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ON PERICARDITIS.

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THE following paper is designed to render our knowledge of Pericarditis more exact, and to bring forward some points in reference to that disease, not dwelt upon by other observers.

Position of the Heart in Health. In order to appreciate the exact changes which take place in the Position of the Heart, and in the superficial outlines of the pericardial sac, in Pericarditis, it is necessary to know the precise position of the heart in health. This knowledge may be readily attained by the aid of the accompanying diagrams.[1]

The heart and pericardium, in health, are in immediate contact with the walls of the chest, over a space limited to the right by a line drawn through the centre of the lower half of the sternum; to the left by a line within the nipple; above, by the fourth left costal cartilage; and below, by a line drawn outwards from the lower end of the sternum. Over the superficial cardiac region, just indicated, there is absolute dulness on percussion, and complete absence of vocal resonance, and of the respiratory murmur; the heart's sounds are there loud, ringing, and clear, and the heart's impulse is to be felt there, if anywhere. The perpendicular diameter of this region is usually from two to two and a half inches, and its horizontal diameter from two and a half to three inches. In the robust, the lungs are ample, and cover a large portion of the heart; consequently the region in question is comparatively small, the heart's impulse is generally feeble, often imperceptible, and the heart's sounds are dull and heard only over a comparatively small space. In the weak,

[1] These diagrams were made by the aid of a tracing frame, suggested to me by my friend Dr. Hodgkin. This frame is described in my paper on the Position of the Internal Organs, contained in vol. xii of the *Provincial Medical Transactions*. I may be allowed to say, that these diagrams, and the communication just quoted, owe their value to the exactness with which the observations were made and depicted, both in life and death, in health and disease, by the aid of the tracing-frame referred to.

on the other hand, the lungs, being small, cover only a small portion of the heart; the region in question is consequently large, the heart's impulse is extensive and strong, and the heart's sounds are clear, sharp, and loud, and are usually heard over the whole chest, being readily conducted to the surface through the smaller and denser lungs. It is manifest from this, that the apparent strength of the heart's action is often in the inverse ratio of its real strength. If the cardiac region, where there is nothing but heart, be small, it is no indication that the whole heart is small. Indeed, in the robust, the heart, as well as the lungs, are larger than they are in the weak; but the lungs are so much larger in the former, that they cover a much larger portion of the heart. This point is illustrated, in a very interesting manner, in persons affected with Laennec's emphysema or bronchitis. In such cases, not only are the lungs unusually and universally enlarged, but the heart is unusually enlarged also; yet, notwithstanding its greatly increased size, a small portion of the heart only is uncovered by lung.

I shall throughout this paper, in referring to the region of which I am now speaking, where there is nothing else but heart, term it the cardiac region. It is over the cardiac region that we discover the earliest signs of Pericarditis; and, when we examine a patient to find out whether he has or has not that disease, it is of the utmost importance to bear in mind the exact seat, form, and size, of the cardiac region,

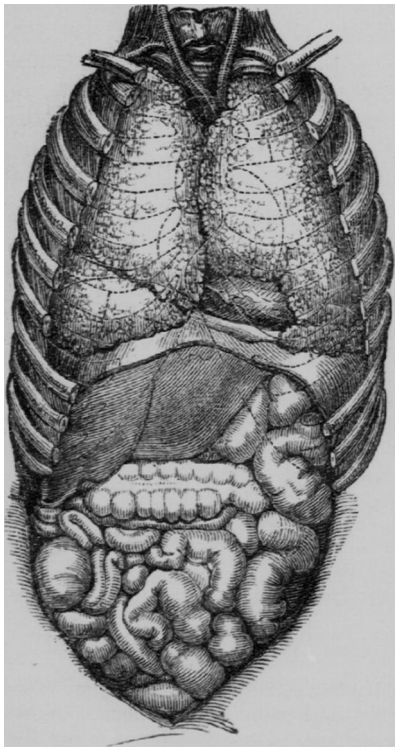

Fig. 1. Superficial view.

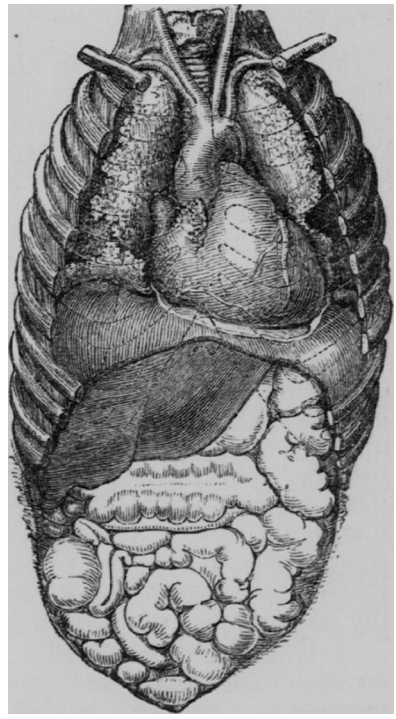

Fig. 2. Deep view.

Position of the Internal Organs in a healthy adult male.

and the possible variations of that region in health, and in the different forms of visceral disease.

In health, the lower end of the sternum indicates the meeting point, where the heart, the right lung, and the liver, come in contact; the diaphragm, pleura, and pericardium, being alone interposed. I ascertained that this was so in more than 119 persons, in none of whom could I detect disease either in the lungs or the heart: these persons varied from each other in sex, age, and in general health; some of them being robust, and some feeble. In all of these persons, the right boundary of the cardiac region was immediately behind the centre of the lower half or third of the sternum, and the lower boundary was indicated by a nearly horizontal line, drawn from the lower end of the sternum to the upper edge of the sixth rib. The variation in the outlines of the cardiac region takes place in the upper and in the outer or left boundaries. In the robust, the upper boundary is usually behind the space between the fourth and fifth costal cartilages, and the left boundary is from two to nearly three inches from the centre of the sternum. In feeble persons, the upper boundary of the cardiac region is often as high as the third costal cartilage, and the outer boundary may extend to the left nipple.

In the majority of persons, especially of those dwelling in towns, the upper boundary of the cardiac region is on a line with the fourth costal cartilage, and its outer boundary is within the left nipple, or about three inches from the middle of the sternum. In these persons, the left boundary is usually indicated by the impulse of the apex of the left ventricle, which is commonly felt between the fifth and sixth ribs, sometimes between the fourth and fifth. During the diastole of the heart, the margin of the left lung is interposed between the left ventricle and the thoracic parietes; but during the systole, the apex moves forcibly forwards, and to the left, pushes outwards, and from before it, the interposed portion of lung, and impinges upon, and elevates the parietes. It may be observed, that in most persons, the impulse of the apex is stronger towards the end of each expiration; and, in some, that impulse can then only be felt; this is due to the expiratory diminution of the thin couch of lung which usually shields the left ventricle from the parietes. It is well to bear in mind, that in most persons, excepting during the periods now stated, it is the right ventricle only which is in contact with the parietes. The diffused and slow impulse which is often felt over the lower half of the sternum, and the adjoining left costal cartilages, is entirely due to the systole of the right ventricle. In the first stage of Pericarditis, before the effusion is considerable, the friction sounds are entirely due to the impulsive and gliding motions of the right ventricle; excepting during the instantaneous systolic blow and brush of the apex upon the parietes, when the systolic friction sound of the left ventricle is also heard.

In the robust, the impulse of the apex is seldom perceived; the right ventricle is usually alone in contact with the parietes, and its diffused impulse may generally be distinguished by the ear, and sometimes by the hand, over the left fifth and sixth costal cartilages. In the feeble, the lungs, being comparatively small, are withdrawn to some extent from between the heart and the parietes; and, in addition to the right

ventricle, a portion of the ear of the right auricle, and a part of the left ventricle, are immediately behind the walls of the chest. In such persons, the impulse both of the apex and of the right ventricle is unusually strong. In some persons, who are feeble, wasted, and confined to bed, whose lungs and heart are free from disease, and in whom respiration and circulation are feeble, a still larger portion of the heart is uncovered by the lungs; the great vessels come in contact with the upper part of the sternum, the right auricle is exposed by the withdrawal of the inner margin of the right lung to the right of the sternum, and the left ventricle is to a moderate extent in contact with the ribs and intercostal spaces. In such, the impulse, both of the left and right ventricle, is extensive, sharp, and strong; and, in addition to the systolic impulse, a second or diastolic impulse is felt between the second and third, and sometimes between the first and second costal cartilages. This second impulse is neither more nor less than a sign, that the upper part of the right ventricle, and the origin of the pulmonary artery, over which it is felt, are in contact with the walls of the chest. This diastolic impulse, which is synchronous with the second sound, is a physiological and not a pathological phenomenon, and is due, I believe, to the sudden return forward of the walls of the right ventricle, and of the origin of the pulmonary artery, immediately after the systole; the parts in question then impinge with a short, sharp tap on the left second and third cartilages, and on the space between them. I have been thus exact in tracing the varieties in the extent to which the surface of the heart is exposed behind the walls of the chest in different persons, as in each of them there would be a distinct starting point in a case of Pericarditis. Besides this, the friction sounds would, at the outset, be heard more extensively, and there would be less difference between the normal outline of the cardiac region, and the outline of the pericardium distended by effusion, in those cases where the surface of the heart is more extensively exposed.

When the lungs are large, and the exposed portion of the heart is small, the extent to which the heart is screened by the lungs from contact with the walls of the chest is considerable. If the lungs, on the other hand, be small, the extent to which the heart is exposed being considerable, a small portion only of the heart is covered by lung.

In examining a case of Pericarditis, it is well to know not only the position of those parts of the heart which are in immediate contact with the walls of the chest, but also the position, in relation to the parietes, of those parts also which are usually covered by lung. The medical man, when he places the stethoscope over the heart, ought to be able, in fact, to say over what particular portion he places it.

The position of the great vessels is easily remembered. The aorta, the central vessel, lies exactly behind that part of the sternum which is above the third cartilage; the pulmonary artery is situated just to the right of the same portion of the sternum, and the vena cava just to the left of it. The right ventricle lies immediately behind the lower half of the sternum, and the left costal cartilages from the third to the sixth; the right auricle, to the right of the ventricle, is behind the sternal half of the right costal cartilages from the third to the sixth, and its appendix lies across the sternum, narrowing from right to left, just

below the third costal cartilages; the small portion of left ventricle which is in front, is just to the outside of the right ventricle,

The auricular border of the right ventricle, commonly called its base, crosses the sternum in an oblique line, from the left side of it at the third costal cartilage, to the right side of it at the lower end. As the most early, severe, and frequent seat of Pericarditis is immediately along the course of this line of the right auriculo-ventricular junction, and over the right ventricle to the left of it, and the right auricle to the right of it, it is very important to have clearly in the mind the position of the parts in question.

Displacement of the Heart by Disease. Should the heart, when displaced by disease, be affected with Pericarditis, the friction sounds, and other indications of the disease will necessarily be present, not over the usual, but over the actual situation of the heart. In such cases, if we would ascertain the presence of Pericarditis, we must examine the heart at the seat of its displacement.

In emphysema, the lower boundary of the heart, as well as that of the lungs, is unusually low; and the heart, although enlarged, is covered to an unusual extent by the dilated lungs. The cardiac region, that is to say the exposed portion of the heart, is consequently remarkably small and low. The exposed portion of the heart, instead of being behind, and to the left of the lower half of the sternum, is completely screened by lung from the sternum, and is seated behind, below, and to the left of the xiphoid cartilage. I possess the notes of a case of emphysema, in which Pericarditis was detected by the presence of friction sounds behind the xiphoid cartilage, and the costal cartilages to the left of it.

In peritonitis with great abdominal distension, the diaphragm being pushed upwards, the cardiac region is unusually high; indeed its lower boundary, instead of being on a line with the lower end of the sternum, may be an inch higher. Should friction sounds from Pericarditis be present in such cases, their situation, even at the outset of the disease, will be unusually high.

When there is extensive effusion into the left pleura, the fluid pushes the heart over to the right of the sternum, the displacement being proportional to the amount of effusion. When the fluid disappears, the heart gradually resumes its normal position. If, after the disappearance of the effusion, the left lung fails to resume its functions, and remains condensed and unexpanding (owing, perhaps, to its being surrounded by a fibrous covering, and by strong intercostal adhesions), the heart, instead of remaining at its normal position, is drawn over unusually to the left, so that the impulse of the apex may be felt to the outside of the nipple. At the same time, the right lung, to compensate for the deficiency of the left, is enlarged, and encroaches to some extent on the left side.

Should the effusion be seated in the right pleura, the heart is pushed over unusually to the left. Should permanent condensation of the right lung be the sequel of the disappearance of the fluid, then the heart will be drawn over to the right. Indeed, in some such cases, the heart is seated behind, and to the right of the sternum; and the left lung, amplified for compensation, encroaches on the right side.

From whatever cause either lung is condensed, whether as the sequel

of phthisis with cavities, or of pneumonia, the heart is drawn over to the affected side; this side is also encroached upon by the opposite lung, which is itself usually enlarged, to compensate for the impaired function of the other.

Movements of the Heart. It occurred to me, that it would give additional precision to the knowledge of the friction sounds excited over different parts of the heart in Pericarditis, if we knew accurately the exact motion of each part of the heart during its systole and diastole. In order to ascertain this, I rendered an ass unconscious by injecting into its veins the wourali poison, with which I had been kindly favoured by my distinguished friend, Mr. Waterton. I then kept up artificial respiration, and exposed the heart by removing the ribs. In order to see the exact motion of each part of the heart, I thrust pins into it in different directions, and then observed the various movements. I have given a detailed account of that experiment in my paper "On the Position of the Internal Organs" (*Provincial Medical Transactions*, vol. xii); and I subjoin a summary of those observations.

The greater part of the anterior surface of the heart, both ventricular and auricular, has a diagonal gliding or friction movement, namely, during systole, from right to left, and from below upwards. The movement from right to left has, as it were, its pivot or hinge in the line of the superior and inferior venæ cavæ; and that from below upwards, has its hinge of movement in the pulmonary veins; the vertical axis, on which the horizontal movements turn, runs through the base of the right auricle; and the horizontal axis, on which the vertical movements turn, passes along the base of the left auricle.

During the systole, the right ventricle becomes narrower, flatter, and shorter. The lower border of the right ventricle and the outlet at the pulmonary artery, gradually approach each other during the systole; the walls everywhere move from below upwards, with a diagonal movement from right to left, until within about half an inch of the pulmonary artery; there the walls are stationary; between that point and the artery they move from above downwards. The pulmonary artery is itself dragged downwards about a quarter of an inch by the neighbouring descending fibres of the right ventricle. The right auricle, previously flaccid, becomes gradually distended during the ventricular systole; the whole auricle becomes wider, and its ventricular margin moves about half an inch from right to left; the auricular portion, before scarcely perceptible, becomes swollen, and advances boldly and rapidly forwards, and from right to left, for the extent of about two-thirds of an inch; and the tip of the right auricular portion, which, at the beginning of the systole, is behind the right margin of the sternum, moves over, during the systole, to its left margin.

The general systolic movements of that part of the left ventricle which lies to the outside of the right ventricle, are also from right to left, and from above downwards. There is, however, a singular diversity in the movements of the part in question; while the apex of the left ventricle moves forwards, upwards, and from right to left, a small portion of that ventricle contiguous to the apex moves from left to right, dragging with it the contiguous portion of the right ventricle, while the two auricular thirds of the ventricle go from right to left. The aorta, like

the pulmonary artery, descends about a third of an inch during the systole.

From this it is to be observed, that the whole of the anterior portion of the heart, and the great vessels, have a gliding or friction movement during both systole and diastole,—that, during the systole, the anterior walls of the heart move diagonally from below upwards, and from right to left, the horizontal movement of those portions of the right auricle and ventricle near their junction, and of the auricular appendage, being by much the most extensive,—and that the aorta and pulmonary artery descend during systole, and ascend during diastole. In short, the various cavities in part exchange places during the systole and diastole; during systole, the ventricles empty themselves, the auricles and the arteries become more full, and where they adjoin the ventricles, both the auricles and the arteries occupy a portion of space previously occupied by the ventricles; during the diastole, the ventricles regain their position, and the auricles and arteries go back to theirs.

For a further description of the interesting phenomena in question, I refer to my own experiment just quoted, and to the valuable report of the Committee of the British Association (composed of Dr. C. J. B. Williams, Dr. Todd, and Dr. Clendinning), on the Movements and Sounds of the Heart.

Artificial Distension of the Pericardium, compared with Morbid Pericardial Effusion. Pericardial effusion being one of the earliest results of Pericarditis, I felt anxious to study, on the dead body, the effect of pericardial distension on the situation and size of the pericardium and of the heart, and on the position of the surrounding organs.

With this view, I imitated pericardial effusion, by injecting into the healthy sac as much fluid as it would hold.

M. Piorry thus describes the difficulties which he experienced when he attempted artificial distension of the pericardium: "Quelques essais tentés sur le cadavre, dans l'intention de simuler des maladies de l'enveloppe membraneuse du cœur, n'ont pas réussi. Des gaz pénétraient par les incisions que nous faisions aux parois costales; les injections se faisaient mal; elles pénétraient quelquefois dans les plèvres; on ne pouvait, après les avoir faites, boucher exactement l'ouverture artificielle qu'elles avaient nécessitée; lors même qu'il aurait pu en être ainsi, l'air qui s'était introduit dans les parties mises à découvert aurait donné lieu à des résultats qui ne pouvaient représenter l'état du péricarde avant l'ouverture du thorax." (*De la Percussion*, p. 135.) In a later work (*Du Procédé Operatoire*, pp. 114) he describes the more successful results of his attempts to inject the pericardium, and impresses on the student of chest-disease the importance of repeating for himself the experiments on the dead body.

Whoever is desirous of putting this valuable advice into practice, will find that the pericardial sac may be artificially distended with perfect facility, if he make an opening into the free pericardium, just large enough to admit the injecting tube; thrust a pin into the membrane at each side of the opening; and then tie in the tube by passing a thread round the opening, just beyond the pins. The pericardial sac may be conveniently opened for injection, either from below, before the chest is opened, through the central tendon of the diaphragm; or, after the removal of the sternum, through the anterior wall of the sac.

The healthy pericardium, when the size of the heart is normal, is incapable of holding a large amount of fluid.

In a boy, aged 6		the pericardium, injected to distension, held	6oz.
——— 9. Heart, 3¾oz. in weight			6
——— 13. —— ———		about	6
In an adult male —— 12oz.	Right cavities distended held ....15oz.; Left 10½	Pericardium distended held	15
In a man, aged 50 —— 13oz.		———	22
In an adult female, whose heart was enlarged		———	26

From these and other observations, it may be inferred that in the

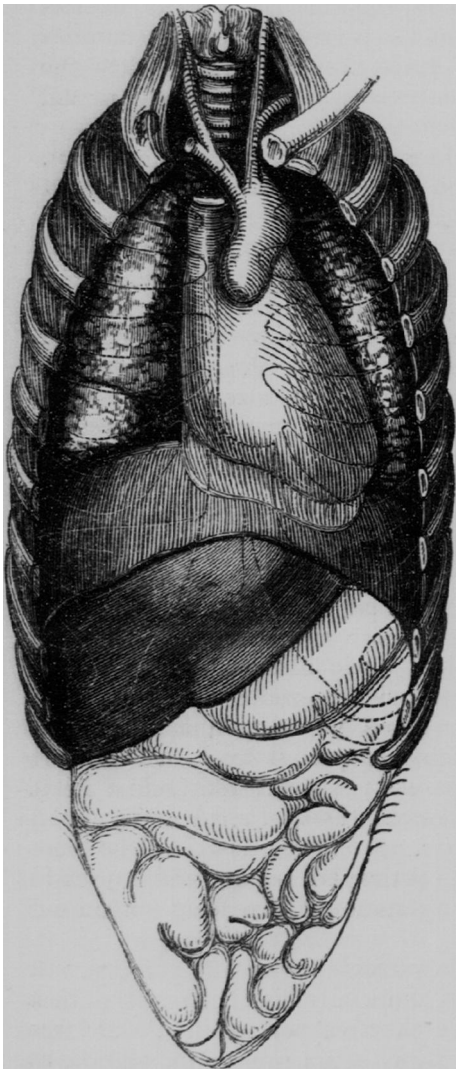

Fig. 3.
Pericardial sac not distended.

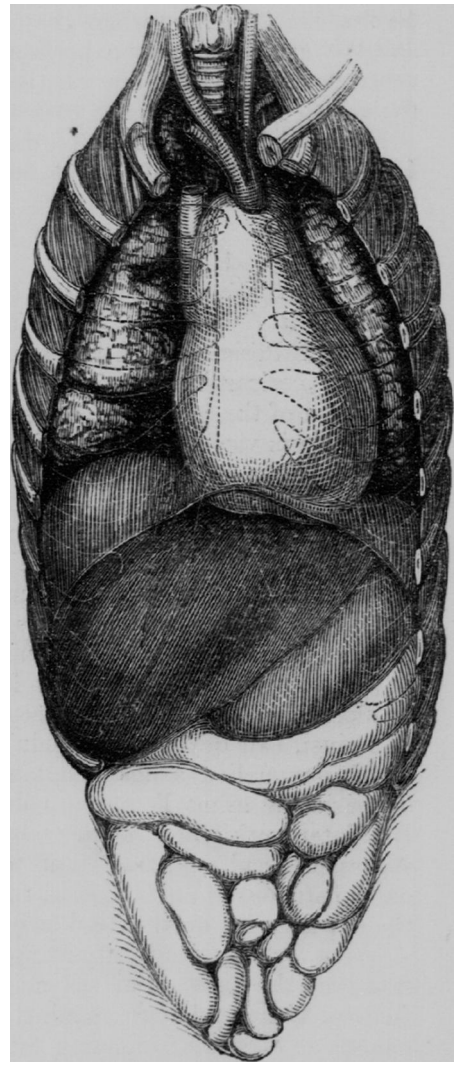

Fig. 4.
Pericardial sac distended.[1]

[1] The lines indicating the margins of the lungs are hypothetical.

adult, when the heart is healthy, the pericardium, when fully distended, can contain from 12 to 15 oz. of fluid. It is worthy of remark that the right cavities of the heart, in the adult male, when distended, hold the same quantity of fluid as the pericardium.

The quantity of fluid that can be injected into the healthy pericardium, falls very far short of the large quantity which it is sometimes found to contain in disease. There are several cases of Pericarditis on record, in which three pints were found in the sac; indeed Corvisart, in his commentary upon Avenbrugger, states that he has found in it seven or eight pints! (Dr. Forbes' translation, p. 57). It is therefore manifest that, not only is the pericardial fluid greatly increased in some cases of Pericarditis, but that the sac itself is, in those cases, very greatly enlarged, and altered in shape. In order, therefore, to understand the physical effects of pericardial effusion, it is not sufficient to observe the effect of artificial distension, but it is also necessary to notice the increased distension which supervenes when the disease is of some standing. During the early stages of Pericarditis, the comparison between artificial and morbid distension of the pericardium is exact.

Fig. 5.
Pericarditis, with extensive pericardial effusion.

The accompanying engravings illustrate very exactly the effect of artificial distension of the pericardial sac. In the first view, fig. 3, the sac not being distended, fits closely around the various parts of the heart, so that the great vessels, the auricle, and the ventricle, can be readily distinguished through the fibrous membrane. The tendinous surface of the diaphragm, on which the heart rests, forms a plane inclined from behind forwards.

When the pericardium is distended, as in fig. 4, the whole sac becomes swollen and globular, or rather pear-shaped. The outlines of the heart itself, and of its various cavities and vessels, are no longer perceptible. The whole pericardial sac is enlarged, and it consequently encroaches upon, and, to some extent, displaces all the surrounding organs. The pericardium is most distended at those parts where it is most distant from its attachments to the heart, namely, at its lower or diaphragmatic portion, and at the left side, especially in the neighbourhood of the apex.

The form of the distended sac is peculiar. It is composed, as it were, of two spheres, one larger than the other, the smaller sphere resting as an apex upon the larger. The larger sphere encloses the heart itself, and is gibbous towards the left side. The smaller sphere envelopes the great vessels, and it presents three projections, one over each vessel; that over the aorta is most prominent, and lies immediately behind the upper bone of the sternum; that over the vena cava, just to the right of the sternum, is small; and that over the pulmonary artery, to the left of the sternum, is large.

The effect of the distension on the form and position of the central tendon of the diaphragm is marked and characteristic,—instead of being somewhat concave, and inclined from above downwards, it is perfectly convex and semi-globular on the under or peritoneal surface; that surface being more than an inch lower than it is when the sac is empty. The liver and stomach, where they adjoin the central tendon, are necessarily displaced downwards, in exact proportion to the amount of pericardial distension. This protrusion of the central tendon of the diaphragm into the abdomen accounts for the pain so frequently observed to be present in the epigastrium, especially when pressure upwards is made over that region; this was particularly noticed by Mr. Nairne in his communication on Pericarditis, in the 7th volume of the *Dublin Journal;* in ten out of eleven of his cases, epigastric pain on pressure was a marked symptom.

Avenbrugger first noticed the swelling in the præcordia in pericardial effusion; and Corvisart, in his commentary on Avenbrugger, correctly attributed this to the fluid of the pericardium depressing the diaphragm below the edge of the sternum. Dr. Forbes, in illustrating the observations of Avenbrugger and Corvisart, carries out those observations still farther, and accurately attributes the præcordial tumor to the left lobe of the liver, thrust forwards and downwards by the depressed diaphragm.

The great extent to which the liver and stomach may be pushed downwards by the pericardial sac, distended by morbid effusion, will be well understood by a reference to fig. 5, which was taken from a case in which the pericardial distension was very great.

The lateral expansion of the pericardium necessarily causes a corresponding lateral displacement of both lungs, where they overlap the heart. As the expansion of the left side of the pericardium is much greater than that of the right, the left side being free, while the right is attached to the venæ cavæ, there is much greater displacement and compression of the left lung than of the right.

Owing to the peculiar form of the upper part of the distended pericardium, where it forms as it were a swollen pouch over the great vessels, the lungs are, in the earlier stages, displaced at that part to each side, in a manner quite characteristic of recent effusion. The upper portion of the region of pericardial dulness has, in the cases in question, a peculiar peaked form; this is rendered apparent in fig. 4, taken from the artificially distended pericardium, and will be still farther illustrated in the figures from the living subject. It may be traced over the upper portion of the sternum, within an inch of its summit, and over the left second and third costal cartilages. The cause of this peaked

form is rendered evident by the diagram. The swollen pericardial sac, as it protrudes forward, comes in contact, at its most prominent part, with the sternum, and thus presses the lungs away to each side of it.

Corvisart, Piorry, and Hope, observed that the dulness on percussion in Pericarditis, is unusually high, extending to the upper portion of the sternum. M. Piorry has assigned a conical form, the base at the diaphragm, to the space of pericardial dulness. I am not aware that any observer has noticed the peculiar peaked form of the upper part of the region of pericardial dulness just alluded to. This peaked form is only present during the earlier stages of pericardial effusion. During the more advanced stages, if the effusion become more considerable than the pericardium can contain when artificially distended in health, the upper part of the region of dulness loses its peaked form, becomes more extended, and rises so as to be in some cases on a level with the left clavicle, as was accurately observed long since by Senac. This is well seen in fig. 5, taken from a case of extensive pericardial effusion of long standing. In this case it will be observed, that the anterior portion of the left lung is displaced completely backwards, so as to be almost quite hidden by the pericardium, while the compression of the right lung is considerable.

In the case just referred to, the pericardial sac is broader than it is long, instead of being, as in the cases of artificial injection, longer than it is broad. It is evident that the great expansion of the pericardium takes place laterally and to the left, and that the sac, as it enlarges, loses its symmetry. The great lateral increase of the pericardium is evidently due to the resistance offered to the expansion of the sac by the ribs and sternum in front, and by the vertebræ behind. The pericardium fills up the space between the sternum and the spinal column—the aorta and œsophagus, and at the upper part, the trachea, being alone interposed; and, as the pericardium cannot expand much in front or behind, and as its expansion above and below is limited by the upper ribs and the diaphragm respectively, the sac is compelled to expand sideways, that being the only direction in which there is no impediment. It is almost certain, that the distended pericardium exerts an injurious pressure on the thoracic aorta, as it lies interposed and compressed between the pericardium and the vertebræ. This view, which is forced upon us by the anatomical position of the parts, is supported by the frequency with which the lower limbs are cold and œdematous in Pericarditis with extensive effusion. It is probable, that an injurious pressure is sometimes exerted on the trachea at its bifurcation, and that this circumstance in part accounts for the extreme dyspnœa so frequently present in cases of Pericarditis.

The pressure of the distended pericardium being exerted in every direction, not only displaces, in proportion to the amount of distension, the adjoining viscera, but it also causes protrusion of the sternum, costal cartilages, and ribs immediately in front. If the amount of effusion be small, there is little or no protrusion; but if it be great, the protrusion is considerable. In extreme cases (such as that represented in fig. 5), the projection of the thoracic walls, caused by the distended pericardium, is very extensive—in fact, co-extensive with the sac. The thoracic projection is greatest from the fourth to the seventh left costal

cartilages, those parts being over the centre of the pericardium. The prominence, however, extends, in proportion to the distension, over the lower half or two-thirds of the sternum, that bone being in the young arched forwards more and more, from the upper to the lower extremity —over the left costal cartilages, from the second downwards, those cartilages being also all of them stretched further apart, and the intercostal spaces widened—over the costal cartilages to the right of the lower end of the sternum—over the left ribs, in the neighbourhood of, and outside the nipple, from the fifth or sixth to the seventh or eighth—and over the xiphoid cartilage, the epigastrium, and the seventh and eighth left costal cartilages. As the amount of effusion increases, the degree and extent of the thoracic prominence increase also; and as it diminishes, they diminish also. The progress of the case may be happily thus indicated to the eye, when, from the application perhaps of a blister, the extent of the effusion cannot be ascertained by percussion. I have, indeed, observed that the prominence over the cardiac region, which, in health, is usually greater than that over the corresponding region to the right of the sternum, may disappear altogether as the effusion diminishes. MM. Louis and Bouillaud give several cases, in which pericardial effusion caused thoracic prominence. It is probable, that the posterior curvature of the dorsal vertebræ is increased by the pressure of the distended pericardium backwards against the spinal column; and that the relief which some persons, suffering from pericarditic effusion, derive from the bent and forward position, is due to the increased space thus given to the pericardium behind.

The physical effect of the increased quantity of fluid in the pericardium upon the size and situation of the heart itself, its cavities and great vessels, is an important subject which did not escape the attention of the earlier observers. Senac (*Maladies du Cœur*, i, 148) remarks, that the water which fills the pericardium, neither permits the heart to dilate readily, nor to come in contact with the ribs; its cavities, being compressed by the surrounding fluid, cannot dilate sufficiently to receive the blood from the caval and pulmonary veins, and the volume of the heart is itself sometimes lessened. It therefore follows, as Lower had remarked, that in these cases the pulse is feeble or altogether imperceptible, and that even syncope may supervene.

These remarks, drawn, by observation, from living pathology, are illustrated by the effect of artificial distension of the pericardium on the size and position of the heart and its cavities. When I injected fluid into the sac, the heart was lessened by compression; the fluid contents of its cavities were in great part forced forwards into the arteries, and backwards into the veins; the lower boundary of the heart was elevated, and the whole heart and the great vessels were forced unusually upwards, evidently under the influence of the pressure of the liquid, which, lessening the volume of the heart, caused the whole organ to rise and approach more nearly to the seat of its attachment to the lungs and to the systemic vessels. During the injection, the fluid finds its way at first to the lower and back part of the pericardial sac, interposing itself between that portion of the sac, and the posterior wall of the left ventricle, gradually separating those parts farther from each other, and pushing upwards the ventricles, and downwards the central tendon of the dia-

phragm. As the sac becomes more and more distended, the fluid gradually rises, so as to cover the heart in front, separating successively the body of the left ventricle, the right ventricle, the right auricle, and the great vessels from the free pericardium. At length, when the distension is complete, it is probable that the left auricle, the base of the left ventricle, and the great vessels at their inlet or outlet, are alone in contact with the pericardium.

Although morbid pericardial effusion is in many respects closely imitated by artificial distension, yet the effusion is not attended throughout by the same effects as the distension. Indeed, it could not; for while, in artificial distension, we have to deal with a dead heart—in morbid effusion it is a living heart that is acted upon. The living, unlike the dead heart, being in continual alternating motion, offers by its muscular movements, a resistance to the compression of the pericardial fluid. It is to be borne in mind, that each ventricle, during its systole, not only propels the blood, the left through the systemic, and the right through the pulmonic arteries, capillaries, and veins; but that also, through those channels, and aided by the elasticity of the arteries, each propels the blood into, and fills the opposite auricle and ventricle. I found in the experiment on the ass, above related, that on compressing the aorta, less blood entered the right auricle at the very next beat; while the same effect was produced on the left auricle immediately after compression of the pulmonary artery.

Although the impulse of the heart is lessened in power by pericardial effusion, it yet retains considerable force, even when there is a great amount of effusion.

The changes in the position of the heart and the surrounding organs, progressively and gradually induced by artificial distension of the pericardium, may be accurately traced on the living subject of Pericarditis with effusion, during the progressive development of the disease.

Dr. Stokes made the important observation, "that in by far the greater number of our cases, the "friction" sounds were not audible beyond the actual region of the heart. This is a most striking character. I have often observed, that in moving the stethoscope little more than an inch from a situation where the sounds were loud, they totally ceased, although the contractions of the heart continued distinctly audible." ("On the Diagnosis of Pericarditis", *Dublin Journal*, iv, 56.)

As the friction sounds perceptible to the ear, and the vibrations and impulse communicated to the hand are, with few exceptions, only perceptible over the region of the heart affected with Pericarditis, we can gain a very accurate knowledge of the progress of the disease, by observing, during its successive stages, the varying seat of the friction sounds, the vibrations and the impulse of the heart, in connexion with the extent of pericardial dulness.

In the early stages of Pericarditis, when the amount of fluid in the pericardium is not materially increased, the heart and lungs retain their normal position; the extent of cardiac dulness is scarcely altered: the to and fro friction sounds, caused by the right ventricle, are heard over the lower half of the sternum and the adjoining left costal cartilages, and the rubbing sound of the left ventricle at the apex is heard only during systole, when the apex, pushing aside the interposed portion of

lung, rubs against the fifth rib and intercostal space; the vibrations are seldom perceived; the impulse of the heart is felt at the usual situation, between the fifth and sixth ribs. As the fluid progressively increases, it pushes aside the cardiac margins of the lungs more and more from before the heart, that organ being itself not yet notably elevated; the extent of pericardial dulness is materially increased; the right auricle is now exposed, and, while the to and fro friction sounds of the right ventricle are heard behind and to the left of the lower half of the sternum, those of the right auricle are heard to the right of that portion of the bone. The auricular tip of the right auricle, during systole and diastole, moves from side to side, first to the right and then to the left margin of the sternum, close to the third costal cartilages; and between those cartilages, the smooth, prolonged, equal double friction murmurs are distinctly audible. The friction sounds over the left ventricle are now usually both diastolic and systolic. The vibrations are sometimes communicable to the hand. The impulse at the apex is perhaps higher, and is more extensive than usual between the left costal cartilages.

When the pericardium is distended with fluid so as to push the heart materially upwards, the extent of pericardial dulness is still farther increased. The friction sounds, instead of being audible as low as the sixth costal cartilage and the lower end of the sternum, are only heard above the lower fifth of the sternum and the fifth costal cartilage. The vibrations are frequently felt by the hand, and occupy the same space as the friction sounds. The impulse of the apex is perceived over the fifth, instead of the sixth intercostal space; the impulse of the right ventricle is felt from the second to the fifth costal cartilages; and the peculiar sharp diastolic impulse may be perceptible both over the first and second intercostal spaces. When the effusion further increases, so that the ventricles are in great part separated by a layer of fluid from the parietes, the upper part of the right ventricle and the great vessels are still in contact with the first, second, and third intercostal cartilages and the spaces between them. The friction sound, the vibration, and the impulse, are now only to be perceived between the first and second, and the second and third costal cartilages.

When the sac is completely distended, and the surface of the heart is completely separated by the fluid from the parietes, then neither friction sound, vibration, nor impulse are anywhere perceptible.

As the fluid gradually disappears, and the heart comes again, by little and little, in contact with the parietes, the phenomena progressively re-appear, descending in the inverse order to that in which they disappeared and ascended; until at length, when the fluid is absorbed, the whole heart returns to its normal position, or, if enlarged, goes even beyond it. The friction sounds and vibrations, if present, are perceptible as low down as they were at first, and the impulse descends from space to space, so that at length the heart's apex beats as usual between the fifth and sixth ribs. As the heart, then, is pushed upwards by the increased effusion, the friction sounds, the vibrations, and the impulse are necessarily pushed up likewise; and as the heart descends, when the fluid diminishes, resuming its position, the friction sounds, vibrations, and impulse descend and resume theirs.

I believe I was the first to point out that the seat of the impulse is raised in Pericarditis with extensive effusion; and I here extract the passages relating to that subject, from my paper on the "Situation of the Internal Organs", published in the *Provincial Medical and Surgical Transactions* for 1844.

"In cases of pericardial effusion, where the heart is not enlarged, the volume of the heart is lessened and pushed upwards towards its point of attachment, and the ventricles being raised and seated behind the middle third of the sternum, and the third and fourth, or fifth costal cartilages.

"As the ventricles are raised, the seat of the impulse, caused by their contraction, is raised also. In a case in which the effusion was very extensive, the second and third costal cartilages, and the first and second intercostal spaces, protruded during the impulse of the ventricles, while the third intercostal space and the fourth costal cartilage fell slightly back, and the fourth intercostal space receded to a still greater extent. These movements of falling back below, while there was advance above, were visible, and gave the effect of undulation; while the upper part rose during systole, the lower part fell; towards the diastole, when the parts resumed their places, the lower parts rose while the upper parts fell. In another case, the impulse was unusually high, being seated between the third and fourth intercostal spaces; but the lower spaces and ribs did not fall back, the effect of undulation was not produced.

"As the outlines of dulness, due to effusion, diminished in the above cases, the seat of the impulse descended."

Dr. Taylor has noticed the connexion of the elevated impulse with considerable pericardial effusion, in the valuable series of cases of Pericarditis, published by him in the *Lancet* for 1845-46. In one case, (the seventeenth) he observed, that as the pericardial dulness diminished, the impulse at the apex fell from the fourth to the fifth intercostal space.

More recently this point has been noticed in the following words, by Dr. Walshe, in a Clinical Lecture on an interesting case of Pericarditis, published in the *Lancet* for Feb. 10, 1849, p. 143:

"Another singularly important sign of pericardial effusion (twisting upwards and outwards of the heart's apex in such manner, that the beat of the apex is felt and seen in the fourth instead of the fifth intercostal space, and on, or a little outside, instead of inside, the vertical level of the nipple) was clearly detected in Cradock; and that the elevation of the heart's point was the effect of the recent effusion (as in ordinary cases), and not of the old inflammation, was absolutely demonstrated by the descent of that point to the fifth intercostal space a few days later."

In the second of the two cases referred to in the quotation from my paper on the Internal Organs, the impulse of the apex and the right ventricle was seated between the third and fourth intercostal spaces, and was somewhat more to the left than usual at the apex; a circumstance pointedly noticed by Dr. Walshe, in his case in the quotation just given. In the first of my two cases, the impulse was only present in the first and second intercostal spaces, and was evidently due to the

movement of the upper part of the right ventricle, and, probably, of the pulmonary artery. In this patient, the fluid must have been in part interposed between the body of each ventricle and the free pericardium, thus shielding the parietes from the more extensive impulse.

The appearance of undulation, caused by the impulse over the first and second intercostal spaces, which was observed in the case just referred to, was noticed in the following words by Senac, one of the earliest writers on pericardial effusion:

"Parmi tant de signes incertains, j'ai cru en remarquer un qui les rendrait moins équivoques, s'il était bien constaté; il est d'autant plus facile à observer, que les yeux peuvent le saisir; on aperçoit très-clairement entre la troisième, la quatrième, et la cinquième côte, les flots de l'eau contenue dans la péricarde, lorsqu'il survient des palpitations; ce n'est pas qu'on entrevoie quelque mouvement semblable dans celles qui ne sont pas accompagnées d'une telle hydropisie; mais elles ne produisent pas un mouvement onduleux, et qui s'étende fort loin."

Dr. Latham, in his recently published Clinical Lectures on Diseases of the Heart, thus notices the interesting subject just referred to:

"In Pericarditis, while the præcordial region is dull to percussion, and the exocardial murmur is heard, an undulating motion often becomes visible to the eye in some of the spaces between the cartilages of the ribs on the left side. It has always been either between the cartilages of the second and third ribs, or of the third and fourth, or between both at the same time, that I have seen motion, and never in any other situation.

"So, too, in Pericarditis, while the præcordial region is dull to percussion, and a murmur is heard, a vibratory motion often becomes sensible to the touch in some spaces between the cartilages of the ribs on the left side. As I never saw the undulation, so I never felt the vibratory motion elsewhere than either between the cartilages of the second and third, or of the third and fourth ribs, or between the cartilages of both simultaneously.

"The vibration, I believe, is the more frequent of the two, and often occurs unaccompanied by any visible undulation. But the undulation was never apparent to my eye without my finger being able to detect a sensible vibration at the very same spot.

"Again where they do appear, it is not (as far as I observe) ever at a very early period of the disease. In Pericarditis (as far as I have observed) they never occur but as accompaniments of the exocardial murmur and the præcordial dulness. And further, when they do occur (as far as I have observed), they always appear later and cease earlier than these do."

These observations of Dr. Latham render it perfectly clear that the appearance of undulation cannot be due, as Senac had supposed, to the presence of fluid at its seat. The co-existence of friction sounds and of vibrations with the undulation, necessarily forbids the supposition that fluid was present; as the presence of fluid would have separated the two surfaces of the pericardium, and so extinguished the friction sound and the vibrations.

It is manifest, therefore, that the appearance of undulation, so often observed in cases of extensive pericardial effusion, is not due to the

reality of undulation from the presence of fluid, but to the slight and peculiar impulse between the cartilages of the first, second, third, or fourth ribs—an impulse due to the slight systolic shock of the upper part of the right ventricle, and which is usually followed, at the uppermost part, by the peculiar sharp diastolic shock of which I have spoken above at p. 895.

When the anterior walls of the heart are altogether separated from the free pericardium, neither impulse, undulation, friction sound, nor vibration, can be any longer perceived. How, indeed, can they, when the heart's surface is no longer in contact with the parietes? It is clear that if, by any means, we can, for the time, remove the fluid from between the roughened and inflamed pericardial surfaces, bring those surfaces again into contact, and so reproduce attrition between them, we shall again bring out the friction sound. This I have been able to effect in such cases, by exerting pressure upon the cartilages of the ribs and the spaces between them. The interposed layer of fluid is usually very thin, and I have found it to be readily displaced by means even of inconsiderable pressure. In order to diffuse the pressure, and so to prevent pain, I inserted a thin plate of wood into the large end of the flexible stethoscope, and I found that when, by careful manipulation, pressure was made with this plate, it excited no uneasiness, and it also, owing to the increased extent to which the surfaces were brought in contact, still further augmented the friction sound.

I found that, by means of pressure, I was not only enabled to bring out friction sounds, previously absent, owing to the interposition of fluid between the opposite surfaces; but that I was also able, in almost all cases where the friction sounds were present, to render those sounds louder and rougher. I wish particularly to call attention to the fact that exocardial murmurs can be heard with greater ease and clearness when pressure is applied over the region of the heart, and to demonstrate the value of the sign in question in the detection of Pericarditis. I shall take a future opportunity of returning to this interesting subject.

15, Lower Brook Street, London, September 1849.