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SOME DEDUCTIONS FROM A STUDY

OF THE

DEVELOPMENT OF THE HEART.

BY

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SOME DEDUCTIONS FROM A STUDY

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DEVELOPMENT OF THE HEART.

A CONSIDERATION of the physical problems arising out of cases in which, on account of the retention of certain embryonic arrangements, deviations from the normal relative pressures existing in the systemic and pulmonic vessels are present during adult life, has led us to seek some means by which it might be possible to establish a basis upon which we may rest with certainty in reasoning upon such conditions. As it seems probable that in the anatomical relations of the two sides of the heart during fœtal life such a secure foundation may be obtained, we have examined the heart of the embryo in order to ascertain the anatomical conditions existing at different stages of its development. During fœtal life the pressure on both sides of the heart must be nearly equal, on account of the free communication allowed by means of the ductus arteriosus and foramen ovale; and it might, *à priori*, be expected that the walls of the ventricles on the two sides of the heart should be of approximately equal thickness.

This expectation we found to be in great part justified by our results, as will be seen in the sequel.

Before entering upon the observations which we wish to lay before the Society, it may be of use to sum up, as briefly as possible, the course of events in the development of the central vascular apparatus.

The vascular system makes its first appearance in the form of two simple lateral tubes in the anterior part of the embryo. These tubes occupy spaces which are continuous with the pleuro-peritoneum, and are composed of two layers apparently developed respectively from the mesoblast and hypoblast. Each tube is continuous in front with the cephalic mesoblast, and terminates behind in the omphalo-meseraic or vitelline veins.

These lateral tubes are developed in the part of the embryo which, on the folding downwards of the body-walls, becomes the ventral wall of the pharynx; and when this wall is completed they meet in the middle line and become fused into a single tube. This remains connected with the vitelline veins behind, and bifurcates in front, giving rise to the primitive aortæ.

At this stage in the development of the vascular apparatus the single median tube begins to pulsate rhythmically, while as yet no muscular tissue can be discerned. This is a point which cannot be denied a considerable degree of significance.

The central vascular tube, at a slightly later stage, becomes somewhat curved by bending over to the right; and at the same time its posterior extremity, connected as we have seen with the venous channels behind, assumes a position dorsal to the rest of the tube. At this period of development superficial constrictions appear upon the tube, dividing it into the venous sinus, the auricle, the ventricle, and the aortic bulb. While these changes are going on muscular fibres are for the first time seen in the substance of the vascular apparatus.

The venous sinus receives the posterior veins already mentioned, and the primitive veins from the cephalic region. It at first communicates freely with the auricle, but afterwards is guarded by venous valves.

The common auricle continues to develop behind the curved ventricular portion of the tube, and in time the right venous valve forms the Eustachian and Thebesian valves, while the left venous valve disappears.

The common ventricle, or curved ventral portion of the tube, receives the blood from the common auricle at its left end, and terminates at its right end in the aortic bulb. It contains in its early stages a fine spongy substance. A slight constriction on its outer surface marks the future separation into right and left ventricles, and a septum, composed of muscular tissue, begins to grow from below and behind, upwards and forwards. This is completed at a later stage by the development of a fibrous septum, which grows from above and before, downwards and backwards. At the same time the spongy tissue in the cavity of the ventricular portion of the apparatus begins to be gathered together in distinct columnar masses.

The common auricle is gradually raised upwards and forwards, so that the opening into the ventricular portion assumes a positiou over the inter-ventricular septum, which grows up, and with the assistance of flaps developed from the inner layer—the future auriculo-ventricular valves—divides the orifice into two divisions. A septum is developed in the common auricle from above and behind, downwards and forwards, in which the foramen ovale is formed. Before this inter-auricular septum is complete, the pulmonary vein is developed.

While these changes are proceeding, the aggregation of the spongy tissue of the ventricles into distinct masses goes on, and by this means the columnæ carneæ as well as the musculi papillares with their chordæ tendineæ are formed, the latter becoming attached to the flaps developed at the auriculo-ventricular orifices. The inter-ventricular septum grows up into the aortic bulb and separates it into two divisions, *i.e.*, aorta and pulmonary artery, each communicating with its respective ventricle. Folds of the lining membrane grow up at the junction of the bulb and the vessels, and by their division into segments form the semilunar valves.

To the development of the great arterial trunks it is not necessary to devote much attention. From the aortic bulb two great arterial arches spring, each running forwards, outwards, and backwards, dorsal to the primitive heart, to form the primitive aorta of its own side. The two primitive aortæ unite at an early period in the middle line about the dorsal region. To these arterial arches four other lateral pairs are in succession added, forming five arterial arches on each side. Of these arches the first and second become the external carotid artery and its branches; the third forms the internal carotid artery. The fourth, on the right side, becomes the subclavian artery, and on the left side it forms the arch of the aorta. The fifth, on the right side, develops as the right pulmonary artery, and its distal portion disappears; on the left side it forms the left pulmonary artery, and the portion beyond remains during fœtal life as the ductus arteriosus. The right descending primitive aorta entirely disappears in its anterior part; the left remains as the permanent descending aorta, and joins the posterior part of the right primitive aorta behind, to form the posterior portion of the permanent descending aorta.

From this description of the development of the heart and great vessels it may readily be understood why it is that the pressure on both sides of the heart is very similar, probably being somewhat greater in early fœtal life on the right side than on the left.

We determined to examine the hearts of the human fœtus at different ages, so as to obtain the evidence afforded by the relative thickness of the walls of the ventricles.

The method which we have followed in our investigations has been to make a series of sections through the ventricular portion of the heart of the fœtus at right angles to its axis, and measure the thickness of the walls at different points in the circumference of the ventricles, as well as at different distances from the auriculo-ventricular groove.

The following is a summary of the results:—

	Wall of Right Ventricle.	Wall of Left Ventricle.
1. Fœtus, 3½ months, . . .	1·5 mm.	1 mm.
2. Fœtus, 4 months, . . .	1·5 „	0·5 „
3. Fœtus, 6 months, . . .	4 „	3 „
4. Fœtus, full term; never breathed,	4 „	3 „
5. Fœtus, full term; never breathed,	5 „	5 „
6. Fœtus, full term; lived 24 hours,	3 „	4 „
7. Female infant, 11 months, .	2 „	5 „
8. Male infant, 22 months, . .	2 „	8 „

These figures show that the left ventricle progressively increases in thickness from the third month, while the right ventricle increases up to the hour of birth, and then rapidly diminishes; the thickness of its wall nearly two years afterwards being actually smaller than in the sixth month of fœtal life.

The accompanying Plate gives copies of life-sized photographs of the sections referred to in the above summary, and the numbers correspond to those of the text. The photographs were all obtained looking down on the sections from above, and they were placed with the anterior side above, so that the side of each to the right is the right ventricle.

From these facts we may fairly conclude that the thickness of the walls of the cardiac chambers is exactly proportional to the work which each has to do. And although an inquiry into the teachings of comparative anatomy is not within the scope of this contribution, we may add that the facts which we have laid before the Society as to the condition of the walls are in every respect supported by observations which we have made on the fœtal heart of the horse, cow, sheep, pig, dog, and cat.

The consideration of these points in vascular development is by no means a matter only of scientific interest; on the contrary, the facts which have been briefly described in the preceding pages show how different malformations are possible through arrested or perverted development, and they point to further important truths. The pulsation of the primitive vascular tube, for instance, before the growth of any muscular fibres in its substance, appears to be evidence in favour of the existence of an inherent tendency to rhythmic propulsive movements in the vascular mechanism. And as during fœtal life the blood-pressure must be nearly the same on both sides of the heart, it is undoubtedly a circumstance of real importance, that up to the time of birth the thickness of the walls of the two ventricles is nearly equal on the two sides. This fact may be taken to prove that the amount of strength developed is strictly proportional to the work that has to be done.

Such results lead to far-reaching conclusions in regard to the possibility of the heart adapting itself to widely different morbid conditions. Some further results relating to the proportional thickness of the adult ventricular walls in different diseases have been obtained, but these must form the basis of another communication at some future time.

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Fig. 1.

Fig. 2.

Fig. 3.

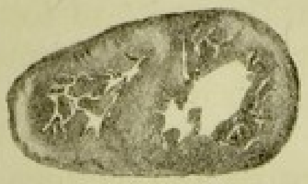

Fig. 4.

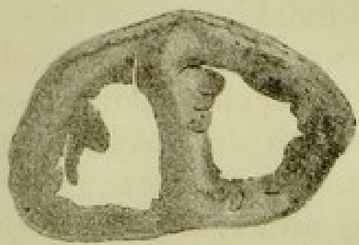

Fig. 5.

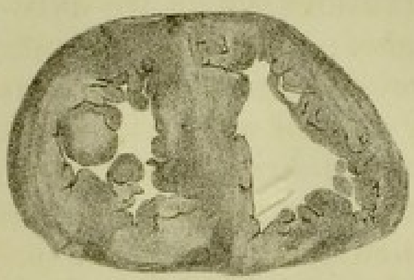

Fig. 6.

Fig. 7.

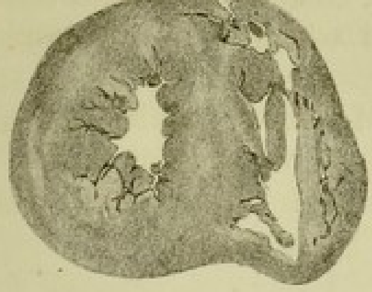

Fig. 8.

Wm CATHIE, LITH.

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