THE TRANSVERSE SECTIONAL ANATOMY OF THE THORAX.

By Richard J. A. Berry, M.D., F.R.C.S.Ed., F.R.S.E., Lecturer on Anatomy in the School of Medicine of the Royal Colleges, Edinburgh.

(Plates I.–III.)

In view of the paramount importance of the normal anatomy of the thorax to the clinician, it may not be out of place to publish the results of a series of horizontal sections through the adult thorax. Sectional anatomy is always instructive, but perhaps nowhere more so than in the case of the thorax. More particularly is this the case if the normal chest anatomy be approached, as perhaps it ought more frequently to be, from its clinical rather than from its more purely anatomical standpoint.

With the exceptions of Wilhelm Braune’s classic work on “Topographical Anatomy,”1 in which there are four plates devoted to the chest, and a series of five sections, by Symington, figured in Quain’s “Anatomy,”2 but little seems to have been done as regards the normal sectional anatomy of the human thorax. This is the more to be regretted, inasmuch as this class of research, necessarily valuable in itself, tends to bring into closer unity the ever more and more diverging sciences of medicine, anatomy, and surgery.

The six sections figured and described in this paper are horizontal sections through the thorax of an adult male of advanced middle age. The subject was thoroughly hardened by injections of formalin, and the sections cut without freezing. That the formalin method lends itself admirably to sectional cutting without subsequent freezing, is well known to all those who have experimented in this direction. Those who have not had any experience in this class of work may perhaps be somewhat sceptical, but a reference to the accompanying plates will surely convince them of the truth of the statement. It is perhaps the more fortunate that freezing was not employed in the present instance, in view of Froriep’s recent paper3 on such a procedure, in connection with the sectional anatomy of the human brain. The present plates may therefore possibly be all the more valuable.

1 Braune, "Atlas of Topographical Anatomy after plane sections of Frozen Bodies," translated by Edward Bellamy, F.R.C.S. London, 1877.
2 Symington, Quain’s "Elements of Anatomy," vol. iii., part iv. London, 1896.
3 Froriep, "Über ein für die Lagebestimmung des Hirnstammes im Schädel verhängnisvolles Artefact beim Gefrieren des menschlichen Cadavers."—Anat. Anz., Leipzig, 1901, Bd. xix.
In every instance it is the upper surface of the section which is figured and described, so that in all the plates the section is viewed from above. On the right side there is slight post-mortem shrinkage of the lung in the region of its anterior border. This, though regrettable, was in the present instance unavoidable, inasmuch as a certain interval necessarily elapsed between the death of the subject and the date of the formol injection, and in this interval of time—an interval which is a legal necessity—the damage occurred. With this slight exception the thorax is in every way perfectly normal and free from disease.

Plate I. Fig. 1 represents the appearances presented by the upper surface of a horizontal section, which has passed posteriorly through the body of the second dorsal vertebra, and anteriorly just above the upper border of the manubrium sterni. The extremely narrow antero-posterior space, 4 cms. in length, between the manubrium sterni and the dorsal vertebra, is occupied in the middle line, in order from before backwards, by some lymphatic glands and the remains of the thymus gland, the trachea, and the oesophagus. As regards the oesophagus, it is interesting to note that it occupies the middle line of the body, although it is usually stated that at about this level it reaches its greatest lateral deviation to the left. In Braune's section, at a slightly lower level than the section now under consideration, that is to say, through the upper margin of the third dorsal vertebra, the oesophagus is occupying its more usually described position, behind and distinctly to the left side of the trachea. In the present example it therefore follows that the oesophagus has either made no lateral cervical deviation whatsoever, or else that the oesophagus, after its deviation, has regained the middle line much earlier than usual. The subject would necessarily have been an unfavourable one for oesophagotomy.

Both the clavicles were removed at the sterno-clavicular articulations, but the articular facets on the manubrium are well seen in the plate. Immediately behind the sternal end of the right clavicle are the large blood vessels. The right innominate vein is in direct contact with the clavicle, with the vagus nerve on its inner side, and with the right internal mammary artery on its outer side. To the inner side of the vein, between it and the trachea, is the innominate artery, which lies directly behind and in direct contact with the sternal end of the clavicle. Immediately behind the innominate artery is the vertebral artery, to the outer side of which is the right subclavian artery, which last vessel occupies a position posterior to and between the innominate artery and the right innominate vein. Behind these large vessels the remainder of the thoracic inlet is occupied by the cervical portion of the right lung.

Immediately behind the sternal end of the left clavicle is the left innominate vein, and to the inner side of that, the left
common carotid artery. Immediately behind the latter structure is the left subclavian artery, giving off the left vertebral artery, which is very closely associated with the body of the dorsal vertebra. The difference between the relative planes of the two vertebral arteries is well shown. In Braune's somewhat analogous section this difference is not so well brought out, inasmuch as the left vertebral artery is separated from the body of the vertebra by the esophagus. Behind and to the outer side of these large vessels on the left side, the remainder of the thoracic inlet is occupied by the cervical portion of the left lung.

A general consideration of the entire section shows that backward dislocation of the sternal end of either clavicle would have been most likely attended by symptoms referable to pressure upon the great vessels, but that the trachea would in all probability have escaped. The left lung projects farther forwards than does the right, and comes into direct contact with the left innominate vein, whereas the right lung is separated from the right innominate vein by the subclavian artery.

Plate I. Fig. 2 represents the appearances presented by the upper surface of a horizontal section which has passed posteriorly through the body of the third dorsal vertebra, and anteriorly through the first chondro-sternal articulation.

In the middle line of the section there are in order from before backwards, some lymphatic glands and the remains of the thymus gland, the innominate artery, the trachea, and the esophagus. The innominate artery, it is interesting to notice, lies directly in front of the trachea. This relationship is somewhat important, inasmuch as (though not brought out in the present instance) it is not unusual for the innominate artery to maintain this relationship to the trachea upwards into the neck. The writer has repeatedly met with instances in the dissecting-room where the innominate artery occupied such a position as to have constituted a serious difficulty in the performance of low tracheotomy.

On either side of the innominate artery, and in direct contact with it, are the right and left innominate veins. Immediately behind the left innominate vein is the left common carotid artery, and behind that again the left subclavian artery. With the exceptions of the right and left internal mammary arteries, the remainder of the section is occupied by the two lungs.

Braune's section through the upper margin of the third dorsal vertebra, and to which reference has already been made, is intermediate in position between this section and the previous one. In his section the left innominate vein is cut almost horizontally, therefore the vein must in that case have occupied a slightly higher level and pursued a more nearly horizontal course than in the present instance.

Plate II. Fig. 3 represents the appearances presented by the
upper surface of a horizontal section which has passed posteriorly through the body of the fourth dorsal vertebra below its middle, and anteriorly through the uppermost portions of the second chondro-sternal articulations.

The middle line of the section—and this is its most remarkable feature—is occupied by the arch of the aorta and the various structures which lie on its right side. Here it may not be amiss to draw attention to two important facts. First, as regards the anatomical subdivision of the thoracic aorta, that important vessel is now divided by all anatomists into three great parts, an ascending aorta which terminates opposite the second right costal cartilage, an arch which terminates opposite the lower border of the fourth dorsal vertebra, and a descending thoracic aorta which becomes continuous with the abdominal aorta opposite the lower border of the twelfth dorsal vertebra. Secondly, as regards the direction of that most important clinical vessel, the arch of the aorta. It cannot be too strongly emphasised that the arch of the aorta pursues an almost directly antero-posterior course through the thoracic cavity, and that its relations must of necessity be referred to as being on the right and left sides, or above and below, as the case may be.

In the section under consideration not only are these general remarks anent the direction of the arch of the aorta well shown, but the section further illustrates the precise direction of the thoracic arch in a remarkably convincing manner. The precise direction of the arch is backwards and slightly to the left, and then directly backwards, the slight deviation to the left enabling the vessel to pass round the prominent trachea. The illustration further shows that the relations of the vessel must be referred to as right and left, and not as anterior and posterior. This point is the more important, inasmuch as more than one modern text-book of anatomy still refers to these right and left relations of the arch of the aorta as anterior and posterior. This being the case, clinicians can hardly be blamed if they fall into a similar error, though a glance at the plate will afford demonstrable proof of the truth of the writer's contention.

The original preparation from which the present illustration has been taken, shows very prettily all the right-sided relations of the aortic arch; these are from before backwards, the deep cardiac plexus, the trachea, the left recurrent laryngeal nerve, the oesophagus, and the thoracic duct. In the illustration only the trachea and the oesophagus are distinctly visible. Similarly with the left-sided relations of the arch. The various nerves which are found on the left side of the arch of the aorta are too small to be visible in a photograph.

The two pleural sacs will be noticed coming into contact immediately in front of the anterior end of the aortic arch, whilst immediately to the right side of the same extremity of the arch is
seen the superior vena cava, occupying precisely the same position as it does in Braune's section through the same dorsal vertebra.

It is perhaps not unreasonable to suppose that this section may prove of value to the physician, as it shows so graphically the various structures likely to be pressed upon in aneurysm of the arch of the aorta.

Plate II. Fig. 4 represents the appearances presented by the upper surface of a horizontal section which has passed posteriorly through the upper border of the body of the fifth dorsal vertebra, and anteriorly through the lowest portions of the second chondrosternal articulations.

The most anterior structures visible in the middle line of the section are the two pleural sacs which have now met together immediately in front of the ascending aorta, and exactly in the middle line of the body. Immediately behind the two pleural sacs is the ascending aorta with the superior vena cava on its right side, the trunk of the pulmonary artery on its left side, and the right pulmonary artery directly behind it. The next structure in the middle line of the section is, as just stated, the right pulmonary artery. Behind this comes the superficial cardiac plexus, and from the appearances of the section it is obvious that the bifurcation of the trachea must have taken place immediately above it and on the same antero-posterior plane. Lastly comes the oesophagus, which, if anything, is very slightly on the right side of the middle line. Immediately to the left of the oesophagus and in contact with it is the descending thoracic aorta. The remainder of the section is entirely occupied by the two lungs.

A general consideration of this section shows that it has been made just below the arch of the aorta, and its value therefore consists in the fact that it illustrates graphically the more important inferior relations of the arch of the aorta.

Plate III. Fig. 5 represents the appearances presented by the upper surface of a horizontal section which has passed posteriorly through the body of the sixth dorsal vertebra, and anteriorly immediately below the sternal ends of the second rib cartilages.

The middle line of the section passes in order from before backwards, through the meeting of the two pleural sacs, the ascending aorta, the left auricle, and the line of contact of the oesophagus, and the descending thoracic aorta.

The ascending aorta lies exactly in the middle line of the section. It has immediately in front of it the meeting of the pleural sacs. Directly behind and in contact with it, the left auricle of the heart. To its right side the right auricular appendix and the superior vena cava. To its left side the trunk of the pulmonary artery, behind which is the left auricular appendix.

The left auricle lies in the coronal plane, and is almost exactly bisected by the middle line of the body. Immediately in front of
it and in order from left to right are the trunk of the pulmonary artery, the ascending aorta, and the superior vena cava. Immediately behind it and in almost direct contact with it are the descending thoracic aorta and the oesophagus.

The descending thoracic aorta and the oesophagus occupy the most posterior plane in the section, they are situated in such a way that the middle line of the body passes between them, or, in other words, the oesophagus is lying to the right of the mesial plane.

The rest of the section is occupied by the two lungs. Though not visible in the photograph, the semilunar valves of the aortic orifice are distinctly visible in the original preparation. Authorities differ somewhat as to the relative position of the odd segment of the cusps in this valve, but in this instance there is no room for doubt. In the aortic orifice the odd segment is anterior, the remaining two cusps being right and left posterior. This is also the case in Braune’s section through the same vertebra, the sixth dorsal.

Plate III, Fig. 6 represents the appearances presented by the upper surface of a horizontal section which has passed posteriorly through the body of the eighth dorsal vertebra. To quote the words of Braune, “the great value of the plate consists in the fortunate section through the heart,” which has in this instance, as in Braune’s section, divided all four chambers of the heart simultaneously. From the singular use of the word “fortunate,” it would appear as though Braune was surprised at the appearances presented by the four cavities of the heart in such a section. But, be this as it may, there is no doubt that many persons find it difficult to realise that the heart is situated so nearly transversely in the thoracic cavity that a horizontal section through the chest in the region of the eighth dorsal vertebra will almost invariably open the four chambers of the heart. The particular section which is here figured (Fig. 6) is not the only one in which the writer has been able to demonstrate this satisfactorily. The fact is that the heart is not suspended in the thorax like a pear dangling from its stalk, but occupies a position which, while oblique in the main, is more nearly horizontal than vertical.

The present section further proves how extremely misleading are the terms “right” and “left” as applied to the chambers of the heart. The so-called “left” auricle, for example, is lying altogether behind the right auricle, the same remark applying to the respective positions of the left and right ventricles. But as these terms have become ingrained with centuries of usage, it would be mere pedantry to suggest an alteration. In employing such terms as “right” and “left,” it is, however, well to realise that they really denote “anterior” and “posterior” respectively.

Immediately behind the left auricle, and intervening between it and the body of the eighth dorsal vertebra, are the descending
thoracic aorta and the oesophagus, the former lying to the left of the mesial plane of the body, and the latter to the right.

The right coronary artery is seen descending almost vertically in the right auriculo-ventricular groove, whilst, lastly, it is interesting clinically to notice that the only portion of the heart uncovered by lung is a small part of the right ventricle, which lies directly behind the body of the sternum. The remainder of the section is occupied by the lungs.

A comparison of the present series of sections with those of Braune and Symington reveals in a singularly striking way the differences which undoubtedly exist in different individuals as regards the relations of the thoracic viscera to the various dorsal vertebrae. The present results conform more closely to those of Braune than to those of Symington. In Symington's series the thoracic viscera are obviously at a lower level relatively to the dorsal vertebrae than usual. As an example, it may be mentioned that Symington figures a transverse section through the ninth dorsal vertebra, which opens all four chambers of the heart simultaneously, but which does not show any part of the diaphragm. Now the diaphragm, or, to be more accurate, its right cupola, usually extends as high upwards as the intervertebral disc between the eighth and ninth dorsal vertebrae, and the left cupola as high as the ninth dorsal vertebra; yet Symington's section through the body of the ninth dorsal vertebra shows no trace of the diaphragm on either side, so that perhaps it is only fair to suppose that in his case the general tendency of the thoracic viscera was to assume a lower position relative to the vertebral column than what perhaps might be termed the normal.

Notwithstanding the importance of this question of the relationship of the various thoracic viscera to the dorsal vertebrae and the chondro-sternal articulations, it is impossible to lay down any general rules built upon the averages obtained from three cases only. An extensive series of observations are required, and it is to be feared that the remarkable paucity of material at the disposal of the anatomist will render such an investigation—badly wanted though it be—a matter of the gravest difficulty. Were the material forthcoming, it should not be difficult to obtain reliable information,—information which would be as valuable to the clinician as it would be interesting to the anatomist.
Plate I.

Right common carotid artery.
Right innominate vein.
Right internal mammary artery.
Rt. subclavian artery
Rt. vertebral artery
Esophagus.

Left innominate vein.
Left common carotid.
Trachea.
Left subclavian.
Left vertebral artery.

2nd Dorsal vertebra.

Right ventricle.
Right coronary artery.
Right auricle.
Esophagus.
8th Dorsal vertebra.

Left ventricle.
Left auricle.
Descending thoracic aorta.
Plate III.

Superior vena cava.

Trachea.

Left recurrent laryngeal nerve.

Esophagus.

Thoracic duct.

4th Dorsal vertebra.

Arch of the aorta.

Left recurrent laryngeal nerve.

Esophagus.

Trunk of pulmonary artery.

Right auricular appendix.

Ascending aorta.

Superior vena cava.

Bronchus.

Esophagus.

6th Dorsal vertebra.

Left auricular appendix.

Left auricle.

Descending thoracic aorta.