PROVINCIAL MEDICAL & SURGICAL JOURNAL.

ON THE CO-OPERATION OF THE FIBROUS PERICARDIUM WITH THE VENTRICLES, IN ACCELERATING THE FLOW OF BLOOD INTO THE AURICLES.

BY J. H. WALSH, Esq., Surgeon, Worcester.

In the physiology of the human heart there is a problem which has never yet been solved in a satisfactory manner, for though the attempt has been made by many individuals of well known skill and ability, still, by the common consent of physiologists, they have never afforded an explanation which could satisfy the mind of an unprejudiced enquirer.*

The difficulty I allude to is, to show the power by which the venous blood from the lower half of the body is returned, contrary to the usual law of gravitation, into the right side of the heart.

It has been held by some physiologists, among whom may be enumerated Sir David Barry, Dr. Carson, and Mr. Mayo, in our own country, that the blood is drawn into the chest, and consequently into the heart, by the dilatation of the thorax during inspiration, and as a proof, they adduce several experiments performed by themselves upon horses and other inferior animals. But they seem to have overlooked the fact that the diastole of the auricle, and the dilatation of the chest, do not coincide in point of time, the former occurring three or four times as often as the latter, hence, during a given time, about one half the number of diastoles would be synchronous with the expiratory effort, and would then, of course, be as much impeded by expiration as they might at other times be assisted by inspiration. From the experiments of Dr. Carson and Sir David Barry it is clear, that during inspiration the blood is drawn into the heart in a greater degree than in the interval, but still the difficulty remains to explain how the blood is drawn into the auricle during *expiration*. It has been suggested by others, that the auricle itself has the power of active dilatation; this is, however, opposed to its structure, which is so thin as to be incapable of any such effort—besides, there is no muscle in the

human body of similar formation, which is endowed with the power of *active* dilatation; and as there is neither proof of such action, nor analogy for it, it can scarcely be considered as a tenable hypothesis.

If, however, we carefully examine the form and relation of the fibrous pericardium, we shall find in that investment of the heart, the power of which we are in search. Hitherto it has only been considered useful in restraining any undue action of the heart contained within it. My object in this communication will be to show that it is the chief agent, though through the medium of the ventricle, in drawing blood into the auricle.

Before proceeding further, it will be desirable to obtain a clear view of the anatomy of the pericardium, and for this purpose I shall avail myself of the description given in the Cyclopædia of Anatomy and Physiology:—

“The pericardium is a fibrous bag surrounding the heart and origin of the large blood-vessels, but without any direct attachment to the heart itself, having its inner surface lined by a serous membrane. It is from this latter circumstance that it is generally termed a fibro-serous membrane. It is placed behind the cartilages of the second, third, fourth, and fifth ribs of the left side, and middle part of the sternum. Posteriorly it rests upon the parts contained in the posterior mediastinum; anteriorly, it corresponds to the anterior mediastinum, and may be reached by perforating the left side of the sternum, as has been proposed in some cases of hydrops pericardii. The pleura adheres to its lateral and part of its anterior surface, by pretty close cellular tissue, when the interposed fat is small in quantity. Below, the fibrous part of the pericardium adheres intimately to the upper surface of the cordiform tendon of the diaphragm, and is also connected by pretty dense cellular tissue to the upper surface of the muscular fibres, running into the anterior part of the left lobe of the tendon. It adheres more firmly to the cordiform tendon at the edges, particularly anteriorly, than at the centre. It is broader below where it adheres to the upper surface of the diaphragm; narrower above, where it is attached to the larger vessels that pass in and out from the heart. Upon these large vessels the fibrous part of the pericardium is prolonged, forming a kind of sheath, which gradually

* For the truth of this position I beg to refer to the recent work of Dr. Carpenter, and to the Cyclopædia of Anatomy and Physiology, art. Pericardium.

becomes thinner, until it is confounded with the cellular coat of the vessels. From the manner, however, in which the vena cava inferior enters the heart, it can have no fibrous sheath of this kind." (P. 597.)

This description agrees with that of Cloquet, except that the latter describes the pericardium as attached to the diaphragm, but not continued upon the upper surface; that is, that the serous layer of the pericardium is actually in apposition with the cordiform tendon. This however is a point of no consequence to my present enquiry. The explanation will be more fully understood by a reference to the accompanying diagram:—

From this it will appear that the pericardium (P) is completely in the form of a tent, having its base at the diaphragm (D,) and its apex at the aorta and great vessels of the heart. This tent is kept, *during life*, in a state of extension, superiorly by the elastic tissue in the aorta and great vessels of the neck; anteriorly by its close apposition to the sternum (S,) posteriorly, by its relations with the posterior mediastinum (M,) and inferiorly by its attachment to the central tendon. By a reference to the diagram, it will be seen how by the contraction of the crus, the posterior and lateral walls are made tense. And here, I may remark, that we must not consider the pericardium, as a flaccid sac, such as is usually presented to us in a *post-mortem* examination; for in this case the sternum has been removed, the anterior attachments of the diaphragm have been divided, and of course that which previously had been a free unyielding tent, capable of resisting considerable force from without, is now, from a removal of some of its tent-pegs, a loose and flaccid bag.

To examine this sac, for the purpose we have in

view, the chest should be left untouched, the abdomen should be opened, and then, by dividing the central tendon, without disturbing any of the attachments of the pericardium, it will, on removing the substance of the heart piecemeal, be found to give the sensation to the hand of a firm elastic tent, such as I have already described.

Assuming that such is the anatomy of the pericardium, let us now see how this will assist us in examining its physiology.

We find this tent containing an organ which, for the sake of simplicity, may be considered as consisting of a single auricle and ventricle, the former being a thin and comparatively powerless bag, communicating with the veins; whilst the latter is thick, muscular, and powerful, and communicates with the artery, the auricle and ventricle also communicating with each other. It is agreed on all hands that the auricle contracts immediately before the ventricle, which contracting impels the blood into the artery, the blood being prevented returning into the auricle by the valve interposed between the two cavities. Now, if it can be demonstrated anatomically that the two cavities, together with their contained blood, always occupy a given space, and if that space is always maintained of the same dimensions by the pericardium, it is clear, that as the ventricle contracts, and throws its blood out of the pericardium, the loss within that sac must be made up by an influx of blood into the auricle, equivalent to that displaced by the ventricle. That these points can be demonstrated, I believe no anatomist will dispute, as they must be apparent to every one who examines the matter for a moment; and if, as I believe, it can also be shown that the pericardium can and does maintain its cavity, in a state of health, nearly always of the same dimensions, it follows, then, that in the muscular ventricle resides the power not only of propelling blood into the arteries, but of sucking venous blood into the auricle by its contraction, and, when taken in conjunction with the blood which, in the state of dilatation, it had previously contained, its consequent diminution of size.

As soon as this tendency to a vacuum within the pericardium has been thus filled by the blood rushing into the auricle, this immediately contracts, and here again the pericardium will be found of use. At this moment, assuming that the auricle and ventricle, with the blood in the former, are contained as it were in an unyielding box, the auricle, on contracting, cannot force its blood out of that box into the veins, or it would create a vacuum, because no blood can re-enter from the artery, in consequence of the valves placed between that vessel and the ventricle; and therefore, as it cannot force it backwards out of the pericardium, it propels it into another cavity contained within the same space, and not in a retrograde manner into the veins. This I conceive to be the explanation of the fact, that there are no valves at the parts where

the veins enter the pericardium, for without this provision the regurgitation would be almost equal to the quantity propelled into the ventricle, and the auricle must be nearly double the size of the cavity of the ventricle, to allow for the loss by regurgitation.

As a proof, that without this beautiful provision, a valve would be necessary at the entrance of the vena cava, I may adduce the fact that there is such a valve at the entrance into the auricle of the only vein, whose whole course is contained within the pericardium, viz., the coronary vein, which, not being protected by the pericardium, would, if unprovided with a valve, according to my hypothesis, be overwhelmed with blood at each contraction of the auricle.

In addition to the arguments I have adduced, which are based on the anatomy of the pericardium in man, let us examine how far they are borne out by its structure in the inferior animals. In man, from his erect position during all his most powerful exertions, such as raising weights, running, leaping, &c., a provision such as I have described is most needed, and consequently we find the formation of his pericardium, and the position of his heart, differing from that of those animals closely resembling him in other respects as to the anatomy of these organs, but who maintain the horizontal position under all ordinary circumstances.

Here, as in all the domestic animals, we find the heart, not lying with its side upon the diaphragm, but having its base towards the throat, and its apex touching the diaphragm; the pericardium is also quite different in its shape, being an oval bag, having its two pointed extremities attached, the one to the great vessels, the other loosely to the diaphragm. Here, there is no tent, and consequently no unyielding cavity, whilst in man we have a totally different arrangement, for which, as far as I am aware, there has not hitherto been adduced any explanation.

But not only is this difference seen in comparing the domestic animals with man, but as we examine the structure of those in the intervening links, we find that exactly as the erect position becomes more and more perfect and frequent, so does the base of the pericardium increase in size, and the apex of the heart incline to the left side. In proof of this assertion, I adduce the following extracts from Professor Grant's lectures on comparative anatomy, recorded in the 24th volume of the *Lancet*:—"This sinistral position of the heart, and its proximity and attachment by means of the pericardium to the diaphragm, become more general and more marked characters, as we ascend through the monkeys and the ourangs to man," having in the previous column of the same page described the structure in the carnivora as follows:—"We see a considerable distance to intervene in carnivorous, and many other powerful quadrupeds, between the passage of the inferior vena cava

through the diaphragm, and its entrance into the right auricle, so that their heart is comparatively free in the chest." p. 955.

In this examination of the structure of the pericardium, I have attempted to show that it is the *passive* means by which the auricle is filled with venous blood from the inferior cava, contrary to the laws of gravitation. This is seen in man most perfectly, but exactly in proportion to the necessity for such an apparatus in the ourang and monkey also. I am anxious to call the attention of the profession to this structure, because I believe my hypothesis explains many points hitherto unsatisfactory in the diseases of the heart. I have lost no opportunity for the last twelve years of investigating the subject, and I believe, that on examining the pericardium in the way I have pointed out, it will be found to present the appearances I have described. I have refrained from making any observations upon the heart and pericardium in a state of disease, as I should wish to establish the truth of the facts I have adduced as to the normal anatomy, before proceeding to the investigation of these organs in the abnormal state.

PRACTICAL OBSERVATIONS ON SOME OF THE MORE IMPORTANT POINTS OF PHYSICAL DIAGNOSIS.

By C. M. DURRANT, M.D., Physician to the East Suffolk and Ipswich Hospital.

(Continued from page 69.)

PULMONARY APOPLEXY.

Auscultation.—Respiratory murmur in the immediate seat of the effusion, feeble or altogether absent; around it, exaggerated or bronchial, accompanied by liquid crepitation, the bubbles of which in the larger tubes convey the impression of greater humidity, as well as magnitude; over the affected part, increased resonance of voice and cough.

Percussion.—Usually a degree of circumscribed dulness, in proportion to the amount of effusion. On applying the expanded hand over the seat of the disease, an increased vocal vibration is often perceptible.

Observations. The history of the case, together with the dyspnoea, and sanguineous expectoration, more particularly if there obtain a co-existing affection of the heart, will materially assist in elucidating the diagnosis. The differential analysis between apoplexy of the lung and pneumonia has been already pointed out.

PULMONARY OEDEMA.

Auscultation.—Respiratory murmur feeble, accompanied, especially at the more depending portions of the lungs, by a muco-crepitating rhonchus, increased by deep inspiration and cough.

Percussion.—Slightly diminished sound, more particularly at the postero-inferior parts of the chest.

Observations.—The proneness of both lungs to be simultaneously affected by oedema, in addition to the circumstance of its pertaining principally to diseases of debility, has already been demonstrated, as distip-