AN ACCOUNT
OF THE
DISSECTION OF THE PARTS REMOVED AFTER DEATH FROM
THE BODY OF A WOMAN THE SUBJECT OF
CONGENITAL MALFORMATION
OF THE
SPINAL COLUMN, BONY THORAX, AND
LEFT SCAPULAR ARCH;
WITH REMARKS ON THE PROBABLE NATURE OF THE DEFECTS
IN DEVELOPMENT PRODUCING THE DEFORMITIES.

BY
ALFRED WILLETT, F.R.C.S.,
SURGEON TO ST. BARTHOLOMEW'S AND TO ST. LUKE'S HOSPITALS,
AND
WILLIAM JOHNSON WALSHAM, F.R.C.S.,
DEMONSTRATOR OF ANATOMY AND OF OPERATIVE SURGERY TO ST.
BARTHOLOMEW'S HOSPITAL; SURGEON TO THE METROPOLITAN
FREE HOSPITAL, AND THE ROYAL HOSPITAL FOR
DISEASES OF THE CHEST, CITY ROAD.

(Received March 11th—Read April 27th, 1880.)

Previous history of the case.—Of the woman J. H—, from whom this specimen of deformed thorax was taken, the following particulars are known :

1. The curvature had existed since birth.
2. She was of average height, and, until uncovered, did not present any noticeable deformity.
3. She had given birth to a living child.

4. Her mother had a curvature of the spine.

5. When undergoing physical examination of the chest, an immobility of the scapula had attracted attention, and on this account she was referred to one of us (Mr. Willett).

6. The immobility of the scapula was found to be due to its union through the medium of a broad bridge of bone with the lower cervical vertebræ.

7. Extremely wide intercostal spaces were noticed, the impulse of the heart's apex being widely diffused and abnormally distinct, as if seen through attenuated structures.

8. She was the subject of mitral disease, and died of cardiac dropsy in her thirty-first year.

Casts taken during life are preserved in the Museum of St. Bartholomew's Hospital.

At the post-mortem examination, the whole thorax, the left scapula, the left clavicle, the upper part of the left humerus, and part of the right clavicle, together with the soft parts connected with them, were removed (see Plate VI and Plate V, fig. 2).

The viscera presented no point of particular interest.

An account of the muscles and other soft parts will be deferred until after the description of the bones, as their attachments and relations will then be better followed.

Description of the bones.—To facilitate comprehension we have thought it advisable to offer a few remarks upon the general appearance of the specimen before proceeding to give a more detailed account of the peculiar abnormalities of the different bones.

General appearance of the specimen.—The portion of the spinal column preserved deviates from the natural condition—1st. In that not only has it lost the posterior convexity, but it has, if anything, a slight anterior curve. 2ndly. There is a sharp lateral curve, with the convexity to the left, in the upper dorsal region, corresponding to the absence of the right half of the third dorsal vertebra. 3rdly. There is a longer and slighter compensatory curve in the lower dorsal region. 4thly. Four and a half of the dorsal vertebra are missing.

The distortion of the thorax corresponds generally to the

altered line of the spine. There are five ribs missing on the right and four on the left side of the chest; the intercostal spaces are abnormally wide. The sternum lies obliquely across the middle line, pointing in its long axis downwards and from right to left. Its upper end is only three quarters of an inch from the spine, its lower end three inches instead of two and nine inches respectively. The cavity of the thorax is diminished in all its diameters, especially in the antero-posterior, in the middle line, whilst this measurement is markedly less on the right side than on the left. The left clavicle deviates notably from the normal. Its general direction from the sternum is upwards, forwards, and outwards, instead of nearly horizontally outwards. It has also only a single posterior curve throughout its entire length.

The left scapula presents a most remarkable deformity. There is a broad bridge of bone extending from the middle third of the posterior border of the scapula backwards and upwards to the lamina and spinous process of the sixth cervical vertebra. The transverse axis of the scapula is elongated, whilst the vertical is shortened and the bone appears rotated forwards, so that the glenoid cavity looks nearly directly forwards, whilst the plane of it is nearly an inch in front of the left sterno-clavicular articulation. The upper border and spine, instead of being directed nearly horizontally outwards from the base, slope downwards and forwards as well as outwards.

Having thus given a general outline of the specimen, we shall now proceed to describe its several parts.

Description of the vertebrae.—Counting the bodies, twelve and a half vertebræ are apparently present in the specimen. Of these the two upper are presumably cervical, the three lower lumbar, and the remaining seven and a half dorsal. We have had considerably difficulty in referring each of these dorsal vertebræ to its number in the normal series. We believe that they correspond respectively to the first, second, half the third, fourth, seventh, tenth, eleventh, and twelfth. The uppermost vertebra in the specimen is apparently the sixth cervical; its body and transverse processes

are fairly normal; its spine is cleft, the left half of the spine and left lamina being fused with the irregularly triangular portion of bone already mentioned, and by it connected to the posterior border of the scapula. The right half of the spinous process is free and projects backwards and to the left, slightly overlapping the triangular portion of bone, to which it is ankylosed at its base. The left half of the medullary canal, viewed from above in transverse section, is round instead of triangular, as it is on the opposite side. The shape of the vertebra and canal are best explained by the accompanying photograph taken from above (see Plate V, fig. 1).

The second vertebra is apparently the seventh cervical. On the right side it has the characters of the normal seventh, but on the left side the body and transverse process are fused with a process of bone, which appears at first sight to be the first rib. This process of bone we regard, however, as a cervical rib, that is, as the anterior part of the transverse process of the seventh cervical vertebra, a process which, as is well known, is developed from a separate centre of ossification, and frequently grows beyond its normal dimensions, constituting a supernumerary rib, which may either remain free, resembling the asternal ribs of birds, or be joined, as in the present instance, by its distal end to the first thoracic rib. The spinous process of this vertebra is fairly normal, and is fused at its apex with the left half of the spinous process of the first dorsal vertebra. The left lower articular process and the lower border of the left lamina are ankylosed with the superior articular process, and the upper border of the left lamina of the first dorsal vertebra. In the recent state, very free movement existed between the the sixth and seventh cervical vertebræ. The scapula, the irregular portion of bone already mentioned, and the sixth cervical vertebra, moved as one piece at this articulation. The first dorsal presents on each side of its body a facet and a half, as is normally the case, a whole facet above for the first rib and a demi-facet below for half of the head of the second rib; the upper facet on the right side, however, is

higher than that on the left, the portion of bone forming this facet encroaching above upon the intervertebral substance between the seventh cervical and first dorsal vertebræ. The bodies of the seventh cervical and first dorsal are ankylosed by bone stretching between them on the left side. The spinous process is cleft, and the two halves separated except at their base, the left half and corresponding lamina being rotated vertically upwards and ankylosed with the spinous process and lamina of the seventh cervical, whilst the right half and corresponding lamina are rotated downwards and ankylosed with the left half of the spinous process of the second dorsal vertebra, which process is likewise cleft and its halves similarly separated.

This displacement of the two halves of the spinous process must have occurred before each lateral arch of the vertebra had united posteriorly; and when viewed in connection with the coincident displacement of the superior facet for the first rib on each side of the body, suggests the idea that the whole of that part of each lateral half of the vertebra which is developed from the lateral centre of ossification was involved in the displacement.

Looking to the way in which the vertebræ are ossified this would appear not improbable. In the dorsal vertebræ, as is well known, the centre for the body does not extend into the lateral masses, but is limited to that portion of the body which is situated between the lateral facets for the ribs; the lateral portions of the body, and consequently the facets for the ribs, are ossified by the extension into them of the centre for the lateral masses, a narrow cartilaginous interval (the neural central suture) existing on each side of the body for some time between the centre for the body and each lateral mass. As the right facet for the rib and right pedicle are higher than the left, whilst the right lamina and spine are depressed below the corresponding parts on the left side, it would appear that each lateral half of the vertebra, already ossified and moving as a whole, had been rotated on an imaginary axis drawn through the transverse process, the anterior half on the right side being raised

and the posterior part depressed, and *vice versa* on the left side. The appearance of the parts, we think, justifies such a supposition, and how this displacement might have taken place we shall endeavour to show later on. The second dorsal vertebra presents as usual two demi-facets on the left side of its body for the second and third ribs, but no distinct facets on the right side. The left half of the body is ankylosed to what appears to be the left half of the body of the third dorsal. At first sight it seems as if the right lamina and right half of the spinous process and transverse process were deficient, but on closer examination it is evident that these parts are not absent, but are fused with the corresponding parts of the fourth dorsal vertebra, these parts of the third being wanting. The left half of the spinous process, the left lamina, and transverse process, are distinct. The left half of the spinous process is ankylosed, as before stated, to the right half of the first dorsal. The left lamina is ankylosed to the laminae above and below, and the transverse process articulates with the tubercle of the second rib, and by its apex is ankylosed to the transverse process of the third dorsal. It would, therefore, appear that the spinous process had remained cleft like that of the vertebra above, and that the right half and right lamina had been rotated downwards in a similar manner to that of the right half of the first dorsal, and in this position had become fused with the fourth vertebra.

The right half of the third vertebra is wanting. Viewed from the front the left half of its body appears as a triangular piece of bone, with its base to the left, wedged in and ankylosed between the bodies of the second and fourth. It presents two demi-facets for the heads of the third and fourth ribs respectively. Posteriorly, the left transverse process, the left lamina, and the left half of the spinous process, are fused below with the fourth vertebra, and above with the second; the left half of the spinous process, as before stated, is also fused in the middle line with the right half of the spinous process of the second dorsal vertebra. As in front, so posteriorly there are no signs of the existence of a right half, although at first

sight what we have described as the right transverse process, right lamina, and right half of the spinous process of the second dorsal might be taken for it.

The transverse process on the left side articulates with the third rib.

The deficiency of the right half of this third vertebra is the cause of the lateral curvature of the spine, the four vertebræ above all leaning to the right. It may also account for the peculiar displacement of the cleft spinous processes. The next vertebra might be considered as the fourth or sixth; we believe it to be the fourth. Its body presents two demi-facets on each side as usual, which articulate with the fourth and fifth rib in the specimen on the left side, and with the third and fourth rib in the *specimen* on the right side. Above, it is ankylosed on the left side with the half body of the third; on the right side it is in contact with the second. Posteriorly, its left transverse process, left lamina, and left half of the spinous process are fused with the similar parts of the third dorsal, as already noticed. Its right transverse process, right lamina, and right half of the spinous process are fused with the similar parts of the second dorsal. Its transverse process articulates with the fourth rib on the left side, and on the right side with the third rib in the specimen, which has characters intermediate with those of the third and fourth.

The next vertebra is apparently the seventh. It presents two demi-facets on each side of the body, as usual, for articulating with the fifth and sixth rib in the specimen on the left side, and with the fourth and fifth on the right side. Posteriorly, its laminæ and spine are increased in depth, having somewhat the appearance as if they had been fused with similar parts of another vertebra.

The next vertebra presents a single demi-facet on each side above for articulation with the sixth rib on the left side and the fifth rib on the right. Posteriorly, its spinous process appears to have been cleft, the left half being bent towards the right, overhanging the right half, which appears to have been imperfectly developed.

The next vertebra presents one whole facet above on each side of the body for articulation with the seventh rib on the left side and the sixth on the right. Posteriorly, it does not present anything remarkable.

The next vertebra is apparently the twelfth. It presents two whole facets on each side of the body above for articulating with the eighth rib in the specimen on the left side and the seventh on the right.

The next three vertebræ are apparently lumbar, and do not call for any special remarks.

It will thus be seen that four and a half of the dorsal vertebræ are wanting; and those present we are inclined to regard as the first, second, half the third, the fourth, seventh, ninth, eleventh, and twelfth.

Description of the ribs.—In dealing with the ribs we have also had much difficulty in referring each to its number in the normal series. On the right side there are apparently seven; of these four are true, one is false, and two are floating. On the left side there are apparently eight or nine, if we regard the portion of bone articulating with the second vertebra in the specimen as a rib. Of these, excluding the above-mentioned rib, there are five true, two false, and one floating. On the right side the first has the character of the first rib; it articulates with the upper part of the right half of what we believe to be the first dorsal vertebra and with the facet on the transverse process of the same, and by its anterior end with the sternum through the intermediation of a costal cartilage, about half an inch long.

The second and third ribs in the specimen are fused posteriorly in about a fifth of their length. The second, we believe, represents the second in the normal series, although it has some of the characters of the normal third. The third in the specimen, although it too resembles to a slight extent the normal third, resembles to a much greater extent the normal fourth, to which rib in the normal series we believe it corresponds. If this is the right interpretation of these ribs, the rib that should correspond to the normal third is wanting on this side. The reason for this we hope to show

further on. From the upper and inner part of the mass of bone formed by the fusion of these ribs, there projects a tongue-like process continuous with the second rib, and articulating with the sides of the bodies of the first and second vertebræ. It is evidently the head of the second rib. From the lower and posterior part of the fused rib-mass there projects a somewhat similar process, which is continuous with the third rib in the specimen, which, as just stated, we regard as the fourth in the normal series. It articulates with the bodies of the second and fourth vertebræ (the third being wanting), and by a facet on its inferior border with the next rib in the specimen. It evidently represents the head of the fourth rib. Near the inner end of the fused rib-mass, and midway between its upper and lower border, is a small foramen, through which the intercostal nerve passed. From this foramen a slight groove extends over the rib-mass to the angle of junction of the two ribs, and clearly indicates the line of their fusion. The free portions of these ribs are flattened laterally in their anterior halves, and their upper and lower borders present a sharp edge, of which the upper is the sharper. The intercostal spaces are very wide, the first space measuring vertically, from costal cartilage to costal cartilage, where they join the ribs, one inch and one eighth; the second space one inch and a half. Posteriorly they are not wider apart than natural. It is difficult to assign the fourth rib in the specimen to its right place, as the vertebra with which it articulates is also doubtful. We are inclined to regard it as the seventh. Unlike the rib immediately above, it is exceedingly slender in its middle. Measured at the junction of its costal cartilage, the third intercostal space is one inch and a half in a vertical direction.

The fifth in the specimen is a false rib. Its costal cartilage articulates with the costal cartilage of the rib above.

The next two ribs are floating; they bear respectively the characters of the eleventh and twelfth, and each articulates by a single facet with what we regard as the eleventh and twelfth vertebræ.

The ribs on the left side.—The first rib in the specimen on the left side we have already stated we believe to be a cervical rib, as the right side of the vertebra with which it articulates bears clearly the stamp of the seventh cervical. It extends for an inch outwards and slightly forwards, and becomes fused, just external to the posterior tubercle of the transverse process of the seventh cervical vertebra, with the rib below. A foramen exists between its neck and the posterior part of the transverse process. The next rib in the specimen, which we regard as the first thoracic, articulates with the upper part of the left side of the body of what we regard as the first dorsal vertebra, and markedly resembles the head of the first rib on the opposite side. After a course of three quarters of an inch it becomes fused with the cervical rib above and with the next rib below, but becomes separated again three quarters of an inch more anteriorly, and is continued to the sternum, with which it articulates by a short costal cartilage. It articulates by its tubercle with the transverse process of the first dorsal vertebra.

The next rib in the specimen, which we regard as the second, articulates with the first and second vertebræ; and after a course of an inch upwards, outwards, and backwards, becomes fused with the rib above, but afterwards separates and continues forwards singly to the sternum. It is ankylosed by its tubercle with the transverse process of the second dorsal vertebra, and also with the first.

The next two ribs in the specimen are fused posteriorly from their angles to the bodies of the vertebræ in a single mass, which mass, half an inch from the body, is perforated by a foramen leading into the spinal canal.

Through this foramen the intercostal nerve emerged. Internally the fused rib-mass presents a slight notch; the portion above the notch evidently represents the head of the third rib. On its upper surface are two facets; the upper one articulating with the facet on the lower part of the left side of the body of the second, and the lower one with a facet on the upper part of the left side of the wedge-like portion of bone, representing the left half of the

third dorsal vertebra. The portion of bone below the notch before referred to clearly represents the head of the fourth rib. It likewise presents two facets on its internal surface, the upper of which articulates with the facet on the lower part of the third vertebra, and the lower with the upper part of the left side of the body of the fourth vertebra. The fused rib-mass also articulates by two processes representing the tubercles with the fused transverse processes of the third and fourth vertebræ. Beyond the angles these ribs are continued forwards separately, and articulate through the intermediation of the two fibro-cartilages with the third bone of the sternum. They are markedly flattened laterally in their anterior thirds, and present a sharp edge above. The next rib (the fifth in the specimen) articulates above with the facet on the lower part of the left side of the body of the fourth, and with what we regard as the seventh vertebra below, By its tubercle it articulates with the transverse process of the seventh vertebra.

The next rib in the specimen is a false one. It articulates in the usual manner with the vertebra above and the vertebra below, *i.e.* with the seventh above, and with what we regard as the ninth below, from its having a demi-facet above on each side of the body. It articulates in front with the costal cartilage of the seventh rib. The next rib articulates with what we regard as the eleventh dorsal vertebra by a single articular facet above. It has more the characters of the ninth or tenth rib than of the eleventh. It articulates in front by a costal cartilage with the costal cartilages of the ribs immediately above. It articulates with the transverse process of the vertebra, as well as with its body. The last rib in the specimen bears the characters of the twelfth, and articulates with what appears to be the twelfth dorsal vertebra. It does not articulate with the transverse process of the vertebra. It resembles in general characters the last rib on the opposite side. It is free in front, that is to say, it is a floating rib.

Description of the sternum.—The sternum is placed somewhat obliquely, the sternal notch looking upwards and to

the right. It measures from the sternal notch to the ensiform cartilage five and a half inches. Like the normal sternum, it apparently consists of three parts (not including the ensiform cartilage), an upper, middle, and lower part. On its right side it articulates with four ribs, on its left with five. The second, third, and fourth ribs articulate with the sternum on the left side at a slightly higher level than on the right. The manubrium appears considerably elongated from above downwards. It measures on the left side, from its upper border immediately to the left of the sternal notch vertically downwards, two inches and an eighth; and on the left side, from the same point of bone downwards, two inches and a quarter. The manubrium is intimately fused with the gladiolus, the angulus Ludovici being scarcely, if at all, marked. The ensiform cartilage is bifid.

Description of the scapula.—The scapula is striking in the resemblance it bears to a scapula at birth. It would seem as if it had retained many of the characters which it possessed at that early period. Thus, it is remarkably deficient in that vertical length so characteristic of the human adult scapula, whilst its spine is imperfectly developed behind, and its supra-spinous fossa extends but a short distance above the spine. The infra-spinous fossa has almost the shape of an equilateral triangle instead of a scalene. The axillary border, which is shorter than natural, slopes nearly horizontally backwards, instead of downwards and slightly backwards. Its superior border is remarkably straight, and slopes upwards, backwards, and inwards. The posterior border first slopes nearly horizontally backwards as far as the spine, then almost vertically downwards, and then downwards, forwards, and outwards, so that it appears as if roughly curved, with the convexity backwards and inwards. To the middle third (the vertical part) is ankylosed a triangular portion of bone, which connects it, bridge-like, with the vertebræ. The spine is slender; the acromion, coracoid process, and glenoid cavity are small, but in other respects fairly normal.

Description of the bridge-like portion of bone.—The bridge-

like portion of bone (Plate V, figs. 1 and 2) connecting the scapula to the spine is of an irregularly triangular shape; its base, which looks outwards, being ankylosed to the posterior border of the scapula, its apex, which looks inwards, to the spinous process of the sixth cervical vertebra. Its inferior border slopes from a tubercle, which remarkably resembles the tip of the left half of the spinous process of the sixth cervical vertebra, downwards, outwards, and a little backwards, and is prolonged in a gentle curve into the lower third of the posterior border of the scapula. Its superior border appears continuous externally with both the superior border of the scapula and with the lower border of the spine of the scapula and runs horizontally and with a gentle curve forwards and inwards towards the spine. The inner third of the superior border is continued upwards and forwards as a tongue-like portion of bone into the lamina and spine of the sixth cervical vertebra. Its base is fused posteriorly with the scapula, except in its upper third, where it is only connected to it by soft tissues, and at a spot in its lower third, where a foramen is left, sufficiently large to admit a pea. Anteriorly a sulcus, filled in the recent state by cartilage, exists between the bone and the scapula. Its anterior surface is concave from side to side and slightly convex from above downwards. Near its lower border and internal angle is a well-marked cup-shaped depression, which is prolonged into a slight groove, running outwards and downwards towards the foramen already described at the junction of the posterior border with the scapula, with which another slightly shelving groove is prolonged upwards and inwards, the two grooves nearly meeting in the centre of the process.

The clavicle.—The photograph of the specimen (see Plates V, fig. 1, and VI) will convey a better idea of the deformity of the clavicle than any verbal description. We may briefly remark, however, that, in place of the two normal curves, the sternal with its convexity forwards, and the acromial with its convexity backwards, it presents a single curve with its convexity backwards. The sternal half appears flattened

out from above downwards, whilst the anterior border is sharp and has a remarkable crenated appearance. The abnormal direction of the bone has already been pointed out. The acromial end is one and a half inch in front of, and one inch higher than, the level of its sternal end.

Description of the muscles.—The pectoralis major on the left side was very thin. It arose in the normal manner from the sternum and clavicle, and from the cartilages of the five true ribs. Its insertion was normal. On the right side it arose from the sternum, clavicle, and the cartilages of the four true ribs. Its insertion was not removed at the post-mortem examination.

The pectoralis minor on the left side arose from the second, third, and fourth ribs; it was well developed and raised the ribs freely. Its insertion into the coracoid process was normal. On the right it arose from the second and third ribs only. Its insertion was not removed.

The deltoid on the left side had a normal origin from the clavicle, acromion, and spine of the scapula; it also arose by an aponeurosis, one inch and a half in length, from that part of the posterior border of the scapula which corresponds with the outer margin of the triangular bridge of bone already described.

The latissimi dorsi were not entirely removed. The left muscle arose from the spines of the three lumbar vertebrae present in the specimen; from the spines of the four lower dorsal, which we regard as the seventh, ninth, eleventh, and twelfth, in the normal series, and from the three lower ribs. It was particularly well developed at its insertion, which was normal. The right muscle had a similar origin. Its insertion was not removed.

The teres major, teres minor, infra spinatus, and subscapularis were well developed, and had normal attachments. The supra spinatus was small; its attachments were normal. These muscles were not removed on the right side. The serratus magnus on the left side arose from the five upper ribs in the specimen; and was inserted, as far as we could determine, into the posterior border of the scapula as usual.

Its upper and lower portions were very oblique and well developed. Its middle portion was exceedingly thin. On the right side it arose from the four upper ribs in the specimen. Its insertions on that side were not removed.

Only the lower portions of the trapezii muscles were obtained with the specimen. They arose, as far as we could make out from all the dorsal spines, which, at the time of their removal, appeared to be five, but which, as we have already described, are made up of eight, variously fused. The left muscle was inserted by thin scattered fibres into the clavicle, acromion and spine of the scapula. The insertion of the right muscle was not removed.

The levator anguli scapulæ on the left side had a normal insertion into the posterior border of the scapula from the superior angle to the base of the spine. It was well developed. Its origin was not obtained. The right muscle was not removed.

The rhomboideus major on the left side was very thin. Its upper part was injured in obtaining the specimen. It appeared to arise from the three upper dorsal spines, which after maceration were found to be four, variously fused. It was chiefly aponeurotic at its insertion. It partly covered the triangular bridge of bone connecting the scapula with the spine. Its exact insertion into the scapula could not be defined. The right muscle had a similar origin.

The rhomboideus minor was injured in removing the specimen. Its exact attachments could not be determined.

The omohyoid had a large posterior belly. Its attachments to the scapula was normal.

The scalene muscles were well developed on both sides. They had normal attachments into the first and second ribs.

The serratus posticus superior on the left side was so irregular that its accurate insertions could not be made out. On the right side the part which was removed with the specimen was attached to the spines of the seventh cervical and first dorsal vertebræ, and was inserted into the second and third ribs.

The serratus posticus inferior on the left side was inserted into the three lower ribs. On the right side it was inserted in a similar manner.

The deep vertebral muscles were very irregular in their origins and insertions. We have not thought it necessary to give their accurate attachments, as they did not, in our opinion, throw any light on the nature of the deformity. We may, however, remark that on the left side both the longissimus dorsi and the accessorius were attached by superficial tendinous slips to the lower border of the irregularly triangular bridge of bone. Their deeper parts, as well as the cervicalis ascendens, transversalis colli, and semispinales and spinales, passed under the bridge of bone to their insertion in the neck.

The intercostal muscles were remarkably thin. They had normal attachments and did not present any tendinous intersections.

Description of the vessels and nerves—The subclavian artery passed over the first rib between the scalenus anticus and medius in the normal manner on both sides.

The subclavian veins were also normal.

The brachial plexuses, as much as was left of them, were normal.

There were eight dorsal nerves on the left side and seven on the right; the third on the left and second on the right emerged from the foramen in the fused rib masses made up of the third and fourth ribs on the left side, and of the second and third on the right side.

Remarks.—Having given a somewhat detailed description of the specimen, we will now offer some remarks on what appears to be the nature of these several deformities. That they were the result of some congenital defect in the development of the embryo, and not of disease, we think so apparent that we will not stay to discuss the point. We may, however, again mention that the deformity was said to have existed from birth, and that the mother herself was the subject of lateral curvature of the spine.

We will first discuss the abnormalities of the dorsal

vertebræ and ribs, and first, with regard to the absence of the right half of the third dorsal vertebra.

Specimens in which a lateral half of a vertebra is absent are described by Drs. Rokitsansky, Otto, Goodhart, and others; and there are similar specimens in the Museums of the Royal College of Surgeons, and of St. Bartholomew's and Guy's Hospitals. The malformations of the vertebræ in the specimens in St. Bartholomew's Museum are not referred to in the description of these specimens given in the Catalogue; and as far as we know have never been described elsewhere. As they seem to throw some light on the deformity in our specimen, we will give a brief description of them.

No. 1. (Series A, 133), described in the Catalogue as "dorsal and lumbar portions of a foetal spine. The spinal canal is wide open behind; the laminæ of nearly all the vertebræ being disparted and turned outwards. They are not deficient in size; rather they are overgrown and expanded at their distal ends." The right half of the ninth dorsal vertebra is wanting, but no mention of this fact is made in the Catalogue.

No. 2. (Series A, 134), described in the Catalogue as "part of a foetal skeleton from a case of hydrocephalus with spina bifida." Except those of three dorsal and two cervical vertebræ, all the laminæ are deformed and disparted like those in the preceding specimen. The left half of the body, the left lamina, and left processes of the body of the ninth dorsal vertebra are wanting. The eighth and the tenth vertebræ are approximated to each other on the left side, and the left laminæ of these vertebræ, which are also in contact, appear overgrown as if to make up for the deficiency of the absent lamina. The ninth rib is also absent on the left side; consequently there are twelve ribs on the right side, eleven on the left. The eighth rib on the left side is slightly wider than the eighth on the right (as if it had been reinforced by some of the tissues which should have constituted the lost rib). The fifth lamina on the left side is in contact in the middle line with both the fourth

and fifth on the right side; and the fourth on the left side is in contact with, although on a little lower plane than, the third on the right. The bodies of many of the vertebræ appear bilobed.

No. 3 (Series A, 137), described in the Catalogue as "an anencephalous female fœtus. The arches of the vertebræ are separated and everted in nearly the whole length of the vertebral column." (See Woodcut, fig. 1.) The dorsal

FIG. 1.

spine is very irregularly malformed. The first dorsal vertebra is fairly normal. The second and third are represented by two distinct halves on the left side, but by a single half on the right side; the single half on the right side is opposite the line of division between the second and third half vertebræ on the left side, so that it is difficult to say whether it is the right half of the second or the right half of the third, and consequently, whether the right half of the second or of the third is wanting. The fourth vertebra consists of two distinct halves. The fifth vertebra is fairly normal, but obliquely placed with its left end considerably higher than the right. The sixth is represented by a left half only, the right half being absent. The seventh, eighth, ninth, and tenth, appear bilobed, but otherwise

normal; the eleventh and twelfth are normal. There are twelve ribs on each side. The upper nine on the left side are indescribably fused together from their tubercles to their angles, and the second, third, and fourth on the right side are likewise partially fused posteriorly.

FIG. 2.

No. 4 (Series A, 164, see Woodcut fig. 2), described as “the skeleton of a foetus in which the left lower extremity and left half of the pelvis are deficient.” The spinal canal is open in the lumbar and sacral regions, through defect of the vertebral arches; indeed, those of the left side of the sacrum and of the last three lumbar vertebræ appear to have been never formed. No mention is made of the malformation of the dorsal spine.

One dorsal vertebra (probably the ninth), together with the corresponding rib on each side, *i.e.* a whole of one of

the vertebral segments of the body, is wanting. Of the other dorsal vertebræ the upper eight are normal, except that some of them are bilobed. The next vertebræ (the tenth and eleventh, if the ninth is the one absent) are represented on the right side by two halves, but on the left side by a single half, to which the two right halves are united, so that it is difficult to say whether this left half belongs to the tenth or to the eleventh vertebra. It may also be noticed that the eighth vertebra, which is bilobed, has its left half on a lower plane than the right. The twelfth vertebra is normal. Posteriorly there are ten laminae on the left side, and eleven on the right; the tenth or eleventh, probably the eleventh, being the one that is on this side wanting.

There are eleven ribs on the right side, seven true, two false, and two floating. On the left side there are also eleven, but the eleventh and twelfth are intimately fused, so as at first sight to appear as one.

No. 5 (Series A, 165), described as the "skeleton of a foetus in which the arches of the lower lumbar vertebræ are deformed, and in the place of the sacrum there is a single distorted bone. The ischia are absent or rudimental, and a single bone representing the heads of both femora articulates with both the imperfect acetabula. The two femora are fused in their upper halves. Their diverging lower halves articulate with the tibiae fused into a single short conical bone. Behind the tibiae a series of small bones represent the fibulae and feet, but cannot be severally recognised." No mention is made of the malformation of the dorsal spine. The cervical vertebræ are natural, with the exception of the left half of the body of the fourth being absent. The body of the first dorsal vertebra is obliquely placed, the left side being much lower than the right. The bodies of the second and third vertebræ appear naturally formed on the right side, but on the left side a single half vertebra, to which they are both ankylosed, takes their place, so that it is impossible to say whether this half vertebra is the left half of the second vertebra or left half of the third; and consequently, whether the left half of the

second or left half of the third is absent. The laminæ corresponding to the second and third on the left side, though somewhat malformed, are present.

The bodies of the fourth and fifth vertebræ appear natural, except that they are bilobed and placed obliquely with their left sides higher than their right.

The body of the sixth is absent, the sixth rib on the right side articulating with a little nodule, which represents that part of the body of the absent vertebra which is external to the neuro-central suture. This nodule is situated between similar nodules belonging to the fifth and seventh vertebræ. On the left side the nodule corresponding to the sixth right half is fused with a similar nodule belonging to the seventh; and the heads of the sixth and seventh ribs on the left side are fused. The laminæ of the sixth vertebra are present on both sides.

The body of the seventh dorsal vertebra is bilobed. It articulates above with the body of the fifth.

The eighth and ninth are fused on the right side, the division between them, however, being distinct. On the left side they are not fused.

The tenth is bilobed, its right side being higher than its left.

The bodies of the eleventh and twelfth dorsal vertebræ are absent on the left side; but the corresponding laminæ are present, though fused into a single mass. The body of the right half of the twelfth is fused to the body of the first lumbar.

There are twelve ribs on the right side, thirteen on the left. The last rib on the left, which is fused with the twelfth, is probably a lumbar rib. The ribs are naturally formed on the right side. On the left side the first and second are fused. The sixth, seventh, eighth, ninth, and tenth, are fused with one another external to their angles, but are separated again further on. The sixth and seventh are fused, moreover, at their heads; the seventh, eighth, and ninth at their tubercles; the ninth and tenth at their heads.

The lumbar vertebræ are so fused one with another that it is next to impossible to determine in what the deformity consists. The laminae are not united behind.

The malformations of the vertebræ in the specimens in the Hunterian Museum are likewise not described in the Catalogue. A very full account of them by Dr. Goodhart will be found in the 9th vol. of the 'Journal of Anatomy and Physiology.' We have examined these specimens carefully; and although we do not quite agree with the account given of them by Dr. Goodhart, we have to acknowledge the aid we have received from his paper in forming an opinion as to the nature of the malformations.

No. 6 (2879 c A, Museum of College of Surgeons). "The skeleton of an adult male sixty-four years of age. In addition to other deformation there is bony ankylosis along the front of the bodies from the seventh cervical to the fourth dorsal inclusive."

The left half of the first dorsal vertebra is apparently wanting. In consequence of this deficiency the left halves of the bodies of the seventh cervical and second dorsal are in contact. A slender process of bone representing the first rib projects from their line of union. It is about an inch in length, and is ankylosed internally to the two vertebræ and externally to the articular process of the seventh cervical. On the right side the first rib articulates in the normal manner with the right half of the first dorsal vertebra.

The laminae of the seventh cervical do not meet in the middle line; the right lamina ends singly in the spinous process, while the left is rotated downwards and ankylosed with the right lamina of the first dorsal, thus taking the place of the left lamina of the first dorsal, which is wanting.

On the left side the second and third ribs are fused and ankylosed with the similarly fused transverse processes of the second and third dorsal vertebræ. On the right side the second and third ribs arise in the normal manner from the fused second and third vertebral bodies, and articulate with the articular processes of the same, which are not ankylosed.

The laminæ and spines of the second and third dorsal vertebræ are completely ankylosed, though a ridge still marks their proper separation.

In the ligament running from the spine formed by the fusion of the right lamina of the seventh cervical and left lamina of the first dorsal to the spine of the third is a small bony nodule, which seems to represent the spinous process of the second dorsal vertebra, the laminæ of which are ankylosed with those of the third.

No. 7 (278, College of Surgeons Museum), described in the Catalogue as "the skull and vertebral column with a portion of the ribs and pelvis of a hydrocephalic male foetus, with distortion of the vertebral column, defective development of the occipital bone, and defective closure of the vertebral canal behind."

In addition to the other malformations the dorsal spine presents the following :

The first dorsal vertebra is normal, the left half of the second dorsal is wanting, the third is normal, but placed obliquely, the right half of the fourth is absent. The remaining ten are normal, except that the upper are bilobed. There are eleven ribs on each side, the left second and right fourth being absent. The lumbar vertebræ are five in number and are normal.

No 8 (1004⁹², Museum of Guy's Hospital). This specimen is described in the Catalogue as follows :

"A congenital malformation of the spine. This is caused by the fusion together of the bodies of the third, fourth, and fifth dorsal vertebræ and the curvature of the new formed mass. A slight oblique fissure passes across the anterior part, whereby it is seen that the body of the fourth vertebra is wholly destroyed, and the third and fourth perhaps so; the one more on its left side, the other more on its right.

Upon the posterior view three transverse processes are seen to be perfect, those of the lower vertebræ retaining their natural position, and respecting those of the other two vertebræ, on the right side, the upper process is seen entering its proper body, and the middle one attached to a very small

portion of the body of the fourth, which remains; on the left side the two upper transverse processes are fused together and join the remains of the body of the third vertebra. The three spinous processes are correct in number; and the two lower ones come off from the remains of their respective vertebræ in the usual way; but the upper spine is continuous wholly with the right arch of the third vertebra, the left arch of the bone not meeting the fellow at all (the two being developed separately), but is welded into the spinous process and arches of the vertebræ."

Dr. Goodhart, in commenting upon this specimen, says, "The bodies of the third, fourth and fifth vertebra are fused together, but of these the fifth is obviously perfect, and merely altered in shape somewhat by reason of the ankylosis and curvature. The fourth is described as wanting in its body, but from the setting of the transverse processes it is, I think, well represented on either side, whether by original body centres, or merely by a growth forward of that part which helps to make up the body, but comes from the lateral masses, is very difficult to say. However, on the left side it seems that the body of the third is rather wanting; on the right side that of the fourth. This description also tallies with what is observed behind; the main right half of the third vertebra is merely an appendage to the upper border of the fourth, and does not meet its fellow in the median line."

Dr. Goodhart, in the paper above referred to, adopting Professor Humphry's conclusion, "that there is sufficient evidence of the occasional development of the vertebral bodies from two nuclei laterally disposed," seeks to explain the deficiency of half a vertebra on the assumption that in these cases only one such lateral nucleus was developed. As to the occasional occurrence of two nuclei in the body of a vertebra, much difference of opinion has been expressed. For while Professor Humphry thinks that in the complete or typical vertebræ two nuclei should be allowed to this part (the vertebral body), one on each side of the middle line, Professor Flower states that "he has found no

evidence in the study of normal anatomy, from which alone he thinks an opinion ought to be formed, of the occurrence of a double nucleus" (Goodhart); and Professor Humphry himself admits that he has examined many foetal spines with great care without ever finding two nuclei, and he states moreover that Meckel, in spite of diligent search, could never find more than one.

We have ourselves examined a number of *normal* foetal spines with a like result.

In the malformed spines already referred to in the specimens of St. Bartholomew's Hospital, and of the College of Surgeons, however, many of the vertebral bodies present a bilobed appearance, as if they had been developed from two laterally placed centres of ossification. We were at first inclined to attribute this bilobed appearance to the bodies having been developed from a bilobed centre, as Müller states that such is the usual form of the centre for the body; and as we were unable for some time to discover any vertebra in which, if two centres had ever existed separately, they were not now united in the middle line. But afterwards by careful probing we found that in a few of the vertebræ in the specimens in St. Bartholomew's Hospital (for example, the third dorsal in No. 2 A, 134) there was no trace of bone stretching across the middle line between the lobes, which clearly indicated that here two nuclei were present.

In that rather rare malformation of the spine, moreover, in which, as the consequence of the non-union of the mesoblastic tissues around the notochord, the bodies of the vertebræ are vertically cleft in the middle line, it is evident that each lateral half must have been developed from two centres of ossification.

The presence of two centres in the specimens under consideration, we believe, can be shown to depend upon a similar, though much less evident, cause.

It would appear, then, that, under normal development, there is no evidence of two centres ever occurring in the vertebral bodies; but that under certain abnormal condi-

tions such may not infrequently be the case. We are not inclined, however, to admit that the suppression of one of these nuclei is usually the cause of the absence of one half of a vertebral body, though we are not prepared to say it may never be so. For we do not see how the suppression of one such centre in a vertebral body could account for the other malformations which so frequently attend upon the absence of half a body, viz. the absence of the corresponding arch, processes, and rib.

As is well known, the arch and processes on each side are developed at or about the same time as the body; the mesoblastic elements on each side of the notochord growing upwards and inwards (the prone position of the embryo here, as in the rest of this paper, being understood) around the medullary canal to form the arch, and inwards and forwards around the notochord to form the body; whilst ossification, which does not begin till some weeks afterwards, starts from three distinct centres, one for each side of the arch and one for the body. The deficiency of the arch on one side, therefore, as well as the deficiency of one side of the body, could only be explained by supposing that the centre for the arch, in addition to one of the lateral centres for the body, was not developed. It could not therefore be said that the deficiency of the lateral centre of the body was the cause of the deficiency of the centre of the arch.

The absence of the corresponding rib, moreover, is not accounted for by this theory, as the cartilaginous rudiments of the ribs, which grow out from the sides of the bodies, are already developed before the centres of ossification for the vertebræ are laid down, and have themselves distinct centres quite independent of those of the vertebral bodies.

Still holding the view that the deformity was dependent upon some defect in the method of ossification, we conceived that it might be explained on the supposition that the centres for one half of the arch and process and the centre for the body had remained undeveloped, whilst the

centre for the arch on the opposite side had extended forwards beyond its normal limit into the side of the body, and so simulated one half of the body. For, as we have already had occasion to remark, the bodies of the vertebræ in the dorsal region are ossified laterally by the centres for each lateral half of the arch extending inwards into the cartilaginous matrix of the body as far as the facet for the rib.

This theory, however, like the former, is open to the objection that it does not explain the simultaneous absence on one side of body, arch, and corresponding rib.

Further, we cannot conceive how any theory of defective ossification can satisfactorily explain these cases. Is it not more probable that these and similar abnormalities are really dependent upon some earlier departure from the normal process of development? Should they not be referred to some fusion, vacuolation, destruction, or non-differentiation of the formative cells or material out of which the parts are developed rather than merely to defects in the methods by which these parts are ossified? Is it not conceivable that they are due to some defect in the development of the mesoblastic elements constituting the vertebral and lateral plates of the embryo at or about the time of the primary segmentation into the protovertebræ or somatomes?

There are many points in these specimens which, we think, favour this view.

First. The condition of the laminæ and spinous processes.

Secondly. Deficiencies of whole vertebral segments.

Thirdly. The absence or defective development of the corresponding rib.

Fourthly. The frequent malformations of other portions of the skeleton.

1st. The condition of the laminæ and spinous processes. These in all the specimens of unilateral suppression of the vertebral bodies we have as yet met with, have exhibited some developmental defect. In the majority of cases the lamina and half of the spine corresponding to the absent half of the vertebra are wanting. This is so in our speci-

men, in 2879 c A and 278, Hunterian Museum, and in Nos. 1, 2, 3, and 4 in the St. Bartholomew's Hospital series. In other cases the laminæ, though present, are in a rudimentary condition, and have not united posteriorly with the corresponding and opposite laminæ in the median line.

In by far the greater number of these specimens, moreover, the laminæ of the vertebræ above and below the one whose body is deficient have also failed to unite. In several specimens this non-union of the laminæ extends throughout the whole spinal column. Now, this non-union of the laminæ is evidently the result of the failure of the coalescence in the middle line of the mesoblastic elements, which normally grow upwards and inwards around the medullary canal; and not of a defect in ossification. For as this coalescence of the mesoblast, as will be remembered, occurs at a very early period (first and second day in the chick) in the development of the embryo, whereas ossification does not commence until a comparatively much later period, any theory founded upon the failure of union of the osseous centres which form in each lateral arch after the mesoblastic elements have normally coalesced above, would only account for the cleft condition of the spine by supposing that subsequently to the union of the mesoblastic tissues and their conversion into cartilage they had again, in some unaccountable manner, become cleft about the period of ossification—an assumption which is surely gratuitous. A rudimentary condition of the laminæ would imply a still further defect in the upward growth of these tissues, and the absence of the laminæ their total suppression. If, then, the non-union, rudimentary condition, or suppression of the laminæ is the result of defective development during the first few days of foetal life, is it not more probable that the abnormal condition of the body of the vertebra originated at the same early period, that is to say, would not the same changes which led to the absence of the arch and processes also account for the absence of the body? Should not any theory that pretends to explain the absence of one part of the vertebra also explain the absence of the other parts?

2ndly. Another fact in favour of these deformities having occurred at a very early period of development is the deficiency in several of these specimens (for example, in our own and in No. 4) of whole vertebral segments of the body—deficiencies which could hardly be explained on the supposition of abnormal ossification.

3rdly. The absence or defective development of the rib of that side on which the half vertebra is wanting is another point which favours this view. Thus, in No. 2 (A 134, St. Bartholomew's Museum), in 278, Teratological Series, College of Surgeons Museum, and in our specimen, the rib corresponding to the absent half vertebra is wanting. In Nos. 5, 3, and 4 (A 165, A 137, A 164, St. Bartholomew's Museum), and in 2879 c A, Hunterian Museum, the rib corresponding to the absent half vertebra is defective, or defective and fused with the next rib in the series.

4thly. Another fact which supports our view is the coincident malformation of other portions of the body, such malformations, that is to say, which could only have been produced at a very early period of development. Thus in No. 2 (A 134, St. Bartholomew's Museum), and in 278, Hunterian Museum, the deformity is combined with hydrocephalus. In No. 3 (A 137, St. Bartholomew's Museum) the fœtus is anencephalic. In No. 4 (A 164, St. Bartholomew's Museum) the left half of the pelvis and the left lower extremity is non-developed. In No. 5 (A 165, St. Bartholomew's Museum) the sacrum is represented by a single distorted bone, the ischia are absent, the femora are fused in their upper halves, and the tibiæ represented by a single short conical bone.

Believing, then, these abnormalities to be the result of some defect in the development of the mesoblastic elements constituting the vertebral plates, we venture to suggest the following as an explanation of the deformity.

To render this explanation more intelligible we must briefly refer to the development of the vertebræ and ribs.

During the first few days of fœtal life the plate of meso-

blast on each side of the notochord splits, as is well known, horizontally into two layers, one of which attaches itself to the epiblast to form the somato-pleure whilst the other attaches itself to the hypoblast to form the splanchnopleure. This cleavage, however, does not extend quite up to the walls of the medullary canal; "hence there is left on either side of the canal, between it and the line along which the cleavage begins, a tract or plate of uncleft mesoblast, which receives the name of vertebral plate, the more external mesoblast being called the lateral plate" (Foster and Balfour).

Very soon, however, the vertebral plate becomes segmented by a number of transverse clefts, stretching inwards from the lateral plate to the notochord, and a little later it becomes cut off from the lateral plate by a vertical cleft parallel to the notochord, so that each vertebral plate is cut up into a number of cubical masses, each cubical mass constituting with the corresponding mass on the opposite side of the notochord a pair of protovertebræ, or as they are now more commonly called somatomes.

Such a protovertebra, after giving off on its outer part the muscle plate, grows upwards around the medullary canal and becomes fused in the middle line with the opposite protovertebra which grows upwards in a similar manner. At the same time the lower portion of the protovertebra extends inwards above and below the notochord, and also becomes fused with a similar process extending inwards from the protovertebra on the other side, so that the notochord and medullary canal are surrounded by an investment of mesoblast. The investment of mesoblast is an extension chiefly from the posterior part of the protovertebra and afterwards constitutes the arch of the permanent vertebra. The clefts dividing the protovertebræ from each other now disappear, and the protovertebræ become fused. Soon again, however, fresh segmentation occurs, and the resulting segments constitute the permanent vertebræ, the new line of segmentation occurring through the middle of what was originally each protovertebra. So that it comes to pass that each

permanent vertebra is formed out of parts of two consecutive protovertebræ, for example, the third vertebra is formed of the posterior part of the third protovertebra and the anterior part of the fourth, whilst the arch apparently no longer springs from the part of the protovertebra from which it is an outgrowth, but from the front part of the permanent vertebra to which it henceforth belongs. While the chief mass of the protovertebra is converted into muscle plate and arch and body of the vertebra, a small portion of the exterior grows downwards in the dorsal region as the rudiment of the rib. These rudiments soon, however, become separate from the bodies of the vertebræ—with whose arches they henceforth alternate.

At first the muscle-plates end opposite the point where the mesoblast becomes split into somato-pleure and splanchnopleure. Soon, however, they extend to a certain distance into the side walls of the body beyond the point of the division into somato-pleure and splanchnopleure. In the first instance, as is clear from their origin, the muscle plates correspond in number with the protovertebræ, a condition which is permanent in the lower vertebrata.

Thus much of the development of the embryo we have thought it necessary to refer to in order to make clear the explanation we are about to offer of these deformities.

We believe that at or about the time of this primary segmentation of the mesoblast into protovertebræ or somatomes, the tissues which should constitute one of the lateral sections of the body, become completely, or in part, destroyed or non-differentiated, whilst the tissues constituting the segments above and below come into contact with, and become fused to, one another, so that when the secondary segmentation occurs one lateral half of the permanent vertebra, together with its arches, processes, and corresponding rib and muscles, will be wanting.

In our specimen, to briefly recapitulate, the bodies of the first and second dorsal vertebræ are normal, and articulate in a fairly normal manner with the first and second ribs. The right half of the third dorsal vertebra is absent.

The left half articulates with the fused third and fourth ribs, that is to say, with the third above and with the fourth below. On the right side, the third rib in the specimen, which we are inclined to regard as the fourth in the normal series, believing the third to be wanting, articulates with the bodies of the second and fourth dorsal vertebræ, and with the transverse process of the fourth. It is fused in its posterior part with the second rib, and has the characters partly of the third and partly of the fourth rib in the normal series, appearing somewhat as if the two had been fused together. The next vertebra (the fourth) articulates on the left side above with the fourth rib and below with the fifth, which we regard as the seventh in the normal series. On the right it articulates above with the third rib, which we consider the fourth in the normal series, and below with the fourth, which we look upon as the seventh. The next vertebra we regard as the seventh, believing the fifth and sixth to be wanting. It articulates on each side, above with what we have called the seventh rib and below with what we have called the ninth.

Here, then, we suppose that the mesoblastic tissues which should have constituted the third somatome or proto-vertebra on the right side were affected (*i.e.* destroyed, fused, or non-differentiated), and that consequently the tissues constituting the second and fourth somatomes on that side came into contact, whilst the tissues constituting the third right somatome would be slightly compressed in the form of a wedge, with its apex to the right, the embryo being slightly bent to the side where the destruction of the formative material had taken place. Hence, when the primary segmentation occurred, three protovertebræ on the left side, the second, third, and fourth, would correspond to two on the left, the second and fourth; and therefore, when the second and fourth on the right side, which were in contact with one another, grew up around the medullary canal, and downwards and inwards about the notochord, they would come into contact, not only with the similar processes from the second and fourth on the left side, but also

with that of the third on the left. Hence, as we should expect, the third arch would be deficient on the right side, and the second and fourth arches be more or less approximated, taking up the space left vacant by the absence of the third. But on the left side the third arch would have formed as usual, and would necessarily be fused in the middle line with the second and fourth arches on the right side, which together occupy the place of the absent third, such as is actually the case in the present specimen.

On secondary segmentation occurring, the first dorsal vertebra would be formed from the posterior half of the last cervical protovertebra and the anterior half of the first dorsal protovertebra as usual, whilst the second dorsal vertebra would be formed from the posterior half of the second dorsal protovertebra and the anterior half of the third on the left side, but from the posterior half of the second and the anterior half of the fourth on the right side (see Woodcuts, figs. 3 and 4). The arch of the second, which is formed from the posterior part of the second, would spring from the usual position, *i. e.* from the front of the permanent second vertebra, as it actually appears to do in this case, and would be normal except by being cleft and its right half bent backwards (the embryo being prone) to fill the space left by the deficiency of the third arch. The second rib, which is formed by the growing out of the second protovertebra, should be normal on each side. The third dorsal vertebra, which is usually formed from the posterior half of the third pair and anterior half of the fourth pair, would be formed on the left side in the normal way. But since on the right side the protovertebra was absent, and the anterior part of the fourth, as we have seen, had already united with the hinder part of the second permanent vertebra, it is clear that there would be no material on this side to form the right half of the third vertebra. This vertebra would therefore only exist on the left side. On the left side the third rib would be formed, as usual, by the growing out of the third protovertebra, while on the right side it would be deficient, as it appears to be in the specimen, the fourth being

approximated to the second and taking its place. The fourth vertebra on both sides will be formed from the posterior part of the fourth protovertebra and the anterior part of the next vertebra in the series, as is natural; the anterior part of the fourth, as we have seen on the left side, having formed the posterior part of the third, and on the right the posterior part of the second. It would hence follow that the fourth vertebra would be in contact on the left side with the third, and on the right side with the second; and that the fourth rib, which is formed from the fourth protovertebra on the left side, would articulate with the third and fourth vertebræ, while on the right side it would articulate with the second and fourth.

This theory commends itself to us in that it explains not only the absence of half the body of the third dorsal vertebra, but also the absence of the corresponding arch and rib. Moreover, if it be correct, we should not be surprised to find the second and fourth ribs on the right side (second and third in specimen) fused as they actually are; for it can readily be conceived that the rib processes growing out from the fused protovertebral elements would also be more or less fused. We should also not be surprised to find each of these ribs partaking (as they actually do) somewhat of the character of the lost rib, for it is quite possible that the tissues, which should have formed the third protovertebra, would not have been entirely destroyed, but would in part have remained and become blended with the protovertebræ above and below; so that the tissue elements which afterwards grew out from these protovertebræ to constitute the second and fourth ribs would be reinforced, as it were, by the elements which remained of the partly destroyed protovertebra, and so both the second and fourth ribs would assume, to some extent, the characters of the lost rib.

Granting that the fusion of the second and fourth ribs took place in the way we have suggested, it can easily be imagined how, as development advanced, and the fused ribs grew downwards into the lateral plates of the embryo, that the normal formative force would ultimately reassert itself,

FIG. 3.

FIG. 4.

The light parts represent the protovertebræ; the dark shaded parts, the permanent vertebræ.

and that the ribs would therefore become separated and continue their growth in a more or less natural direction ; although each would still be affected by the reinforcement of the formative material which it had received at starting from the partly destroyed protovertebra, and would permanently retain some of the characters of the lost rib. The fusion of the third and fourth ribs on the left side, on this supposition, is also not difficult to account for, as it would naturally be expected that, although the tissues constituting the protovertebra on one side were chiefly affected, those constituting the corresponding parts on the other side would not entirely escape, but would become to some extent blended, &c., with the tissues above and below, so that the parts on the left side would not undergo complete differentiation, but remain more or less fused or ill developed, as is exactly the case.

The fusion of the cervical with the first and second ribs just external to the tubercle, we think, is due to an entirely different cause. Here it will be seen that the three ribs are not fused where they articulate with the vertebræ, but only just external to the tubercles. This fusion we believe to be the result of the second and third ribs taking an abnormal direction in consequence of the curvature of the spine which was produced by the loss of the left half of the third dorsal vertebra, so that in their growth they would be thrown together at or near the tubercle and become fused.

Below the fourth vertebra the complete destruction of the next two pair of protovertebræ has apparently occurred, as the fifth and sixth vertebræ, with the fifth and sixth ribs, seem to have totally disappeared.

At first sight it may seem improbable that the fourth vertebra should be formed and the fifth and sixth be wanting. We can offer no solution of this difficulty. Still, the specimen presents the fact very clearly. The fourth vertebra, therefore, will have been formed out of the posterior part of the fourth, and the anterior part of the seventh, dorsal pair of protovertebræ. This would account for it articulating above with the fourth rib and below with the

seventh. The next vertebra might be either the eighth, ninth, or tenth, it is difficult to say which, but from its general characters we are in favour of its being the ninth. If this be so, the eighth and tenth are then wanting. The spine of the ninth appears to have been cleft at its base on the right side. The next two vertebræ are apparently the eleventh and twelfth.

The explanation we have offered of the malformation of the vertebræ in our specimen holds good for the similar malformation of these structures in the other specimens to which we have referred. The slight variations observed in many of the latter as regards the condition of the laminae and ribs, we believe are differences of degree, not of kind—*i.e.* that they depend upon the destruction of the tissues constituting the protovertebræ having occurred to a greater degree in some instances than in others. In No. 4 there appears to have been complete destruction of the corresponding protovertebræ on both sides, *i.e.* of the whole of one of the primary vertebral segments of the body, since the ninth dorsal vertebra, together with the corresponding rib, on both sides are wanting. In Nos. 2 and 278, Hunterian Museum, an entire protovertebral segment on one side appears to be affected, as in No. 2, the left half of the ninth dorsal vertebra (body, lamina, and processes) and the ninth rib are suppressed, and in 278, the right half of the second dorsal vertebra and second rib on the right side and the left half of the fourth dorsal vertebra and fourth rib on the left side are absent. The former of these two specimens is perhaps the most important of the series, as here it is quite evident that the entire half of one of the permanent vertebral segments is suppressed; whereas in the other specimens, including our own, and in 278, Hunterian Museum, such an entire suppression, although we are ourselves convinced of it, cannot be so clearly demonstrated.

In Nos. 3, 4 and 5, St. Bartholomew's series, and in 2879 C a, Hunterian Museum, the destruction of the protovertebræ appears to have been limited. Thus, in No. 4 the left half of the body of the eleventh dorsal vertebra, together with the

left lamina and processes, are wanting, but the corresponding rib on the left side, although fused with the rib below and otherwise defectively developed, is present. Here, then, we may suppose that the lower portion of the protovertebra which grows downwards to form the rib escaped the destructive process which the rest of the eleventh protovertebra underwent, and became partly fused or blended with the like process growing out from the protovertebra below.

In 2879 C a, College of Surgeons, the destructive process, whilst affecting the body and lamina, as in the former specimen, would have appeared to have involved more of the process which forms the rib, as this structure is here merely represented by a very slender process of bone, which has become ankylosed to the transverse process of the vertebra above. In this specimen, moreover, the destructive process was evidently not confined to half of one vertebral segment, but involved many more, as is seen from the fusion of the vertebral bodies from the seventh cervical to the fifth dorsal, and the attending partial fusion of the upper ribs. In No. 3 the destructive process appears to be chiefly limited to the half of a body, as the lamina and the processes and rib on that side were present; the rib, however, presents a somewhat rudimentary condition, and is fused to the rib above.

In No. 4, in which the left half of the eleventh dorsal vertebra is wanting, the left half of the vertebra above, *i.e.* the tenth, is on a lower level than the right half, appearing as if it had fallen down to supply the place left vacant by the absence of the half body, hence the two half vertebrae on the right side correspond to one half only on the left, so that it is, at first sight, difficult to say to which vertebra this half belongs, and conversely, whether it is the left half of the tenth, or left half of the eleventh, which is absent. On closer examination, however, it is clearly seen to be the left half of the tenth. The left half of the vertebra next above is also on a slightly lower plane than the right half. This appearance is readily explainable on our theory; indeed, we think it lends support to it. Now on the

destruction of the tissues constituting the eleventh protovertebra on the left side, and the approximation of the tissues of the protovertebræ above and below, it would come to pass that the tenth, eleventh, and twelfth protovertebræ would correspond to the tenth and twelfth on the opposite side, and hence that the anterior part of the twelfth left protovertebra would necessarily be on a lower level than the anterior part of the eleventh on the right side. Now, while the anterior part of the permanent tenth vertebra will be formed from the posterior part of the tenth pair of protovertebræ, its posterior part will be formed on the right side from the anterior part of the eleventh protovertebra, and on the left side from the anterior part of the twelfth, so that it follows that its left half would be on a lower level than its right half. The lower level of the left half of the next vertebra above the tenth is also what we should expect, as it is conceivable that by the approximation of the tenth and twelfth the next protovertebra would also be on a slightly lower level than its opposite half. In the vertebræ below the right halves, for the same cause, are on a slightly higher level than the left halves. In our specimen there is an appearance as if a similar state of the parts might have existed at an early stage of development.

Remarks on the triangular portion of bone.—Although we have discussed the probable explanation of the malformation of the dorsal vertebræ first, the triangular portion of bone stretching from the scapula to the spine is perhaps the chief point of interest in this very remarkable specimen. We have already given a detailed description of the bone; we will now endeavour to offer what appears to us some explanations of its origin and significance. We have looked through the Hunterian and several other museums, but have failed to discover any like deformity; neither have we come across any specimen resembling it in published records. We know of no exactly homologous condition of the shoulder-girdle in the animal kingdom, although it bears a resemblance to the supra-scapular bone of some of the lower vertebrates; for example, the frog and

the skate. Development does not materially help us. "The pectoral arch," as remarked by Huxley, "may be connected with the skull or with the vertebral column by muscles, ligaments, or dermal ossification, though primitively it is perfectly free from and independent of both," this arch, as is well known, being developed from a "rod of cartilage" unconnected with the ribs or the vertebræ.

There are several theories, more or less probable, which we beg to submit to the consideration of the Society. These, for convenience, may be classed under three heads, according as they are based upon one or other of the following hypotheses :

1st. That the process of bone was formed in connection with the vertebræ, and afterwards became anchylosed to the scapula.

2nd. That it was originally a scapular element, and secondarily became fused to the spine.

3rd. That it was formed independently both of the spine and of the scapula.

In favour of the first theory is the intimate fusion which exists between the internal end of the bone and the left half of the spinous process and left lamina of the sixth cervical vertebra. We first thought that it might be an outgrowth of the spinous process—an over-development of the epiphysis that normally exists at the apex of this process, and that it might be homologous to the exceedingly high and compressed spinous processes of the ungulata, processes which, as is well known, are developed from a very early autogenous ossification, and soon become united to the upper part of the arch. Such a theory, however, offers no explanation why the process should only have united to the left side of the arch, and why it should have become bent outward and fused to the scapula. The excessive growth of the epiphysis in the ungulata, moreover, only occurs in the anterior dorsal region, not in the cervical. Or, again, the bone is perhaps homologous to one of the laterally projecting processes (called hyper-apophyses by Mr.

Mivart) developed near the extremity of the spinous processes of the third, fourth, fifth, and sixth cervical vertebræ of the *Mycetes*. In favour of this is the apparent connection of the bone to the side of the spinous process near its apex, the small tubercle marked A in the specimen evidently being the apex of the left half of the spinous process. We are not aware, however, that these hyper-apophyses have ever been observed to grow out to anything like the dimensions of the process of bone in the present specimen, and this theory, like the former, offers no explanation of the ankylosis of the bone and the scapula.

2ndly. On the hypothesis that the bone is a scapular element, it may be regarded as probably connected with an overgrowth of the epiphysis which normally exists along the posterior margin of the scapula, and which, from some unexplained cause, has become ankylosed to the spine of the sixth cervical vertebra. This epiphysis, as is well known, extends normally the whole length of the posterior margin of the scapula. But as the bridge-like portion of bone is only connected to about the middle third of this margin, the overgrowth of the epiphysis, if the portion of bone is due to such, could only have been partial. The partly cartilaginous suture already described, which connects the portion of bone with the scapula, would, according to this view, represent the line of union of the epiphysis with the scapula. To this it has been objected that an epiphysial line apparently exists anterior to the suture before mentioned, that therefore the suture is not the epiphysial line, and consequently the triangular portion of bone is not an epiphysis. There can be no doubt that the epiphysis is united in the lower third, as in this situation the line of union is well indicated by a distinct ridge. On tracing the line upwards, however, it appears to us to be continued into the suture between the bridge-like portion and the scapula, not to pass anteriorly to it, *i.e.* the bridge-like portion appears continuous with the epiphysis, which has united with the scapula along the lower part of its posterior border.

That the upper part of the epiphysis of the posterior

border does sometimes take on an overgrowth, extending backwards and inwards beyond the rest, receives support from some specimens in the teratological series contained in the College of Surgeons Museum.

In 322 and 323 such an outgrowth has apparently occurred. In the Museum of St. Bartholomew's Hospital there is a specimen of a foetus in which both scapulæ present a backwardly projecting process from the lower third of their posterior border.

If, then, an overgrowth of the epiphysis, the bone may, perhaps, be homologous with the supra-scapula of some of the lower vertebrata. It certainly bears a superficial resemblance to that of the frog and toad, in which creatures, however, it is not united to the spine. As far as we know, the only vertebrata in which the supra-scapula is so united are the skate tribe. "In the thornback skate" to quote Professor Parker, "the cervical spine is closely wedged between the supra-scapulæ, just as in the birds the sacral vertebral spine is wedged between the iliac crests. The supra-scapula of the thornback skate is separated from the scapula by a complete transverse cleft, which results in a perfect joint cavity. Each supra-scapula is irregularly four-sided, its upper edge straight, its anterior concave, its posterior margin sigmoid, whilst its scapular margin has an oblique convex outline, the scapula mounting upwards behind it. The supra-scapula is thick below and thin above, and by its thin margin it is attached by strong fibrous tissue (there is no joint cavity here) to the jutting edge of the vertebral spine. It is gently concave above and gently convex below."

If this bone is really a supra-scapula we may regard its occurrence as an instance of reversion to an earlier type, *i.e.* of a reversion of the human shoulder-girdle to the very rudimentary girdle of the placoid fishes. We merely suggest the idea of reversion as not altogether an improbable explanation of the deformity. We do not attempt to discuss the argument for and against it, as to do so we should have to enter upon the much wider question of

reversions in general, a discussion which would here be obviously out of place.

3rdly. On the hypothesis that the bone was developed independently of both the spine and the scapula, we may ascribe its formation to the ossification of one of the inter-muscular planes which stretch between these parts. The suggestion of its being an ossified "rhomboideus minor" can be disposed of at once, as that muscle was found in a nearly normal condition on the dissection of the specimen.

It is further possible that the bone is composed of some of the lost ribs which had been displaced and fused with the spine and scapula in their abnormal situation.

We have already drawn attention to the resemblance which the process of bone bears to a scapula. It may possibly be a rudimentary scapula, and its presence as such may be accounted for by supposing that the upper part of the embryo from which our specimen was developed was originally cleft into a right and a left half, and that the left half, with the exception of the left scapula, a few of the ribs on the left side, and the right scapula (represented by the process of bone), were suppressed or fused to the right half.

This theory, fanciful as it may seem at first sight, is not perhaps without some claim to our consideration. Nearly all pathological museums contain specimens of double monsters, all grades of which are known to exist; but it is that form in which the upper half alone is cleft to which we have to refer as bearing upon the present specimen. The accompanying drawings,¹ taken from Förster, represent some of these malformations. In A the doubling is nearly complete, the individuals being merely attached by the sternum. In B the doubling is much less complete, the individuals being attached, not only by their sternum, but by the pelvic bones and by one of their upper and one of their lower extremities. In C and D it affects all the parts above the sacrum. In E, it is limited to the upper part of the dorsal spine and head and neck. In both D and E one

¹ Shown at the time the paper was read.

half of the double monster is smaller than the other. This irregularity of size must be due either to a disproportion in the rate of growth of the two halves, or to the atrophy of one of them. Now, we believe we are right in saying that it is generally believed by teratologists that the latter is the more common cause. Indeed, it is said by some that atrophy of one half, accompanied by fusion with the other half, may proceed to such an extent as to leave but little trace of the original double condition ; and that in extreme cases a third arm or leg, or the rudiments of the same, may alone remain as an evidence of it.

Granting that those cases in which such rudiments are found are due to the atrophy and fusion of one half of the double embryo with the other half, it is going but a step further to suppose that in the present specimen a still greater atrophy, accompanied by fusion, has occurred, and that here the right scapula alone remains as evidence of the original doubling.

If we adopt this view the specimen would consist in greater part of the right half, and to a less extent of the left half of the originally double embryo. Thus the head, neck, upper part of the dorsal spine, with the ribs, scapula, and arm on the right side, would be developed from the right half of the embryo, while the left scapula, the left arm, and a few of the ribs of the left side, and the process of bone would be formed from the left half. The parts of the right embryo which would have been suppressed are the left scapula and left arm ; and of the left embryo, the head, neck, upper part of the dorsal spine, and the right arm, the scapula remaining as the triangular piece of bone.

The strong resemblance of the process of bone to the scapula, and the jumbling together of the vertebræ, have been urged upon us as reasons for accepting this theory. It has been pointed out to us, though we fail to see it, that the process of bone presents evidences of a spine and glenoid cavity, and that the inclination of the upper portion of the dorsal spine to the right, and the inter-collation of the half vertebra, are indications of a bifurcation of the spine at this

spot. In the College of Surgeons there is a specimen of a bifurcated spine of a calf, in which the vertebræ at the place of bifurcation are jumbled together in a somewhat similar manner to those in the present specimen. We believe, however, that this state of the vertebræ has been better accounted for by the explanation we have already given in the former part of this paper. The resemblance of the process of bone to the scapula is not to our mind sufficiently marked to warrant us to regard it as such; and although we admit the possibility of its origin from the doubling of the embryo and suppression of the greater part of one half, we confess that such an explanation appears to us highly improbable.

DESCRIPTION OF PLATES V AND VI.

Dissection of the Parts in a Congenital Malformation of the
Spinal Column, &c. (Mr. A. Willett and Mr. W. J. Walsham.)

PLATE V, Fig. 1.—View from above.
Fig. 2.—Back view.

PLATE VI.—Front view.