation; mitral stenosis and regurgitation.

12. Aortic stenosis; mitral regurgitation; tricuspid regurgitation.

13. Aortic regurgitation and stenosis; mitral regurgitation; pulmonary regurgitation.

14. Aortic stenosis and regurgitation; mitral stenosis.

15. Aortic regurgitation; mitral stenosis.

16. Aortic regurgitation; mitral regurgitation; tricuspid regurgitation.

17. Mitral stenosis; tricuspid regurgitation.

18. Aortic stenosis; mitral stenosis and regurgitation; tricuspid regurgitation.

19. Aortic stenosis; mitral stenosis.

20. Aortic regurgitation and stenosis; mitral stenosis and tricuspid regurgitation.

21. Aortic regurgitation; mitral stenosis and regurgitation; tricuspid regurgitation.

22. Aortic regurgitation and stenosis; mitral stenosis and regurgitation; tricuspid regurgitation.

23. Aortic regurgitation and stenosis; mitral stenosis and regurgitation; tricuspid stenosis and regurgitation.

24. Aortic stenosis; pulmonary stenosis.

25. Aortic stenosis; mitral stenosis and regurgitation; tricuspid stenosis and regurgitation.

26. Mitral stenosis and tricuspid stenosis.

Of the 12th and 13th there are the same number, 5 out of 705; of the 14th, 15th, and 16th, each 4, and of the last 5 each 1. Of the double or combined murmurs, it is generally conceded that that at the mitral orifice, indicating stenosis and insufficiency, is the most frequent, and women are far more liable to this lesion than men. In an analysis of cases at the Glasgow Infirmary, Dr. George S. Middleton found a far larger proportion of the simple double aortic lesion than Dr. Smith, 22 per cent as against 4 per cent., and Walshe makes the simple double aortic lesion the second in frequency. But when we add together the cases of double aortic lesion and those of double aortic lesion combined with lesions at the other valves, as suggested by Dr. Sansom, we have also almost exactly 22 per cent., and it is well known that in the majority of cases affecting the aortic valves, the mitral and tricuspid valves become sooner or later affected.

Although but one case of tricuspid stenosis associated with mitral stenosis is found by Smith in his 705 cases, Bedford Fenwick has collected a large number of cases of stenosis of the tricuspid valve, in which the lesion was almost invariably accompanied by stenosis of the mitral orifice. Dr. Wilks regards the narrowing of the mitral orifice in these cases as secondary to that of the tricuspid, which allows only a small quantity of blood to pass into the right ventricle and lungs, in consequence of which a like small amount passes to the left heart, whence a reduction in the size of its cavities and orifices.

The relative gravity of cardiac affections, beginning with the most serious, is also given by Walshe as follows :—

1. Tricuspid regurgitation.
2. Mitral obstruction and regurgitation.
3. Aortic regurgitation.
4. Pulmonary obstruction.
5. Aortic obstruction.

It will be remembered, however, that I have said that aortic regurgitation is the most irremediable of the valvular defects, at least of the more common forms, and the most serious from the standpoint of tendency to sudden death. It will be noted that no place is assigned by Walshe to simple mitral obstruction, and it is indeed difficult to assign the final position of this lesion with a good left auricle. Such cases run along for a long time, but the resulting congestion of the lung is troublesome and invites to circumscribed pneumonias, which are of frequent occurrence.

ACUTE ENDOCARDITIS.

The two well-acknowledged forms of endocarditis, **simple** and **infectious** or ulcerative, furnish no distinctive physical signs by which they can be recognized one from the other. It is rather by the history and symptoms that such distinction is made, the almost invariable succession of the former upon rheumatism and of the latter on some coexisting infectious state being valuable aids.

Both have their most frequent site on the left side, the most vulnerable, and in the mitral leaflets. A systolic mitral murmur, in the course of a rheumatism, means almost invariably an endocarditis. The aortic leaflets may also be the seat of inflammation, though more rarely, when a basic murmur is the consequence. But not every aortic murmur in the course of rheumatism implies endocarditis, as the condition of the blood predisposes to a hæmic murmur; nor every murmur at the apex, because the state of the muscle predisposes to imperfect closure of the auriculo-ventricular orifice. Unless there has been previous valvular disease, there is no enlargement, so that neither palpation, inspection, nor percussion gives any information.

PERICARDITIS.

The only distinctive physical sign in the *first stage* of pericarditis is the friction sound, described on p. 129. In addition, the impulse may be strong.

The *second stage*, or that of effusion, has usually, but not always, signs discoverable to *inspection* and *palpation*. The præcordium may be bulging and the interspaces obliterated, and the impulse undulating, tumultuous, and indistinct. *Percussion* furnishes the most striking change. The area of dulness is enlarged, and peculiarly enlarged. It becomes rudely triangular, with the apex toward the inner end of the left clavicle and the base as low as the seventh rib, and extending in extreme cases from nipple to nipple. *Auscultation* confirms palpation; the impulse is feeble, indistinct, and often tumultuous. The heart-sounds are indistinct and best heard at the top of the sternum.

The *third stage* consists in a gradual return to the normal state of affairs, which may be by the intermediation of a *friction redux* or not. Adhesions may result between the heart and the sac, embarrassing its movements permanently, and producing retraction of the chest-wall with systole. On the other hand, necropsy has often revealed close adhesions between the heart and the pericardium which were not suspected during life. Permanent roughening by organization in chronic pericarditis may produce permanent friction sound.

Hydropericardium, as a part of a general dropsy, is a rare condition, and furnishes the same physical signs as the inflammatory effusion.

DISEASES OF THE MYOCARDIUM.

The heart is subject to alterations in its muscular substance independent of valvular defect. Simple hypertrophy, fatty infiltration, and fatty metamorphosis, or true fatty degeneration, are the most important. Myositis, abscesses, and aneurysms of the walls of the heart are such rare conditions that they need only to be mentioned in passing, especially as there is no way to recognize them before death.

Hypertrophy of the left ventricle, without valvular disease, is always the result of obstruction to the movement of the blood through the aorta beyond the valves, or to some demand for compensation. The most common remote cause is chronic Bright's disease. Any variety of chronic Bright's disease may cause it, but it is most frequently associated with chronic interstitial nephritis. We have nothing to do here with the mechanism of its production, except to say that it seems likely that it is in some way compensatory. Atheroma and aneurysm of the aorta are attended by less degrees of hypertrophy, also compensatory, because of the loss of the elastic force in the arteries, requiring additional power on the part of the heart muscle.

Inspection and *palpation* furnish much the same information as in hypertrophy of the left ventricle from valvular disease. *Percussion* shows enlargement to the left and downward. To *auscultation* there is no murmur, but a distinctive intensification of the aortic second sound is heard, quite characteristic, and itself of great diagnostic value. The first sound, while louder, is also duller, more prolonged, and diffuse, qualities which sometimes suggest a systolic mitral murmur which is not present.

Pure hypertrophy of the right ventricle is the result of emphysema of the lungs, and sometimes, to a less degree, of fibroid disease of the same organs, compression of the lungs by effusion or adhesion, or of any cause which resists the movement of the blood from the right heart. We have here the signs of enlargement in the direction of the right heart, also without murmur, but with sharp accentuation of the second sound at the pulmonary interspace to the left of the sternum.

General hypertrophy or physiological hypertrophy or symmetrical hypertrophy of both sides of the heart may be brought about by severe muscular exercise, demanding extra nourishment. Exophthalmic goitre is often accompanied by the same condition, due to overnourishment, the result of vaso-dilator influence on the blood-vessels.

Dilatation of the Heart, either of its right or left ventricle, may occur independently of valvular disease. A heart cavity is said to be dilated when it is enlarged out of all proportion to the thickness of its walls, even though the latter may be somewhat thicker than normal. Commonly, however, the walls are thinner or no thicker than in health, and when the muscular wall is thickened while the cavity is enlarged we commonly speak of the condition as **hypertrophy with dilatation.** The term **simple dilatation** is used to indicate undue enlargement of the cavity while the walls remain of normal thickness; **attenuated dilatation** where the walls are thinned.

Dilatation without valvular disease occurs rapidly and slowly: Rapidly in connection with grave cases of the acute infectious diseases attended with degeneration of the muscular substance of the heart. Such are typhus fever, typhoid fever, scarlet fever, smallpox, acute rheumatism, and infectious endocarditis. More slowly in connection with vesicular emphysema, when, of course, it is in the right heart, and succeeds hypertrophy. In like manner the hypertrophied left ventricle of chronic Bright's disease may become dilated. Whatever causes obstruction to the outward flow of blood from a ventricle may cause dilatation, which is always, however, preceded by hypertrophy. Aneurysm is such a cause, therefore, for the left heart.

Inspection and *palpation* discover a diffuse feeble impulse and the pulse is weak. *Percussion* elicits signs of enlargement, while *auscultation* finds the sounds generally feeble and indistinct. I speak now of dilatation without valvular disease. When valvular disease is present its signs are superadded.

Fatty infiltration or obese heart is often a part of the condition of general obesity and has the same causes. It is something very different from the true fatty heart, or fatty metamorphosis, in which the muscular fasciculi are converted into granular fat. In the fatty infiltration the fat first covers the surface of the heart, then insinuates itself between the fasciculi, and although these are never themselves invaded, in extreme cases they undergo degeneration and atrophy from the pressure of the intervening fat. The heart is therefore not only embarrassed by the fat around and between its fibers, but the integrity of its essential substance may also be impaired by interference with its nutrition, and occasionally death results from sudden failure, just as in true fatty metamorphosis.

Such a heart is usually somewhat symmetrically enlarged, but the heart-sounds are feeble and indistinct, and the same is true of the impulse. There are, of course, no murmurs unless the condition be complicated with valvular disease.

Its recognition is based chiefly on the association of the symptoms of cardiac weakness with general obesity.

True fatty metamorphosis consists in an actual substitution, to a greater or less extent, of the muscular substance of the heart by granular fat. It is constantly associated with dilatation of the heart. Such a heart muscle is soft and flabby, and its contraction power is greatly impaired.

The physical signs of such a condition are not at all distinctive. There is feebleness of sounds and impulse. The latter as well as the pulse may even be inappreciable. There may be some enlargement of the heart, the result of dilatation of the soft and yielding muscle. Nor is there murmur unless there be valvular disease.

It is rather by watching a case over a considerable period of time that the truth is arrived at. Treatment is without result, and its total inefficiency is an aid in diagnosis. Fainting is frequent and sudden death the usual termination.

Acute myositis associated with acute rheumatism or fever may be a cause of fatty degeneration, but there is no way of determining with certainty its presence. It may be suspected when, along with, or subsequent to, intense rheumatic fever, there is evidence of heart-failure.

THORACIC ANEURYSM.

Thoracic aneurysm occurs in the arch of the aorta, in its ascending, transverse, and descending portions, and in the thoracic aorta below the arch. The greater frequency of aneurysm in the male sex and during early middle life may be mentioned in passing.

The pressure symptoms of thoracic aneurysm are so important, so frequently precede the physical signs, and so frequently are necessary to a correct diagnosis that their consideration is indispensable and will be added after a study of the physical signs.

Inspection does not always discover changes, but if the sac grows outwardly, sooner or later a **swelling** makes its appearance, to the right of the sternum if in the ascending limb, possibly raising a rib or the end of the clavicle; above and behind the sternum, if in the transverse portion, raising the manubrium or boring its way through it; and to the left of the sternum if in the descending limb of the arch. Such a tumor may **pulsate** or not. The aneurysm is, as it were, a rudimental heart, dilating with every jet of blood that is shot into it so long as the wall is yielding, and contracting on the withdrawal of the intravascular pressure. Should this property be lost, either as the result of calcification or the lining of the sac with successive layers of coagulum, such dilatation becomes impossible, and pulsation does not occur. The pulsation is, however, of great importance in the diagnosis. When present it is synchronous with the systole of the ventricles. The heart itself is sometimes displaced downward, as may be recognized by the lowering of the apex.

If the aneurysmal tumor press upon the great veins of the neck there may be **venous engorgement** on one side of the neck or both, according as the innominate of one side only is compressed or the descending cava itself.

Palpation also appreciates the **impulse** of the aneurysm if it is visible, and sometimes when it is not visible. This beating is somewhat peculiar, being *expansile,* and by this peculiarity differs from the rising of a tumor over a pulsating blood-vessel. A **thrill** is also often felt, a vibration in the walls of the sac caused by the whirl of the blood in it. It is by no means, however, invariable, and it may come and go.

Percussion over the swelling of an aneurysm invariably elicits **dulness,** varying greatly in extent. On the other hand, the adjacent lung may be compressed by an aneurysmal tumor, and the area of dulness thus extended beyond the tumor itself. In the absence of swelling there may be no impairment of resonance.

Auscultation is no exception, as compared with the other modes of physical investigation, in the inconstancy of its results, sometimes furnishing the most distinctive signs, while at others it is totally negative. The **murmur** or **bruit** heard over an aneurysm is various. Sometimes it is double, like the sounds of the heart, the first intense and prolonged, the second fainter and shorter. Sometimes but one murmur is produced, systolic, corresponding with the first sound over the ventricles, but more intense; more rarely it is diastolic only. More frequent than either systolic or diastolic is the combined or double murmur, both systolic and diastolic. It varies greatly, being sometimes rough, sometimes soft, sometimes musical. The murmur is, however, often absent. The mechanism of these sounds is not settled. The systolic is most easily explained. There can be little doubt that it is produced by the entrance of blood into the sac. When the aneurysm is at the beginning of the aorta, the diastolic murmur will probably be an aortic regurgitant murmur, due to stretching apart of the aortic valves. When the aneurysm is distant from the aortic orifice, the diastolic murmur may be due to the elastic recoil of the aneurysmal sac propelling the blood through the sac with additional force. Rarely there is a diastolic murmur only, probably thus caused.

But any one or all of these signs may be wanting.

Particularly is this the case where the aneurysm occurs just after the aorta has left the heart. The most valuable are the pulsation, distinct and separate from that of the heart, and the sounds, separate and distinct from those of the heart, or, as graphically put by Da Costa, "two hearts, apparently, each with its own distinct beat, its own distinct sounds." *

Pressure symptoms.—Not only may all these signs be wanting, but identical murmurs may be produced by double aortic disease, *i. e.*, aortic stenosis with regurgitation, and I have known a case to be diagnosed as double aortic disease after weeks of study, when the autopsy disclosed an aneurysm of the ascending limb of the arch of the aorta. It is most important, therefore, to place alongside of these the so-called pressure signs of aneurysm, some of which often precede the physical signs.

The first of these is *pain*, which may be sharp and acute when nerves are directly involved, or dull and boring when the result of pressure on the bone. In the latter case, too, it is localized; in the former it may extend all over the chest and down the arms, simulating that of angina pectoris. It may be unilateral. It may occur in aneurysm of the ascending or descending part of the arch.

Dysphagia from pressure of the tumor on the œsophagus is also an occasional symptom.

Other signs are *alterations in the voice*, such as hoarseness, aphonia, stridor; also brassy cough, and defective

* Op. citat., p. 451.

vocalization. Some of these symptoms may be produced by direct pressure on the trachea itself, others by pressure upon the left recurrent laryngeal nerve. A stridulous voice unaccompanied by dysphagia or aphonia was early pointed out by Tufnell, as indicating that the pressure is on the right side of the trachea and does not affect the œsophagus or recurrent laryngeal nerve. On the other hand, hoarseness, aphonia, and defective vocalization and various degrees of paralysis of the vocal cord are due to involvement of the left recurrent laryngeal nerve, which passes around the arch of the aorta. The paralytic phenomena may be present without any other laryngeal symptoms. Hence any alteration of voice or defective vocalization in a person presenting symptoms of heart disease demands a laryngoscopic examination. Such examination may show little alteration in the position of the vocal cords in *ordinary* breathing, or the left may be a little nearer the median line. In total paralysis, which is one of abduction and adduction of the left vocal cord, this cord stands in the so-called cadaveric position, *i. e.*, midway between the position of ordinary respiration and phonation. On *deep inspiration*, however, the right vocal cord is well abducted, the left remaining quiescent. The attempt at *phonation* is more or less abortive. During it the right vocal cord may go to the median line, leaving a small opening between it and the motionless left cord, or it may even cross the line to its paralyzed neighbor.

If only the abductor twigs of the left recurrent laryngeal nerve are involved in the pressure, there ensues gradually a permanent shortening or " paralytic contracture" of the antagonistic abductors, and the paralyzed cord is drawn by this into a position of constant phonation,—that is, into the median line. The result is that breathing may be entirely unobstructed and the voice natural, the paralyzed cord being in the position of adduction, while its tension is mainly regulated by the external branch of the superior laryngeal nerve, which is uninfluenced in aortic aneurysm.

These phenomena imply, of course, a functional destruction of the nerve, which may either be the result of simple pressure which will lead sooner or later to structural degenerative change, or the latter may result from a primary neuritis, the early stages of which, together with an associated irritation of the entire pneumogastric, may be held responsible for certain attacks of extreme *dyspnœa* sometimes experienced by subjects of aortic aneurysm. Associated with the neural degeneration is also found atrophy of the left abductor muscle—the crico-arytenoid,—while the adductors remain nearly intact. Constant dyspnœa is more likely to be due to direct compression of the trachea.

How shall these phenomena, which are, also, so much like those of a laryngitis, be interpreted as due to aneurysm instead of the latter affection in the absence of the physical signs of aneurysm?

In acute laryngitis we have often the cause—exposure to cold—to help us,—in chronic we have not. In laryngitis there is more huskiness and less of stridor in the voice, nor is the cough so brassy, or the voice so uniformly changed; it is more apt to alternate with normal voice. In aneurysm the voice grows progressively worse until aphonia results. The dyspnœa is more apt to be attended with wheezing, and is sometimes relieved for a time by coughing. Stokes called attention to the fact that in aneurysm the stridor of the voice seems to come from the notch of the sternum rather than from the larynx itself. In aneurysm the breathing is more apt to differ in the two lungs. Then we have the laryngoscopic picture. There is no swelling of the cords in aneurysm and there may be the paralytic phenomena detailed. Finally, in laryngitis there is apt to be fever.

Then there is the *tracheal tugging* of aneurysm. This is a dragging downward of the larynx with each systole of the heart. The trachea is held up by gently inserting the ends of the fingers under the edge of the cricoid cartilage, when with each impulse the larynx is pulled downward. The patient sits with his head slightly thrown back and the examiner stands behind him. It is said that it may be the sole sign of aneurysm, and a sign, also, that the position of the aneurysm is such as to involve the posterior aspect of the arch. It is said never to be present in aneurysm of the innominate.

Aneurysm of the arch of the aorta affects the *pulse* in distal arteries chiefly only when it involves the origin of blood-vessels leading to those arteries, as the innominate on the right and the carotid or subclavian on the left. If the right radial pulse is enfeebled or delayed, the aneurysm will be on the right, involving the origin of the innominate; if on the left, involving the left carotid or subclavian. Great care should be taken in these investigations, and they should be made from the center to the periphery; that is, the carotids, the subclavians, the brachials, the radials should be successively examined as recommended by Sansom.

These effects are produced by the aneurysmal sac acting as the elastic air chamber in a pump, diminishing thus the pulsatile force, or by its obstructing the entrance of blood to the blood-vessel, or by pressure of the external coat of the aneurysm upon the vessel itself. Osler calls attention to the fact that the pulse even in the abdominal aorta and its branches may be thus obliterated by a large thoracic aneurysm.

Inequality of pupils is another valuable sign of aneurysm of the thoracic aorta, due to the involvement of the sympathetic, its organic or functional destruction, with resulting paralysis of the dilator fibers of the iris, which is thus given over to the control of the third nerve. Hence the pupil is contracted, more frequently on the left side.

Unilateral sweating is similarly caused.

Aneurysm of the *descending aorta* below the arch, between it and the diaphragm, has its most constant symptom in pain—boring pain—generally due to intrusion on the vertebræ, and any persistent boring pain in this locality should suggest a thorough examination. The *bruit*, more apt to be systolic only, is often not heard, sometimes faintly. A *bulging* of the ribs in the posterior thoracic region should be sought for, and a *dulness* on percussion.

Aneurysm of the *innominate* is especially indicated by its murmur, thrill, and an impulse in the vicinity of the inner end of the right clavicle, which is sometimes raised by the resulting tumor; also by the comparative absence of signs of pressure on the larynx or œsophagus. The differences in the right radial pulse alluded to are especially here present.

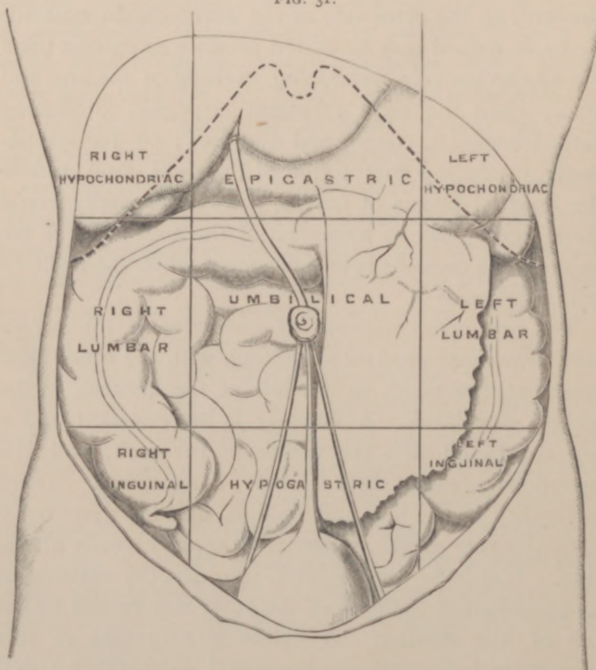
If the *subclavian* is involved, the signs are further outward, on the outer side of the sterno-cleido mastoid. To those named may be added pressure symptoms upon the subclavian vein, producing swelling of the arm and neck; upon the right recurrent laryngeal, producing defective speech, cough, and dyspnœa; on the sympathetic, producing contraction of the right pupil, and on the brachial plexus of nerves, pain. Especially would these signs point to aneurysm of the subclavian if the pulse of the carotids is uninfluenced, while the right or left radial pulse is.

The very rare condition of aneurysm of the *pulmonary artery* may produce a swelling, with the other local symptoms described, to the left of the sternum, in the second interspace. A murmur is less constant and is not conducted into the vessels of the neck, while the superficial pressure signs are more conspicuous. There is lividity of the face and œdema, and the dyspnœa is naturally very great. There is no cough or voice alteration. It is to be remembered, too, that the swelling of an aneurysm of the arch of the aorta *may* extend to the left of the sternum. A pulsating empyema in this vicinity in my experience resembled so closely a pulsating aneurysm that I feared to tap it until suitable preliminary exploration was made.

PHYSICAL EXAMINATION OF THE ABDOMEN.

In mapping out the abdomen for the study of the topography of its organs it is usual to divide it as we do

FIG. 31.



Drawing Showing Regions of the Abdomen. (*After Gray.*)

the thorax, by a set of lines which apportion it into nine regions. First, a line is drawn horizontally around the body at the level of the edge of the thorax; another at the level of the crest of the ilium. Then two vertical lines are drawn through the outer end of the cartilage of the eighth rib above, and the middle of Poupart's ligament below.

The following table of the viscera contained in each of the regions is from Gray's Anatomy :—

Right Hypochondriac. The right lobe of liver and the gall bladder, hepatic flexure of the colon, and part of right kidney.	**Epigastric Region.** The middle, and pyloric end of the stomach, left lobe of the liver and lobulus spigelii, the pancreas, the duodenum, parts of the kidneys, and the supra-renal capsules (aorta and branches, vena cava, semilunar ganglion, thoracic duct)	**Left Hypochondriac.** The splenic end of the stomach, the spleen and extremities of the pancreas, the splenic flexure of the colon, and part of the left kidney.
Right Lumbar. Ascending colon, part of the right kidney, and some convolutions of the small intestine.	**Umbilical Region.** The transverse colon, part of the great omentum and mesentery, transverse part of the duodenum, and some convolutions of the jejunum and ileum, part of both kidneys (and the receptaculum chyli).	**Left Lumbar.** Descending colon, part of the omentum, part of the left kidney, and some convolutions of the small intestine.
Right Inguinal (Iliac). The cæcum, appendix cæci (ureter, spermatic vessels).	**Hypogastric Region.** Convolutions of the small intestine, the bladder in children, and in the adult if distended, and the uterus during pregnancy (often the cæcum, appendix vermiformis, and sigmoid flexure of colon).	**Left Inguinal (Iliac).** Sigmoid flexure of the colon (ureter, spermatic vessels).

The middle region of the upper zone is known as the *epigastric* region, the two adjacent the right and left *hypochondriac*. The central region is called the *umbilical*, and the lateral regions in this zone the right and left lumbar. The inferior central region is the *hypogastric*, and the lateral regions the *right* and left *inguinal* or *iliac*.

INSPECTION.

Inspection notes alterations in the shape of the abdomen, from distention by gases or dropsical effusions, morbid growths, enlarged organs like the liver and spleen, pregnancy, distortions due to positions necessitated by occupation or caused by tight lacing. The abdomen of the little child and that of the man past fifty are both more protuberant than that at an intermediate age; the lower or pelvic portion of the woman's broader than that of the man. There is in nature quite a decided difference in the length of the waist or distance between the lower edge of the thorax and the crests of the ilia. Apart from the effect of tight lacing in women there is naturally a good deal of difference in the width of their waists. In lacing the pressure is generally brought to bear on the hypochondriac and the epigastric regions, the effect of which is to make the waist appear longer, or "wasp-like." After a full meal the upper part of the abdomen is fuller.

Undue enlargement of the superficial veins is sometimes observed in inspecting the abdomen, the result of obstruction to the flow of blood in the portal vein or vena cava, while epigastric pulsation is very commonly seen, being most frequently of no significance, but occasionally due to aneurysm of the abdominal aorta. When the abdominal wall is very thin the outline of certain organs may be traced, and even peristaltic motions in the stomach and bowels are recognizable. Through such an abdominal wall the outline of an enormously distended stomach may even be recognized.

The patient should also be examined in the knee-elbow position, which will permit movable tumors to fall forward and facilitate their recognition by inspection as well as by palpation.

PALPATION.

Palpation of the abdomen should be practised by laying the hand flat upon the abdomen and depressing the ends of the fingers as the hand is moved about, rather than by "poking" with the fingers of the straight hand obliquely placed. The abdominal walls, too, should be relaxed by semi-flexing the thighs on the abdomen, and the legs upon the thighs. Thus we learn of the consistency and situation of various organs and abnormal growths, whether they are smooth or uneven, whether there is tenderness or tenseness. In so doing the degree of pressure must vary. Some pains are relieved by pressure, others aggravated. The former are more apt to be due to neuralgia or colic, the latter to be inflammatory.

The presence of fluid may be settled by fluctuation, which is produced by placing the hand on one side in the flank and tapping the other side gently with the fingers, by which a wave is produced and is felt by the palpating hand. Our knowledge of the more precise situation of fluid, and even of growths, is often aided by changing the position of the patient. Circumscribed fluctuation may sometimes be detected in hydatid cysts of the liver, ovarian cysts, and rarely cystic kidneys. Sometimes a friction or roughness can be felt in connection with enlarged liver and spleen.

Under favorable circumstances the edge of the *liver* and even the end of the gall-bladder can be felt, especially if the latter is distended with bile or gall-stones, or is itself the seat of morbid growths. Especially can the liver be felt if it is much enlarged.

Only when enlarged can the *spleen* be felt downward and forward.

Likewise the *kidneys* are too deep-seated to be felt in health. When movable or floating, the right, which is that almost invariably involved, is often felt more toward the median line, below the liver, and may sometimes be recognized by its kidney shape and easy mobility, while more rarely even the beating of the renal artery can be felt. A deep inspiration will generally cause such a kidney to move downward. Enlargements of the kidney may bring the organ into such position that it can be felt anteriorly. Pressure of the normal kidney gives rise to a peculiar sickening pain like that caused by bruising the testicle.

The *pancreas* is beyond reach in health, and even when the subject of diseased enlargement is rarely felt. Sometimes, however, between the right mammillary line and the median line and behind the edge of the liver can be felt a tumor covered by intestine, which is either the enlarged head of the pancreas or a part of the duodenum with adjacent glands, and which, if associated with *jaundice*, is likely to be a tumor or cyst of the pancreas. A tumor of the *pyloric orifice of the stomach*, also commonly higher up and more toward the median line, is characterized by its greater mobility and change of position with varying degrees of distention of the stomach. A peculiar rotary motion of such tumor is characteristic.

Only under the most unusual conditions can enlargements of the *suprarenal capsules* be felt.

Enlargements of the *mesenteric glands* are characterized by their smoothness and mobility. They differ from *fecal* tumors, which may often be felt in the right groin, by the softness and compressibility of the latter and their gradually forward motion. Only after great enlargement do the deep-seated or posterior abdominal glands come to the front, uniting with the more superficial glands to form large tumors, having communicated to them the impulse of the aorta from behind.

The *uterus* and *bladder*, always behind the pubes in health, when empty, rise as palpable central tumors when distended by their physiological contents, whose distinctness depends largely upon the thinness of the abdominal walls, and is much more accurately investigated by percussion.

The *ovaries*, not to be felt in health, when enlarged from tumors, rising up from the pelvis into either flank, and thence toward the center of the abdomen. When their contents are liquid, circumscribed fluctuation may be recognized, although it is irregular and inconstant, and there is this difference between such liquid and liquid free in the abdominal cavity—the latter falls away into the flanks as the patient lies down, while the ovarian tumor remains central.

These latter organs, particularly the uterus and ovaries, are, however, even more satisfactorily investigated by palpation through the vagina, in the case of the uterus further aided by the uterine sound. In abdominal dropsy fluctuation may also be detected through the vagina, less commonly in ovarian cysts. In abdominal dropsy the uterus is not usually displaced unless simply prolapsed ; in ovarian tumor it is apt to be displaced. The aortic impulse is sometimes conveyed to an ovarian tumor, heaving it forward with each pulse. This is not the case in an abdominal effusion.

The *rectum* may be similarly explored, the hand being sometimes carried far up into it after careful and gradual dilatation of the sphincters. Rectal exploration in this manner should, however, be cautiously carried out, as the possibility of producing rupture exists. This organ as well as the uterus is also investigated by the aid of specula, to which modern invention has added the electric light. So, too, the bladder is now being similarly explored.

PERCUSSION.

Much more tangible in abdominal investigation are often the results of percussion. So far as the hypochondriac, epigastric, and even lumbar regions are concerned, the normal percussion phenomena have been necessarily detailed under thoracic percussion.

For abdominal percussion the patient should be placed in a relaxed position, like that described for palpation. A pleximeter is here conveniently employed, and the force of the blow must be judicious in accordance with the viscera to be investigated. Thus, if studying the lower boundary of the liver or spleen, too strong a blow will bring out the tympany of adjacent gas-containing viscera, while the upper borders of these organs require strong percussion.

Percussion of the spleen requires some special consideration. Its dull sound is limited by the resonance of the adjacent lung and tympany of stomach and intestines, and at times it may even fail of detection. It may be percussed with the patient standing fully stripped or lying on the right side with the legs flexed. Pretty strong percussion should then be commenced in the mid-axillary line from the axilla downward toward the crest of the ilium. At the ninth rib, usually, sometimes a little lower in health, the dull sound comes out, associated with greater resistance. It usually continues downward as far as the eleventh rib or a little below, where it is replaced by the tympany of the intestine. The anterior boundary of the spleen is determined by percussing backward of a line drawn downward from the anterior fold of the axilla. The spleen is seldom found anterior to the mid-axillary line in health. Posteriorly the splenic dulness is not separable from that of the left kidney. Abnormal enlargements of the spleen are downward and anteriorly and may reach colossal proportions.

The percussion borders of the **kidneys** have already been outlined on page 50.

Of the remaining abdominal organs the **stomach** and **intestines** alone approach the surface in health in such way as to make their limitation possible by percussion. They require also some delicacy in discrimination of shades of sound, more particularly in pitch. The quality met in percussing these organs is, for the most part, tympanitic, and it is chiefly variations in the pitch of this which are to be discriminated. The same organ may exhibit different degrees of this under different conditions. Thus, the stomach when moderately distended with gas gives a low-pitched tympanitic sound when percussed; when more distended it gives a higher pitch; when more distended still it may give a dull sound. (See p. 41.) Given the stomach and intestine in an equal degree of tension, the stomach will respond to percussion with a lower-pitched tympany than the intestine because it is a larger cavity. This is sometimes spoken of as less tympanitic; sometimes the stomach percussion note is ringing, amphoric, echoing. By means of these differences when present we can distinguish one hollow organ from another. Again, the presence of liquids or solids in the stomach influences the percussion note.

The hollow viscera *en masse* can be mapped out by determining the boundaries of the solid viscera just described. But we want to do more than this. Below this line is the tympany of the whole abdominal cavity. We want to separate one hollow organ from another — the stomach from the small intestine, the small intestine from the large. For this the patient must be recumbent. As stated, the stomach tympany is ordinarily lower pitched than bowel tympany. Bearing this in mind, we can generally determine the stomach boundaries when the organ is not overdistended with liquid, gas, or food. The upper border of the stomach, as recognizable by percussion, corresponds with the lower edge of the liver and inner border of the spleen, as above outlined. To the left of the apex of the heart the stomach tympany is mixed with the resonance of the lung. At this point, about the seventh rib, is the cardiac end of the stomach. Percussing downward from these boundaries, we are generally able to find a difference of note—a higher pitch, a purer tympany, belonging to the transverse colon—in a curved line which crosses the left edge of the thorax at about the inner end of the tenth rib, the median line just above the umbilicus, and passes thence upward to the edge of the liver to the right of the median line. This is the boundary of the greater curvature of the stomach, and includes between it and the upper border alluded to a hand-breadth space called by Traube the half-moon space of the stomach tympany, better termed crescentic shape, while Leichtenstern has applied the name pulmono-hepatic angle to the point of junction between the lower edge of the left lobe of the liver and the lower border of the left lung. The tip of this angle is behind the sixth rib just below the apex seat, and is bisected by the pleural angle, which, it will be remembered, is not filled by the lung except in deep inspiration. (See p. 41.) This is the highest part of the chest wall reached by the stomach, and it is a point pretty constantly maintained. This half-moon tympanitic space may be converted into one of percussion-dulness by filling the stomach with food, or the line of demarcation may be made more distinct by having the patient drink a glass of water just before the examination; or, as originally suggested by Frerichs, by taking in rapid succession the two portions of a Seidlitz powder, tartaric acid and sodium bircarbonate, or a glass of soda-water. The gas thus liberated rapidly distends the stomach even beyond the limits described. The normal limit of the lower curvature may, however, be put above the umbilicus, although it cannot be said to be abnormally low when at the umbilicus, an event not unusual after fifty years of age. In men the greater curvature is not quite as low as in woman, and in working women not so low as in others. When the lower curvature is much below the umbilicus the stomach may be said to be dilated.

As stated, the percussion note of the large intestine.

is higher pitched and more purely tympanitic than that usual to the stomach. When containing fæces it is rendered duller, and in consequence of this fact there is often less resonance in the left iliac fossa than in the right, although fæces may also accumulate in the latter, and an impaction in the head of the colon give positive dulness. The colon may also be artificially distended with gas, for examination, if desired.

The percussion note of the small intestine is still higher pitched than that of the large, and by this it may be distinguished from that bowel, if not filled with solid matter or liquid. The differences in percussion note alluded to are not always equally marked, and it is not always possible, in consequence, to demark the organs.

The *bladder* is recognizable by its dull note above the pubis when distended with urine.

It remains to make some allusion to peculiarities in the percussion of **ovarian cysts** with fluid contents, as compared with dropsical effusions into the abdomen. In the former, the percussion note is dull in the central abdominal region, while in the flanks there is apt to be tympanitic percussion, from the fact that the intestines are pushed into them. With change of position, the dulness in ovarian dropsy does not change position, while in abdominal dropsies it does.

The two may, however, be combined, when the difficulty is increased, and a preliminary tapping may be necessary to settle the question.

AUSCULTATION.

Auscultation, of all the means of physical diagnosis, gives us least information in abdominal investigation. An aneurysmal murmur may be heard over the aorta, and sometimes a murmur may be heard in an enlarged spleen, and even a friction sound may be heard. Borborygmi are sometimes audible at a distance, and metallic tinkling from the splashing of fluid in a distended stomach.

Certain *deglutition murmurs* are described by Ewald. First there is a deglutition murmur, of no diagnostic significance, produced by swallowing a mouthful of liquid, propagated from the pharynx into the esophagus and heard all along the latter tube. In addition are heard, only *near the cardia*, during deglutition, two murmurs. The best site for auscultation is just below the xiphoid cartilage. The first, or *hissing murmur* (Durchspritzgeräusch), occurs almost immediately after the beginning of deglutition, and sounds as if fluid was being directly squirted into the stethoscope. The second sound, or *pressure murmur* (Pressgeräusch), is heard six or seven seconds later, and described by Ewald as a series of tones rapidly following one another, either "gurgling, clucking, splashing, or sprinkling."

These two sounds alternate. The first is heard but rarely, and is said to indicate a relaxation of the cardiac orifice.

The second sound is quite constant, and is absent only when the first is heard. Its cause is not precisely determined, being ascribed by some to audible vibrations of the cardiac orifice, caused by the passage of food over it; by others to a "pressing through" of air swallowed with the food.

It is on the absence, therefore, of the second murmur that diagnostic value depends; *i. e.*, it is apt to be wanting in obstructive disease of the cardiac orifice, although too much stress must not be laid on this sign, since the murmur is not invariably present in health.

The *fœtal* heart beat and *placental murmur* should be mentioned as auscultatory abdominal phenomena.

APPENDIX.

EXAMINATION OF BLOOD AND SPUTUM.

THE COUNTING OF BLOOD CORPUSCLES.

Decidedly the most convenient instrument for estimating the number of corpuscles to the cubic millimeter is the cytometer of Thoma-Zeiss. The directions for its use appended are essentially those of the maker—Zeiss.

The apparatus consists of three parts:—

(1) A graduated pipette with india-rubber tubing and mouth-piece.

(2) A divided cell upon an oblong slip.

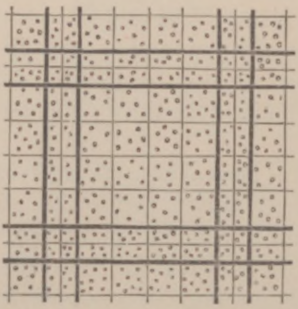
(3) A cover-glass with plane ground surfaces.

In order to count the red corpuscles of human blood, the tip of any finger is cleaned with water and alcohol, and then rubbed between the fingers of the other hand. A slight arterial hyperæmia of the tip of the finger will arise, so that a fairly deep puncture with a lancet-like needle is sufficient to cause a drop of blood to appear. The point of the pipette is quickly placed into it and the blood sucked in up to division 1. Then the point of the pipette is cleaned from the blood sticking to it by a cloth kept ready for the purpose, and it is placed into a 2½ per cent. filtered solution of bichromate of potash, or 3 per cent. filtered solution of common salt. This also is immediately sucked up, so that the fluid enters into the spherical enlargement of the pipette. As soon as the sphere is filled up to division 101, the sucking is interrupted and the mouth-piece of the india-rubber tube closed by putting the finger upon it. The contents of the spherical enlargement are now to be mixed by careful shaking. Thus in this sphere ninety-nine parts by volume of the solution are mixed with one part by volume of blood, or 100 parts by volume of the mixture contain one part by volume of blood, for the fluid in the capillary tube does not enter into the mixture.

If the blood is drawn in up to another division, say 0.5, instead of division 1, then with the same mode of proceeding another dilution is obtained, viz., 1 : 200. Afterward, by blowing air into the india-rubber tubing, the solution may be removed from the capillary tube, and by constant shaking, about one-half of the sphere is emptied. The next drop of the mixture is emptied upon the middle of the bottom of the divided cell, after the latter has been carefully cleansed. The cover-glass is immediately placed over it, and the apparatus is transferred to the horizontal stage of the microscope and left standing quietly for some minutes, so that the blood corpuscles may settle down.

It is necessary for a successful enumeration that the divided cell and cover-glass should be thoroughly cleaned. If this is done properly the Newtonian rings will be perceived along the edge of the cover-glass as far as it rests upon the wall of the cell, and this indicates that the cover-glass lies well upon it. At the same time it must be seen that no fluid enters between the cover-glass and the wall of the cell. On the contrary, the drop of blood should be placed in the center of the cell, and spread thence to fill up the space between the cover-glass and the bottom of the cell for some square millimeters.

FIG. 32.



Group of 16 Small Squares, each of a Capacity of $\frac{1}{4000}$ c.mm., Making One Large Square of the Thoma-Zeiss Cytometer, Magnified.

Special care should be taken to keep the pipette in clean condition. Every time after having been used it should be rinsed with (1) the diluting fluid, (2) distilled water, (3) absolute alcohol, and (4) ether. If dust or coagulated blood should still stick to the pipette, it should be removed with strong acids or alkalies by repeated rinsings, assisted, if necessary, by a bristle.

The corpuscles may be counted by any object glass magnifying about 300 diameters.

Every fifth square of each horizontal and vertical row of squares is crossed by an additional line to facilitate the counting. Each square occupies an area of $\frac{1}{400}$ sq. mm., and above each square there is a space of $\frac{1}{4000}$ c. mm., since the distance of the bottom of the cell from the lower surface of the cover-glass amounts exactly to $\frac{1}{10}$ mm. The corpuscles which first were suspended in this space have now settled and are lying on the bottom of the cell, where they may be counted. The corpuscles lying upon the lines should be counted, but, of course, only once. Thus, all corpuscles lying on the horizontal lines should be counted in the squares above them, and all corpuscles lying on the vertical lines should be counted in the squares to the right of them.

The calculation is as follows: If by a dilution of the blood in the proportion of 1 : *a*, *z* corpuscles have been counted in *n* squares, then 1 c. mm. of undiluted blood will contain:

$$4000 \times \frac{a \times z}{n} \text{ blood corpuscles.}$$

If, for example, by a dilution of the blood in the proportion 1 : 100, as we supposed above, in 200 squares altogether 2570 red blood corpuscles were found, then the calculation will give for 1 c. mm. of blood—

$$\frac{4000 \times 100 \times 2570}{200} = 5,140,000 \text{ blood corpuscles.}$$

For counting the white blood corpuscles a pipette should be used which allows a dilution in the proportion of 1 : 10, and instead of the salt solution an aqueous ⅓ per cent. solution of acetic acid should be chosen for diluting. The red corpuscles will disappear in this fluid, but the white ones will remain and are easily counted. The method of calculation is the same as that given above for the red blood corpuscles.

Studies by Thoma and others, with a view to determining possible errors with the instrument whose use has just been described, go to show the constant errors to be insignificant, less than one per cent., while the accidental and variable errors, which are unavoidable, diminish with the number of corpuscles counted. Thus, by counting 200 corpuscles they amount to five per cent. of the total result, by counting

1,250	corpuscles	amount to	2	per cent.	of	the	total.
5,000	"	"	1	"	"	"	"
20,000	"	"	½	"	"	"	"

Recently, in 1885, Professor Blix, of Upsala, Sweden, suggested the use of centrifugal force in estimating the volume of red blood corpuscles, and Dr. S. G. Heden has devised an instrument called the *hematokrit* for this purpose. Dr. Judson Daland has further improved this instrument so that after the blood, diluted with an equal bulk of a 2.5 per cent. solution of bichromate of potash, has received the requisite amount of rotation, the percentage *volume* of red corpuscles may be read off from the cylindrical tubes in which the blood is placed, and from this deduced the *number* in each cubic millimeter by simply adding six ciphers to the reading.

Dr. Daland regards the hematokrit as both more speedy and more accurate than the cytometer, basing his conclusions on a very large number of comparative observations. He used also a great variety of fluids for dilution, and concluded that the above solution of bichromate of potash is, for many reasons, the best. The hæmatokrit also enables one to measure the volume of colorless blood corpuscles, but no method has yet been devised for calculating their number.

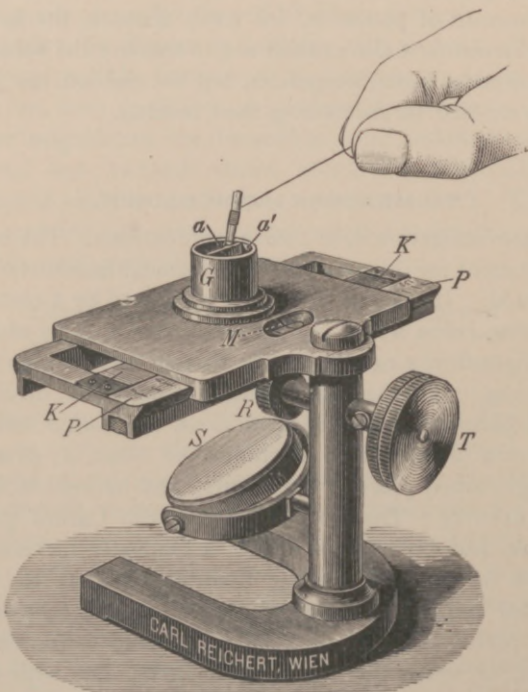
TO MEASURE HÆMOGLOBIN.

Such estimation is, of course, approximate. The best instrument for this purpose is the hæmoglobinometer o Fleischl. It consists of a stage perforated by a central opening, below which is a gypsum reflector, *S*, by which the light from a candle may be thrown directly into the opening. Into the latter is fitted a cylinder, *G*, divided by a partition into two equal parts, one half, *a*, being over the unobstructed opening, the other, *a'*, over a wedge-shaped piece of glass interposed between it and the opening. The glass is colored with Cassius' gold purple, and presents, of course, a gradually increasing depth of color in passing from the thinner to the thicker end. The wedge of glass is movable by a rack and pinion alongside of a scale graduated in 100 equal parts, of which the figures 100 corresponds with the depth of color of a mixture of normal blood, and lower figures correspond with that of thinner blood.

To use the instrument each demi-cylinder is filled with water, and into the one, *a*, opposite the *unob-*

structed opening is put a quantity of blood measured in the little cylinder shown in the cut. The wedge of glass

FIG. 33.



Hæmoglobinometer of Fleischl.

is then moved along by the milled head, *T*, until the color of the blood solution exactly coincides with the color of the opposite half cylinder containing water only, but placed over the colored glass. The figure attained on the scale when the shades are identical indicates the percentage of hæmoglobin. In point of fact, it rarely happens that a normal blood exceeds ninety per cent., a fact which should be borne in mind.

STAINING OF TUBERCLE BACILLI.

Of the various methods of staining tubercle bacilli that by the *carbol-fuchsin* solution of Ziehl-Neelsen, with or without *Gabbet's* counter stain of methyl blue, appears to stand the test of time as well, if not better, than any other. By this method the bacillus takes a bright red color from the fuchsin, the mordant being carbolic acid.

The *carbol-fuchsin solution* is made as follows:—

Powdered fuchsin, ...	1 part.
Alcohol, ...	10 parts.
Five per cent. solution carbolic acid,	100 parts.

Mix and filter.

The older the solution the better.

Two methods are practised with this staining fluid, a rapid and a slow, the former being more commonly practised for diagnostic purposes.

1. *The rapid method with carbol-fuchsin without or with counter stain by methylene blue.*—A very small clump of the most solid part of the sputum mass is selected and brought with forceps or platinum loop

on a clean cover glass. Upon this another cover glass is superimposed and the two are pressed and rubbed over each other until the specimen is thoroughly smeared over both. They are then separated and two specimens are thus obtained. When dry, one of these covers is passed, specimen side up, three times slowly over the flame of a spirit lamp or Bunsen-burner, by which the albumin is coagulated and the specimen fixed. The specimen is then completely covered with the staining fluid and held over the flame until the solution begins to vaporize, care being taken to keep all parts of the glass thoroughly covered. At the end of one minute it is washed in water. It is then decolorized in acidulated alcohol, eight or ten drops of HCl or five drops HNO_3 to a watch crystal of alcohol, and examined in the latter solution, preferably by a one-twelfth oil-immersion and Abbé's condenser, although a little experience with a dry lens of 350 diameters or higher will soon lead to the recognition of the bacilli, which are stained a handsome red.

The preparation is more brilliant and its study rather less trying to the eyes if *counter-stained* by Gabbet's acid blue, composed of—

Methylene blue, ...	2 parts.
Twenty-five per cent. solution sulphuric acid, .	100 parts.

After being washed in water, the specimen is immersed for one and a half to two minutes in the acid blue, washed off in water, dried between filtering paper, and examined in water.

2. *Slower method with carbol-fuchsin, and counter-stain with Gabbet's acid blue.* This slower method is always more satisfactory if time permits, and should alone be used for permanent preparations.

The steps are the same until the staining stage is reached, when the cover-glasses containing the specimen are placed in the carbol-fuchsin solution, say at five or six o'clock in the evening, and allowed to remain until next morning. They are then washed in water, counter-stained by Gabbet's acid blue solution, washed in water, dried between filtering paper, and studied in water, or if it is desired to mount the specimen permanently, it is passed through alcohol, xylol, or oil of cloves into Canada balsam. Specimens stained in aniline colors should not be mounted in glycerin, as this gradually withdraws the stain.

Sections are treated similarly by the slow method and mounted in balsam.

When bacilli are very few, in viscid sputum, Biedert's method may be used. Fifteen centimeters of the sputum are mixed with 75 to 100 centimeters (about two teaspoonfuls) water, four to eight drops, according to the density of the fluid, of liquor potassæ added, and the whole boiled, four to six teaspoonfuls of water being gradually added, if necessary, until a thin fluid results. This is then allowed to stand in a conical glass for two days, when the supernatant fluid is removed and the sediment examined as before. It is to be remembered that bacilli treated with alkalies stain slowly, and a longer immersion in the staining fluid may be necessary on this account.

THE PNEUMOCOCCUS.

The Pneumococcus of Fraenkel-Weichselbaum is characterized by its lance-shape and capsulation as found in tissues and sputum. In cultures it is without capsule. Found most frequently in the lung in croupous pneumonia, it also occurs in the sputum of pneumonia, in fresh endocardial vegetations, and the pus of cerebrospinal meningitis. It usually occurs in pairs (diplococci), sometimes in filaments of three or four elements.

The simplest extemporaneous stain is the carbol-fuchsin solution (p. 203). An immersion of a few minutes usually suffices, when the coccus itself will have become intensely red, while the capsule has assumed a light reddish tint. The capsule may also be stained in the same way as that of Friedlander's bacillus, as below.

The Fraenkel bacillus may also be stained by Gram's method, as follows:—

1. The cover-glass preparation is placed for from two to five minutes in warm *Ehrlich-Weigert's* saturated anilin-water solution of gentian violet.*

2. Transfer directly without washing into Gram's solution (iodine 1, iodide of potas. 2, water 300) for from two to three minutes, where it becomes quite black.

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* Anilin oil, ...	4 parts.
Distilled water, ...	100 parts.

Shake, filter through moist filter and then add

—Saturated alcoholic solution (stain 1, absolute alcohol 4) gentian-violet, or methyl-blue,	11 parts.

Filter.

3. Wash in absolute alcohol until the primary black color becomes pale gray. All the cellular elements are decolorized except the microörganism, which has assumed a deep blackish blue.

4. Mount in Canada balsam.

This method is particularly valuable in the differential diagnosis between this and the—

Pneumococcus of Friedlander.—This bacillus is oval, encapsulated, and occurs, also, in pairs, and is sometimes found in the lung of croupous pneumonia.

It is also stainable in aqueous staining solutions as the bacillus of Fraenkel-Weichselbaum, the capsule remaining unstained. It cannot be stained by Gram's method.

To stain the *capsule* in cover-glass preparations, Friedlander directs:—

1. The prepared cover-glass, drawn three times through the flame, is placed in 1 per cent. acetic acid solution for two minutes.

2. Remove the acetic acid by blowing on the cover-glass through a pointed glass tube, and allow to dry in the air.

3. Stain for ten seconds in saturated anilin-water-gentian-violet solution.

4. Wash in water, dry between filter paper, mount in balsam.

For sections:—

1. Stain for twenty-four hours in warmth in a solution composed of concentrated* alcoholic gentian-violet solution 50, distilled water 100, glacial acetic acid 10.

* Ten grams of the powdered dye, 40 grams absolute alcohol.

2. Wash in one per cent. acetic acid solution.
3. In alcohol to dehydrate.
4. Mount in balsam.

Bacillus of Diphtheria.—The short, curved bacillus assigned by Löffler as the cause of diphtheria is well stained by Löffler's methylene blue solution of—

Concentrated alcoholic solution methyl-blue (1–40),	30 c.c.
Caustic potash (1 : 10,000),	100 c.c.

The Typhoid bacillus is stained by the same solution. It is not stainable by Gram's method.

The Cholera Bacillus is stained in the concentrated aqueous solutions of fuchsin; sections by fuchsin solutions or methyl blue. A flocculent mass from a stool is treated between glass covers and dried and fixed as in the case of sputum.

Bacillus of Syphilis.—*De Giacomi's method.* The cover-glass preparations made from the pus are warmed for a few minutes in the anilin-water fuchsin solution, then washed in water to which a few drops of a chloride of iron solution have been added, and decolorized in a concentrated solution of chloride of iron. They are finally washed and studied in water. The syphilis bacillus remains red, while all other cells are decolorized. If desired to mount dehydrate rapidly in absolute alcohol, clarify in xylol and mount in Canada balsam.

The gonococcus is very well stained by the carbolfuchsin method already described for the tubercle bacillus. The true gonococcus is not stained by Gram's method. It is thus distinguished from similar microbes.

CHEMICAL EXAMINATION OF GASTRIC CONTENTS.

A variety of test meals has been suggested, the products of whose digestion are submitted to examination. That which, on account of its simplicity, convenience, comparative cleanliness, and easy manipulation of products, I prefer, is the test breakfast of Ewald. It consists of an ordinary dry roll,* weighing thirty-five grams (540 grains), and about one-third of a liter (ten ounces) of either warm water or weak tea without milk or sugar, taken fasting.

One hour after the ingestion of the meal the product is removed by the flexible stomach tube. It is sufficiently lubricated by dipping into warm water, after which it is introduced by a process of deglutition. The tube should be about ninety-five centimeters (thirty-seven and a half inches) long. From the fundus of the stomach to the incisor teeth is sixty to sixty-five centimeters (23.5 to 25.5 inches), and about this much should be taken up when the tube is well in place. The Ewald tube is usually marked at this place. A long tube allows the stomach to be emptied by syphonage after a little pressure on the abdomen has

* Such a roll containing about 7 per cent. of nitrogen, .5 per cent. of fat, 4 per cent. of sugar, and 52.5 per cent. of non-nitrogenous extractive substances, and 1 per cent. of ash, includes, therefore, the usual elements of a mixed diet.

been exerted to start the motion of the contents, or they may be removed by aspiration. The amount withdrawn, which should be about 40 c. c., is first examined for blood or other abnormal constituents, and then filtered, being previously well shaken. This is done in order to diffuse uniformly the acid constituent.

In healthful conditions, in ten or fifteen minutes after food ingestion the gastric contents are acid, the acidity depending on free acids or acid salts. At this stage the free acid recognized is lactic. Up to thirty to forty-five minutes the lactic acid predominates, while the color tests for hydrochloric acid are negative. Then comes a stage in which traces of HCl can be demonstrated, co-existing with lactic acid. Finally, the lactic acid disappears altogether, and at the end of an hour HCl only should be present. HCl is present from the beginning, but its recognition is interfered with because it is partly in combination, and because of the acid salts present. It gradually increases in amount until at the acme of digestion it reaches .15 to .2 per cent. after a light meal, and .2 to .33 per cent. after an abundant meal.

To Determine the Total Acidity.—The reaction of the filtered fluid being determined by litmus or Congo red paper, the total acidity is then determined by titration. A Mohr's burette is filled with a decinormal solution of caustic soda. Ten c. c. of the filtered solution are placed in a beaker and one or two drops of an alcoholic solution of phenolphthallin added as an indicator. The solution is then slowly dropped from the burette until the red color produced in the fluid by the action of the alkali on the phenolphthallin no longer disappears on shaking. As a rule, the acidity of the gastric contents, an hour after such a meal, requires four to six c. c. of the decinormal solution to neutralize it in normal digestion. Figures above and below this are therefore abnormal. The acidity may be expressed in percentage; thus, if four c. c. were required to neutralize ten c. c. there would be 40 per cent., or, if six c. c., 60 per cent. total acidity. If the acidity is due to HCl alone its percentage is easily estimated. One cubic centimeter of the decinormal solution is equivalent to .003646 HCl.* If, therefore, the number of cubic centimeters used to neutralize ten c. c. of the solution be multiplied by .003646 and again by ten the result will be the percentage. Thus, if six c. c. of the deci-normal solution be used the percentage will be $6 \times .003646 \times 10 = .218$, within the normal range, which is from .14 to .24 per cent.; if four c. c. be used the HCl percentage will be $4 \times .003646 \times 10 = .11$, or less than normal.

To Determine Whether Acidity Depends on Free Acids or Acid Salts.—This may be roughly done by the anilin dyes, of which congo-red and tropæolin o o, *l'orange Poirier* of the French, are commonly used. A saturated watery or alcoholic solution is made, or in the case of congo-red, strips of filtering

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* Decinormal solution of soda $\frac{N}{10}$ NaHO = 4 grams NaHO dissolved in 1000 c. c. distilled water. Each c. c. of this solution exactly neutralizes 0.0036 gram HCl.

paper are dipped into such solution, dried, and thus preserved for use. The paper is, however, less delicate than the solution, which strikes a beautifully *sky-blue* reaction with a solution containing but 0.02 per 1000. Acid salts produce no change.

The tropæolin solution is dark yellowish red, and a solution of free acid, as HCl, .025 to 1000, changes it to a deep dark brown. It is slightly less delicate, therefore, than the congo-red. Acid salts, as acid sodium phosphate, make it straw yellow. In all of these tests it is necessary to use an excess of the fluid to be tested. This is accomplished by placing five or ten *drops* of the reagent in a test glass or porcelain capsule and adding one to two *c. c.* of the filtered contents.

Only rough determinations can thus be made, as the delicacy of these tests is seriously affected by salts and albuminoids, especially albumose and peptones. It is better, therefore, to employ *Leo's carbonate of calcium* test, based upon the fact that $CaOCO_3$ in cold solution neutralizes free acids only, not reacting with acid salts. A strip of blue litmus paper having been previously moistened with the filtrate as a standard, a few drops of the filtrate are thoroughly mixed in a watch-glass with a small amount of *chemically pure* powdered calcium carbonate. After the complete neutralization of the free acids and disappearance of the separated CO_2, the reaction is tested with another piece of litmus and the result compared with the standard. If the litmus is no longer reddened the acidity was due to free acids only, while if there is still redness, but less in degree than that of the standard, there are both free acids and acid salts.

This test may be rendered still more delicate by extracting the fatty acids by heat and the lactic acid by ether, when the free acid remaining will only be HCl, of which, according to Leo, .0002 per cent. may be detected if decided amounts of acid phosphates are not present, and even then .008 per cent.

Determination of Hydrochloric Acid.—For this purpose Günzburg's or Boas's test should be used; the former is the more delicate. Günzburg's solution is made as follows:—

Phloroglucin, ...	2 parts (gr. xxx).
Vanillin, ...	1 part (gr. xv).
Absolute alcohol, ...	30 parts (f ℥ j).

The solution is pale yellow and has a decided odor of vanilla. On exposure to light it assumes a dark golden-yellow, and it must therefore be kept in dark-hued bottles or be freshly made as required.

A drop or two of the reagent is placed on a porcelain plate or capsule with an equal quantity of the gastric filtrate, and a *gentle* heat applied, not to boil, but simply to evaporate. Very soon a beautiful rose-red tinge will appear at the edge of the mixture, or red stripes will be observed. Blowing at the edge will favor the appearance of the red stripes. This test is unmistakable, and surpasses all others in delicacy, being available when HCl is present in the proportion of 1 to

20,000, or .05 per mille. Filtration of the gastric contents is not necessary. The reaction is not simulated by albuminates nor interfered with by salts in the normal proportion, nor by organic acids.

Günzburg's test may even be used for quantitative estimation. By successively diluting the stomach contents until they no longer respond to the test, and bearing in mind that the limit of reaction is reached when there is but one part HCl to 20000, we may make the required estimation. Thus, if it barely responds when the gastric fluid is diluted one-half, the proportion is 2 to 20,000, or 1 in 10,000; if after being five times diluted it is 5 to 20,000, or 1 in 4000, and so on.

Or Mintz's method may be used, as follows: Ten c. c. of the stomach contents are titrated with the decinormal soda solution until a response with Günzburg's reagent no longer occurs, testing a drop or two of the partly neutralized gastric contents with the addition of each one-tenth c. c., or fraction thereof. Then as one c. c. decinormal soda solution equals .0036 HClO., we have simply to multiply .0036 by the number of c. cs. used and the result will be the percentage required.

Boas's test is based upon the fact that resorcin strikes a similar reaction with hydrochloric acid. The solution consists of

Resublimed resorcin, ...	5 parts	(gr. lxxv).
White sugar, ...	3 "	(gr. xlv).
Dilute alcohol, ...	100 "	(f℥ iiiss).

Three to five drops of the reagent are poured into a porcelain dish and an equal quantity of stomach contents added. Heat is applied as in Günzburg's test, and a purple red color appears at the edge of the drop. It is said also to detect .05 per mille of HCl.

Determination of Organic Acids.—These include lactic acid, acetic acid, and the true fatty acids, especially butyric. These acids, especially lactic, are normal in the early stage of digestion, but in the later stages, if detectable by the ordinary reagents, they are pathological.

Lactic acid is recognized by its effect upon a very dilute, almost colorless, solution of neutral ferric chloride, which is converted into a canary-yellow color by its action. This is Uffelman's test. It it rendered more certain when a few drops of a neutral ferric chloride solution are mixed with one or two drops of pure carbolic acid, and adding water until the solution assumes an amethyst blue color. Instead of the pure carbolic acid about ten c. c. (fʒijss) of a two to five per cent. solution of the acid may be used and the dilution completed to the proper tint. A few drops of even a .05 per mille solution of lactic acid (1 in 20,000) will change the blue to the distinctive yellow color.

There are, however, sources of error. The lactates cause the same reaction, but this matters not, because we desire to recognize the lactic acid, whether in combination or not. The reaction, however, takes place with alcohol, sugar, and certain salts, especially phosphates, which are often found in gastric contents. The color produced by phosphates is not identical, but if the filtrate operated with has a yellow tinge the resulting color may approximate very closely. Under these circumstances the lactic acid must be extracted with ether. Two to five c. c. of the stomach contents are thoroughly shaken with three or four times the amount of ether. The ether is allowed to rise on top, which it does rapidly, and is then poured off into a glass beaker. More ether is added and the washing repeated until in all about 30 c. c. (f℥j) of ether have been used. The ether is then evaporated by placing the beaker, with its contents, in a vessel of hot water. The residue is redissolved in a few drops of water and *one or two* drops of Uffelman's reagent allowed to fall from a pipette into the solution. Too much of the solution may mask the reaction. This test is much more delicate than tropæolin, which may fail to show a reaction for free acid because of its concealment by acid salts.

The *fatty* acids, especially *butyric*, strike a tawny yellow color with a reddish tinge with Uffelman's chloride of iron solution, but .5 per 1000 or 1 in 2000 is required before the reaction occurs.

Fatty acids may also be detected by heating to the boiling point a few c. c. of the gastric filtrate in a test tube, over the mouth of which a strip of moistened neutral or blue litmus paper is placed. On this the vaporized acid will produce the usual change.

The oily particles of pure *fat* may be recognized floating in the gastric contents or in the aqueous solution of the residue after evaporating the ethereal extract. Butyric acid may also be separated in the form of drops by adding small pieces of calcium chloride.

Acetic acid is easily recognized by its odor, but it may also be detected by neutralizing with sodium carbonate the watery residue after the removal of the ethereal extract, and then adding neutral ferric chloride solution. A striking blood-red color is struck, also produced by formic acid, but this is never a constituent of gastric contents.

Alcohol, which is sometimes formed in the stomach in intense yeast fermentation, may be detected by Lieben's iodoform test applied to the distillate of the stomach contents, as follows: To a portion of the distillate add a small quantity of liquor potassæ, then a few drops of a solution of iodine and iodide of potassium (1, 2, 50). If alcohol is present a yellowish precipitate of iodoform takes place slowly. The same precipitate occurs with acetone, but rapidly.

Examination of Products of Albumin Digestion.—The term proteolysis is applied to albumin digestion, in which all proteid substances are converted into peptone. It takes place partly in the stomach, but probably even to a greater degree in the small intestine. In this process the first step is the production of certain substances intermediate between albumin and peptone which are called *albumoses* or *proteoses*. Those which are of chief importance in the study of gastric digestion are syntonin or acid albumin, and propeptone or hemialbumose. In the ordinary process of digestion with a normal gastric juice some or all of these substances should be present at the end of a certain time. So far as they are the products of gastric digestion they may be studied by the aid of a test meal and removal of the gastric contents as already described.

Propeptone and Peptone. — Propeptone at the maximum of normal digestion should be present only in traces and must be removed before peptone is tested for, since it responds to the same test,—the biuret test.

To remove propeptone treat 2 or 3 c.c. of the stomach filtrate with an equal quantity of a saturated solution of chloride of sodium and then add one or two drops of strong acetic acid. Propeptone if present is thus precipitated, and may be filtered out. To the filtrate add one c.c. of liquor potassæ, then a few drops of a one per cent. solution of sulphate of copper. A purple red color indicates the presence of peptone, and we may approximately estimate its amount by the intensity of the biuret reaction provided we always use the same proportion of stomach contents, solution of potash, and cupric sulphate. Should it happen that a handsome biuret reaction is struck before removing the propeptone, and but a faint one or none at all afterward, the proportion of propeptone is large and peptone small. Cahn has shown that in dogs, at least, the quantity of peptone remains at a certain percentage, being probably kept at that figure by its removal as formed. Hence the only index of the rapidity and extent of albumen transformation is the amount of propeptone formed or remaining. Finally, Ewald and Gumlich conclude that the formation of true peptone in the human *stomach* is slight, albumoses being mainly produced, the chief transformation of which is effected in the small intestine.

To Estimate the Activity of Proteolysis, or Albumin Digestion.—By Ewald's method, coagulated white of egg is cut into thin slices and out of these small disks are cut by a cork borer or similar instrument. These may be prepared in quantity and kept for use in glycerin, which should, however, be washed off before using. An equal quantity of the filtered gastric fluid is placed in four small test-tubes and one or two disks of albumen put into each. To the first nothing else is added, to the second enough hydrochloric acid to make a solution of about* 0.3 to 0.5 per cent. This is accomplished by adding two drops of hydrochloric acid to five c.c. (90 minims) of stomach contents.

To the third is added a definite quantity of pepsin, about 0.2 to 0.5 gram [gr. iij to gr. vijss], to the fourth both hydrochloric acid and pepsin. The test-tubes are placed in an incubator at about 100° Fahr., and from time to time examined with a view to learning how far the liquefaction of the disks of albumen has proceeded. The rate of this will inform us whether digestion would have occurred without the addition of anything, or whether acid or pepsin or both were neces-

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* The difference between the strength of the acetic acid of the German pharmacopœia (25 per cent. of the anhydrous acid), intended by Ewald, and that of the U. S. P. (32 per cent.) is not sufficient to necessitate a change of proportion.

sary. We will learn, also, whether by adding more hydrochloric acid we have made the acidity excessive.

It must be remembered, however, that after the peptone has reached a certain percentage, its further production is retarded, or even suspended, so that there may be an apparently slow reaction with even a very active gastric juice. Ewald happily reminds us that all laboratory attempts to imitate digestion are defective in the important respect that with our test-tubes and flasks we can neither imitate absorption on the one hand, nor, on the other, allow for the onward movement to the intestines of the gastric contents, two important functions by which the stomach strives to maintain a fairly uniform degree of concentration of its contents.

The Action of Rennet, the Milk-coagulating Element of the Natural Gastric Juice.—The simplest method of estimating the action of rennet is that of Leo. To ten c.c. of *raw* milk are added two to five drops of stomach contents. Raw milk is used because it coagulates ten times more rapidly than boiled milk, while neutralization is unnecessary because of the relatively small quantity of gastric juice used. The mixture is placed in the warm chamber at 100° F., and coagulation should take place in from one minute to several hours. The characteristic coagulation of rennet is a cake of casein floating in clear serum, while acids produce lumpy and flaky masses.

The rennet-ferment, or enzyme, does not exist primarily as such, but as a rennet-zymogen or proenzyme, which itself has no action on milk but is converted into rennet by the action of any acid, as hydrochloric, or of warm chloride of calcium. This may be shown as follows: If the spontaneous coagulating action of gastric juice on milk be destroyed by neutralization by an alkaline carbonate, this property may be restored by digesting with dilute hydrochloric acid or by the addition of a five per cent. solution of calcium chloride. While fasting and at the beginning of digestion zymogen only is present in the stomach, but later both it and the ferment are found. An acid reaction for the curdling action of rennet is not absolutely necessary.

Digestion of Starch and Sugar.—It is well known that during digestion starch is converted into grape sugar, and cane sugar is converted into *invert* sugar—a mixture of cane and grape sugar. This action, commenced in the mouth by the ptyalin of saliva, is continued to a less degree so long as the acidity is slight, (.01 per cent. for HCl, .1 or .2 per cent. for lactic, .4 per cent. for butyric) in the stomach, and is finished in the small intestine by the trypsin of the pancreatic juice. As in albumin digestion, there are intermediate substances between albumin and peptone, so between starch and grape sugar there are similar intermediate products. The order is as follows:—

(1) Starch, (2) Dextrins (Erythrodextrin, Achroödextrin), (3) Maltose, (4) Dextrose = grape sugar.

Starch is recognized by the deep blue color struck with iodine or Lugol's solution (iodine 1, iodide of potassium 2, distilled water 200), and the reaction grows less vivid as the starch is converted. Of the dextrins, erythrodextrin strikes not a blue, but a purple color, while solutions of achroödextrin, maltose, and grape sugar take on only the yellow color of the iodine solution. Where a mixture of these substances occurs the first few drops of the iodine solution produce no color at all, or only a transitory one, being taken up by the dextrose and maltose, while the addition of more iodine strikes the purple of erythrodextrin or blue of starch.

If, therefore, amylaceous transformation has progressed normally in the mouth and stomach, so much starch should be changed into achroödextrin, maltose, or dextrose that the addition of small quantities of Lugol's solution does not strike the characteristic color. If, however, the blue or purple reactions appear, conversion has not been sufficiently rapid into maltose, the principal product of gastric conversion, the change into dextrose, being completed in the small intestine. This may be due either to a deficiency of ptyalin or a too rapid production of acid in the stomach. From such event we might also infer a hyperacidity of the gastric juice.

To Determine the Rapidity of Absorption from the Stomach.—Penzoldt's method is that generally followed. A capsule containing iodide of potassium (.1 gram or gr. jss) is swallowed, being first carefully wiped to remove any adherent particles. The appearance of the iodide in the saliva indicates that absorption has taken place from the stomach. To determine this, starch paper is first prepared by moistening with starch paste and drying. Then, after the salt is swallowed, a piece of the paper is moistened every five minutes with the saliva, and the moistened spot touched with fuming nitric acid. As soon as the iodine appears in the saliva the characteristic blue reaction is struck.

When absorption is normal this reaction usually takes place in ten or fifteen minutes, but where absorption is abnormally delayed, the reaction is also delayed half an hour or more, or it may not occur at all.

To Test the Motor Function of the Stomach.—Three methods are practised. First, remove the gastric contents six to seven hours after the ingestion of a large meal, or two and a half hours after an Ewald's breakfast, and note the amount of solid substance remaining. Second, salol is administered and the products of its lysis sought for in the urine. Third, a definite quantity of olive oil is introduced into the empty stomach and the remnant unabsorbed is withdrawn at the end of two hours. The second, though not without drawbacks, is preferred. Salol is composed of phenol and salicylic acid, into which it is broken up by the action of the pancreatic juice, but not by the acid gastric contents. Salicyluric acid, a product of decomposition of salicylic acid, appears in the urine 40 to 60, or at most 75, minutes after taking one gram (15 grs.) of salol when gastric peristalsis is normal. Salicyluric acid is readily detected in the urine by the violet color produced on the addition of neutral ferric chloride solution. The method employed is to place a drop of urine on a piece of filter-paper and bring in contact with this a drop of a 10 per cent. ferric chloride solution. The edge of the drop will strike a violet color in the presence of a mere trace of salicyluric acid.

The objection to the salol test is that the decomposition of the salol may be delayed by an undue acidity of the gastric contents discharged into the duodenum. But practically this is found not to be a serious drawback, tolerably constant results being obtained by Ewald and Sievers. To meet this objection, however, Huber suggested that the outside limit of excretion of salicyluric acid be determined, that is, the point noted when salicyluric acid fails to appear in the urine after the ingestion of a gram (15 grs.) of salol. This should be at the end of twenty-four or thirty hours. If, therefore, it is continued after this, peristalsis must be slow.

In Klemperer's oil test 100 c. c. (3⅓ oz.) of olive oil are introduced into the stomach by the stomach tube after the stomach is thoroughly washed out. Two hours later the stomach is aspirated, and if there is motor sufficiency the remnant of oil should be a minimum. If any decided quantity remains peristalsis is slow.

THE MAKING OF AN AUTOPSY.*

Previous to section a general survey of the body should be made with a view to noting marks, scars, state of the body as to obesity and emaciation, and degree of *rigor mortis*.

A position to the right of the body is usually more convenient for the right-handed examiner, while the left side is more convenient to one who is left-handed. To the ambidexter it is indifferent on which side he stands. The appended directions imply that the knife is held in the right hand.

The first incision is made with a strong, broad-handled knife by a sweeping traction movement down the median line from the suprasternal notch to the pubis. Then the skin and subjacent muscles of the thorax are cut back and the section through the abdominal walls carefully completed, avoiding perforation of the intestines. The muscles are also separated from the edge of the thorax and the abdominal walls laid back, so as to expose as much as possible the abdominal viscera *before opening the thorax*. This is done in order to preserve the natural relations of the abdominal viscera to each other and to the diaphragm, relations which are altered as soon as the thorax is opened by

* The directions here given are for an autopsy for clinical purposes, and not for the medico-legal investigation, which is much more elaborate. The general plan adopted is that laid down by Virchow in his little book on "Post-mortem Examinations," which the writer has followed for many years with great satisfaction.

the removal of the sternum and attached cartilages An inspection of the abdominal contents is then made, the absence or presence of fluid or abnormality noted, *without, however, as yet removing or making any section of the organs.*

Then the cartilages are cut through near their junction with the ribs from the second downward; this is often done on each side by one sweep of the knife in the hands of the skilled sectionist, if the subject is not too old. If not complete, the section of the cartilages and muscular interspaces should then be thoroughly completed, by the bone forceps if necessary, and the clavicle and first rib disarticulated from the sternum, bearing in mind that the articulation is an oblique one. Or, if it is preferred, the knife may be drawn through the middle of the second cartilage, when it will strike the junction between the first and second bones of the sternum, leaving the manubrium, with the articulation of the clavicle and first rib, intact. This, however, restricts the space over the origin of the great vessels rather inconveniently, and the former method is to be preferred unless the latter is necessitated for some special reason. The sternum should be raised, beginning with the tip, and the muscles and other tissues shaved close to its under surface. This act uncovers the mediastinal septum and opens the two pleural sacs, without, however, incising the pericardium, if the section has been successful.

The *pleural sacs* should now be examined by inserting the hand between the lungs and the ribs and the diaphragm, with a view to finding adhesions or fluid, and the latter, if present, should be removed and measured. Outgrowths or inequalities of the pleural surfaces, pulmonary, costal, and diaphragmatic, should be looked for. The lungs should, however, be left remaining *in situ* as yet.

The *pericardium* should then be opened, and the position of the heart observed. If an abnormal amount of fluid is present, it should be removed and measured. The external appearance of the heart, its size, shape, and consistence, should be noted; also the state of fulness of the superficial vessels, the amount of superficial fat, adhesions, or other abnormality.

The heart should then be opened in situ, with the purpose of examining the quantity and quality of blood in the separate cavities and the size of the orifices. In thus opening the organ it is held in the left hand with the index finger pressed well under and against the base, so that the ventricles project laterally. It is then rotated to the left until the right border comes into view, being easily recognized by the relative thinness of the wall here as compared with that of the left ventricle on the other side of the septum. At the right border, close to the base, the knife is deeply thrust into the *right ventricle*, and drawn to the apex. With the heart still thus held, the *right auricle* is incised midway between the entrances of the two venæ cavæ. The blood is then removed from the right auricle, its quantity and quality observed. The index and middle fingers of the left hand are now passed from the auricle through the tricuspid orifice into the right ventricle. Then the blood is removed from the right ventricle. The right normal auriculo-ventricular orifice in the adult should receive three fingers, the index and middle finger of the left hand so far separated that the index finger of the right may be passed up between them from the right ventricle.

To make the openings for the left side, the apex of the heart is drawn up to the left, and placed in the left hand in such way that the fingers encircle it at the base. Pressure is now made so that the wall of the left ventricle bulges out a little and separates itself from the septum, when the incision is made behind the base through the wall into the *left ventricle* and out at the apex. For the *left auricle* the incision begins at the left superior pulmonary vein, and ends in front of the base usually indicated by the coronary vein, which should not be injured.

The blood is now removed from the left cavities, and the size of the auriculo-ventricular orifice determined. Here we have to consider the contraction of the ventricle which closes the orifice, and we have to gradually overcome this contraction, when we may introduce the three fingers named above with less facility than into the tricuspid orifice, the mitral being 4.5 cm. (1.8 in.) in diameter as against 5 cm. (2 in.) for the tricuspid. The fingers should be very carefully introduced and withdrawn, so that no abnormal vegetations or coagulæ are removed, for *the valves have not yet been examined.*

The next step is the *removal of the heart.* This is done by thrusting the index finger of the left hand into the left ventricle and the thumb into the right through the existing openings. The heart is then raised and the venæ cavæ, pulmonary veins, the pulmonary artery, and aorta severed as far as possible from the heart. The orifices of the aorta and pulmonary artery are then examined with a view to discovering changes in their walls or lumen.

The hydrostatic test is then applied for the sufficiency of the aorta and pulmonary valves by pouring water into each vessel while the heart is freely suspended. Previously, however, all coagula should be carefully removed from the orifices and ventricles. The plane of the orifice should also be exactly horizontal, and for this two hands are necessary to accomplish the proper support, and the water must be poured in by a second person. The aorta should also be cut again, short enough to enable one to see from above the state of the valves. Care should be taken to avoid wounding the coronary arteries, for if this accident happen, the water may run off into them and give the impression of insufficiency when it does not exist.

There is no hydrostatic or other test available to show the sufficiency of the auriculo-ventricular valves.

We are next ready to open the ventricles and examine the interior, including the valves. The heart is placed on a board or table, as nearly as possible in its position in the body. A long pair of scissors is the most satisfactory instrument for this purpose. For the *right ventricle* one blade is introduced into the apex end of the incision previously made in the right border and carried on to the middle of the exposed surface of the pulmonary artery, care being taken to pass in front of the anterior papillary muscle of the tricuspid valve with its chordæ tendineæ.

To display the *left ventricle* is more difficult. We introduce one blade of the scissors at the apex close to the septum, and while drawing the pulmonary artery to the right, cut to the left and behind the vessel midway between it and the right border of the left auricle through the anterior wall of the left ventricle and the aorta. If we pass too far to the left we will cut through the right border of the base of the *mitral* valve, *which corresponds* with the right border of the left auricle; if too far to the right we cross the pulmonary orifice and may cut through the valves of the pulmonary artery.

The auricles can be further opened by cutting with the scissors on the right between the openings of the venæ cavæ, and on the left between those of the pulmonary veins.

The adult heart *weighs* in health in the male 50 to 60 years old about 335 grams (11.8 oz.); in the female 295 grams (10.44 oz.).

The average *thickness of the wall* of the left ventricle is 1.6 to 1.7 cm. (5/8 to 2/3 in.); of the right ventricle .4 to .6 cm. (1/6 to 1/4 in.).

The *lungs* are now removed, their surface examined for emphysematous distention or subpleural deposits, and then incised longitudinally with a view to the discovery in their interior of tubercular infiltration, cavities, changes in the bronchi, etc.

The lungs weigh, in the male, the right, 859.5 grams (30.3 oz.); the left, 811.6 grams (28.6 oz.); in the female, the right, 552 grams (19.48 oz.); the left, 296 grams (10.4 oz.).

For the examination of the *pharynx*, *larynx*, *œsophagus*, and *thyroid gland*, the central incision should be carried up to an inch below the chin. The first three should be slit up with the enterotome, the last dissected off. The thyroid varies a good deal in weight, usually about 30 grams or 1⅛ oz.

The Abdominal Organs are now examined in the following order:—

1. The omentum.

2. The spleen, which is longitudinally incised.

The organ in health weighs about 176 grams (6.23 oz.).

3. The left and right kidney, with their suprarenal capsules and ureters; the kidney being stripped of its capsule and longitudinally incised.

The adult kidney weighs 124.7 to 154.3 grams (4.4 to 5.4 oz.); the suprarenal capsules 4 grams to 8 grams (60 to 120 grains).

4. The bladder, prostate gland, vesiculæ seminales, urethra. The prostate weighs in health about 31 grams (1¼ oz.).

5. Testicles, spermatic cord, and penis. The testis

with the epididymis weighs about 24.5 grams (½ to ¾ oz.).

6. Vagina, uterus, Fallopian tubes, ovaries, parametria. The average weight of the uterus is 14 7 to 56 grams (1 to 2 oz.); of the ovaries 3.9 to 6.5 grams (60 to 100 grains).

7. The rectum.

8. The duodenum, portio intestinalis of the ductus communis choledochus.

9. Stomach.

10. Hepato-duodenal ligament, gall ducts, venæ portæ, gall bladder, *liver*.

The *stomach* and *duodenum*, under ordinary circumstances, should be examined *in situ*. The duodenum should be opened first, its contents examined above and below the biliary papilla. The latter should be examined, its contents expressed, and its patulousness determined by pressing gently on the gall bladder. Finally, the common bile duct should be slit up. The vena cava should be examined, and not until then should the liver be removed and examined. Sections should be made through the organ horizontally, from right to left, to display its interior. The gall duct should not be probed, as a duct essentially closed may thus be opened.

The liver weighs in health, from about 1247.4 grams (44 oz.) in the female to 1569.7 grams (55 oz. avoirdupois).

11. The examination of the pancreas naturally fol-

lows the stomach and duodenum and liver, and after it the cœliac (semilunar) ganglia.

The organ weighs 70 to 108 grams (2⅓ to 3½ oz.).

12. Mesentery with glands, vessels.

13. Small and large intestines. These, after the examination of the stomach and duodenum *in situ*, should be removed, placed on a board or in water, and laid open, care being taken on opening the small intestines to keep on the line of the mesentery. The solitary glands and glands of Peyer should be carefully examined.

14. Retro-peritoneal lymphatic glands, receptaculum chyli, aorta, vena cava inferior.

Examination of the Brain.—The scalp is divided by an incision across the top of the head from ear to ear, and reflected backward and forward, noting the presence or absence of extravasated blood. The skull-cap is now sawn through by a horizontal cut, care being taken not to wound the dura mater. To this end the chisel and hammer are used to break through the internal table. But it is sometimes impossible, to avoid injuring the dura and it may even be necessary to cut it through in consequence of the difficulty in separating it from the skull-cap. The thickness of the cranial bones, their internal surfaces, and the condition of the diploë are examined; also the external surface of the dura mater and the state of the sinuses. The brain is then removed, severing the cord as low as possible through the foramen magnum, and effusion on the base of the cranium looked for. The dura is separated and the appearance of the arachnoid and pia noted. Also that of the large arteries at the base; atheroma is especially sought. In health the visceral arachnoid presents a faint, opalescent appearance, and any turbidity or opaqueness beyond this points to meningitis. The state of the blood-vessels in the pia is carefully examined, and the presence or absence of effusion noted. As the pia mater is drawn aside the blood-vessels which dip down between the sulci into the fissure of Sylvius are examined, especially their sheaths.

The pia being removed, the surface of the brain is examined, the depth of the sulci, flattening of the convolutions, and any marked deviations in their arrangement noted.

The dissection of the brain is now commenced, beginning with the opening of the lateral ventricles. This is done, after drawing apart the halves of the cerebrum, by an incision one millimeter ($\frac{1}{25}$ inch) on each side of the median line in the corpus callosum directly downward, when the middle portion of the lateral ventricle is reached at the depth of two or three millimeters ($\frac{1}{12}$ to $\frac{1}{8}$ inch). The anterior and posterior cornua of the lateral ventricle are then opened by horizontal incisions from this point into the anterior and posterior lobes of the brain. Thus the lateral ventricles are exposed throughout their extent, and their contents, the state of their walls, and the venous plexuses examined; also the septum lucidum, with its contained fifth ventricle.

The septum is then seized from behind the foramen of Monro and the scalpel pushed in front of the fingers through this foramen, and the corpus callosum cut through obliquely upward and forward, and then these parts (the corpus callosum, septum lucidum, and fornix) are carefully detached from the velum interpositum and choroid plexus, which are examined as to the state of their vessels and tissue.

The handle of the scalpel is then passed from the front under the velum, which is thus detached from the pineal body and corpora quadrigemina, which are examined. The third ventricle is then exposed. Finally, the corpora quadrigemina and the cerebellum are divided as far as the aqueduct of Sylvius and the fourth ventricle.

The hemispheres of the cerebrum and cerebellum are now sliced by *transverse* incisions rather than longitudinal ones, because in this way the parts can again be more easily united if desired, with a view to determine the relation of parts or the seat of lesions.

The optic thalami and corpora striata are cut by *fan*-shaped incisions radiating from the peduncle of the cerebrum.

The adult brain of the male weighs on an average about 1400 grams (49½ oz. avoird.), of the female 1245 grams (44½ oz. avoird.). The cerebrum alone weighs 1244 grams (43 oz. 15 dr.) in the male, and 1098 grams (38 oz. 12 dr.) in the female; the cerebellum 148⅔ grams (5 oz. 4 dr.) in the male, in the female 137 grams (4 oz. 12½ dr.). The pons and medulla oblongata weigh 28 grams (15¾ dr.) in the male, and in the female 28.8 grams (1 oz. ¼ dr.).

The removal of the *spinal cord* is a laborious operation. The spinal canal is opened, preferably from behind, by dissecting back the skin from the median line and sawing upon each side of the spines of the vertebræ, or by using a double saw. The cord when removed is carefully examined as to its membranes, and transverse incisions made at intervals of a half-inch or less, leaving the membrane intact at one spot, so that the pieces are all held together like the leaves of a book.

The spinal cord weighs 37.2 grams (1 oz. 5 dr.) in the male, and 35.43 grams (1 oz. 4 dr.) in the female.

ORDER OF EXAMINATION OF PATIENT.

Name, nativity, and residence.

Age.

Occupation.

Social condition [married or single].

Habits of patient [*i. e.*, as to mode of living, temperance in eating and drinking].

Family history.

Health of parents, brothers, sisters, and children.

History of previous diseases. [Previous history.]

The diseases experienced by the patient before the present illness [*i. e.*, diphtheria, scarlet fever, typhoid fever, rheumatism, malaria, pneumonia, pleurisy, venereal diseases, etc.

History of present disease or of previous attacks of same disease.

1st. Ask how long patient has been sick. Ascertain this definitely by suitable questions. 2d. Get the symptoms in regular order from the beginning to the present.

Present condition, that is, the symptoms of which the patient complains at present.

Physical examination. [Patient stripped.]

1. General appearance of patient.
2. Chest: Inspection, palpation, mensuration, percussion, auscultation.
3. Abdomen.
4. Special parts.

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