THREE FORMS OF SPINAL DEFORMITY.

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Looking through works of surgeons who have paid special attention to the subject of spinal curvature, I find in them no definite reference to the forms of spinal deformity produced by the occupation of the individual.

In a vague way, cases of curvature commencing in the dorsal region and followed by compensatory curves are referred to, as a form of ordinary lateral curvature, but no pathological information is given. I may quote the most recent English work ('On Curvatures and Disease of the Spine') by Brodhurst. In it he writes, "Again, other causes of spinal curvature exist, namely, such as increase or diminish the power of a single limb. Thus the power may be increased by extraordinary use, as through carrying a burden on one arm, or as occurs in certain trades, where one arm is much more employed than the other. And it is found that nurses, needlewomen, tailors, shoemakers, compositors, and some others are unusually liable to spinal curvature through the inordinate use of one arm."¹ As these

¹ 3rd edit., p. 15.

deformities are so common, I must say I am much surprised at not finding any described specimens in our museums, though I hope to show that some are present under other names.

Their frequency in the dissecting room is easily accounted for, as the supply of male subjects is drawn from a class who have to work hard for their living, and who have usually had some heavy manual labour to perform.

In this paper I shall describe three distinct forms, of each of which I have several pathological specimens, and I will take them in their order of frequency, the first being the most common, and occurring in men whose occupation is to carry heavy and bulky burdens on their right shoulder, as, for example, draymen, who carry barrels of beer in that way.

Let a strong man be made to bear on his right shoulder a heavy body as a barrel of beer, and you find he is no longer able to remain in the erect position. His head and neck are thrown forwards and to the left, partly that his head shall be out of the way of the object, but chiefly that its weight shall be transmitted more directly to the spinal column.

The upper dorsal spine will be found to share in the forward flexion of the cervical vertebræ.

The spines of the vertebral column will now be seen to form an arc with its convexity to the right side, the most convex portion corresponding to the position of the sixth dorsal vertebra. The curve is but slightly marked in the lumbar region, being chiefly limited to the dorsal and lower cervical spine. It is a long single curve, and there is no indication of any compensatory curve, which is only what one would expect. The chest wall is seen to be altered in shape. The left half of the chest is thrown more forwards and the right half backwards, so that the right chest is more prominent behind than the left, especially below. The ribs here are also found to be separated by a larger interval from one another than on the left side. This is owing to the rotation of the vertebræ which

accompanies the lateral flexion, and is an attempt on the part of nature to form a larger supporting basis which will transmit the weight to the spine partly through muscles attached to the ribs and partly through the leverage they possess on the bodies and transverse processes of the vertebræ.

The right upper ribs cannot be observed owing to the presence of the weight. One can, however, feel and see that they must support the greater part of the weight, and must transmit it to the spine. The rest of the weight is sustained by the muscles which support the scapula or arm, and partly by the articulations of the clavicle and sternum and costal cartilage, this last being an indirect means of support.

Now, suppose we go a step further than we can see in our subject, and follow in our imagination the changes that ought to take place in the osseous and ligamentous tissues of a man whose occupation it is to carry these heavy weights frequently, and for some time. Owing to the frequent lateral flexion of the spine, the intervertebral substances, where they correspond to the concavity of the curve, become thinned, perhaps develop a synovial membrane (*Gelenkhöhle* of Luschka), or become completely destroyed, and the bones may come together and fuse, and throw out from their margin large osteoplastic growth.

Also the anterior portion of the intervertebral substances between the upper dorsal vertebræ will become thinned owing to the increased antero-posterior flexion of this portion of the spine, and lipping of the vertebræ may also take place.

This lipping and thickening of the vertebral margins is probably an attempt to increase the breadth of the column where it is most needed, which is of course at the concavity of a curve.

The upper ribs on the right side are pressed downwards and forwards by the weight which rests upon them, and they by their immense leverage on the transverse processes of the upper four or five dorsal vertebræ will tend to

rotate their bodies to the opposite side, namely, to the left, and will render this portion of the dorsal curve which was at first convex to the right, now almost a straight line, and then later, convex to the opposite side. This secondary curve will extend, however, slightly if at all to the left of a line joining the upper cervical vertebræ and lower lumbar.

Accompanying this rotation of the upper dorsal vertebræ you get the upper ribs on the left side raised somewhat, the intervals between them being increased in size, and their angles project more backwards. The opposite condition has taken place in the upper right ribs. The single convex line formed by the spines of the upper dorsal vertebræ is unaffected by this rotation of their bodies. If any change takes place it will be in the direction of an increase of the convexity of the curve to the right. In the case of the leverage of the rib, the fulcrum corresponds to the articulation of its head with the body and intervertebral substance, and the resistance or weight to the ligamentous attachment of the tubercle and neck to the transverse processes. So that in examining a living subject, one would not be able to recognise the presence of the secondary (not compensatory) curve by the position of the spines, as only one curve would be visible.

Owing to the formation of the upper curve, you would expect an increased destruction of the left half of the intervertebral substances and vertebræ corresponding to the concavity of the primary curve, and this will be most marked about the fifth and sixth dorsal vertebræ and a similar progressive destruction corresponding to the concavity of the secondary or upper dorsal curve. The middle ribs on the left side will be still more approximated.

Now, to make up for this damage to the upper part of the dorsal curve, that the weight may be transmitted as much as possible to the spine, an increase in the primary curve and increased rotation of the bodies of the lower six or seven dorsal vertebræ must take place, resulting in

a greater destruction of intervertebral substance and vertebræ at the concavity of curve, most marked at the union of the two curves, with changes in the lower ribs as before described. This is by no means as simple a process as is the change of shape of the chest which one sees in the ordinary lateral curvature which develops in young adult life.

Fig. 1 shows exactly the changes we have arrived at synthetically. I have chosen this specimen as it is the best marked of the five specimens which I possess of this form of deformity. It was obtained from the body of a great, powerfully-built man, who had been a drayman. He was about forty-five years of age, and had all his teeth. His muscles were in excellent condition, and his bones dense and strong. Death had been due to heart disease. Till the chest was opened, while the body was lying on its back, there was no indication of the condition of the spine. I would particularly call attention to the fact that in this condition there is no compensatory curve or rotation in the lumbar region, the articular processes of the lower lumbar vertebræ being in a transverse plane, while the upper lumbar vertebræ share in the primary curve. Except for the secondary curve in the upper dorsal region there is no rotation of the bodies of the vertebræ to the left. I mention this as in the forms of lateral curvature described, most authors will not allow that a rotation to one side can exist without a compensatory curve to the opposite side. One can easily see that the formation of a compensatory curve in the lumbar region to the opposite side would be detrimental. What has taken place is simply that the spine has been bent in such a way so that with the ribs it forms a sort of shelf on which the weight rests, and by which the pressure is transmitted equally to the legs. By placing this specimen in the normal position, and by applying pressure on the upper ribs on the right side, the purpose of the curvature and the mode of its formation can be seen very plainly. A practical point I would call attention to, as exemplified by the upper

dorsal curve, or secondary curve as I have called it in this paper, is the immense power that can be exercised by the ribs in rotating the vertebræ. This explains the benefit sometimes observed from pressure well applied to the side of the chest, and also indicates that it should be made to act in a direction obliquely downwards and inwards rather than inwards or upwards and inwards. Out of thirty-five male subjects dissected during the winter session, I found five very well-marked examples of this curvature. They were almost exactly identical in character, but varied somewhat in degree.

The second condition is one which is present in men who carry heavy bulky weights on their backs, as coal-heavers, &c. If one watches a coalheaver at work, one sees that, when carrying a load, his body is bent forwards. The weight is seen to rest on the back of his head, neck, and trunk, being retained in position by both hands.

Let us attempt to arrive at the changes one would expect to find in the bones and ligaments of a man who had pursued this occupation for many years. If dying before his tissues had commenced to degenerate, the osseous tissue of the vertebræ will be found to be very dense. This is most marked in the cervical and upper dorsal region on account of the small size of the bodies of the vertebræ in this region. The weight, being a rigid one, diminishes the natural convexity of the upper part of the dorsal spine, partly by direct pressure, and partly indirectly by pressure on the ribs, so rendering the upper two thirds of the spine nearly straight.

The force then exerted on the flexed lumbar spine by the chest with its load, and by the load itself pressing directly on the lumbar spine may be resolved into two component forces, the one acting at right angles to the upper and lower surfaces of the bodies of the lower dorsal and lumbar vertebræ in a direction parallel, and the other at right angles to their opposing surfaces.

These will cause, first, an increase in the lumbar curve.

Where the straightened dorsal spine joins with the convex curve of the lower dorsal and upper lumbar vertebræ there will be destruction of the bodies and intervertebral substances of the tenth, eleventh, and twelfth dorsal and first and second lumbar vertebræ, especially in front.

The spine at this point may not deviate laterally, but this occasionally happens owing to the unequal lateral destruction of the bodies of the vertebræ, due probably to some inequality in the support given by either arm.

The bodies of the third, fourth, and fifth lumbar vertebræ with the intervening fibro-cartilages, as they form part of the convexity of an antero-posterior curve, will be but little diminished in depth in front.

Owing to the sudden transition from the convex lumbar curve to the concave sacral one, the force tending to displace the lumbar vertebræ forwards and downwards acts at this point at an immense advantage.

This will cause the fifth lumbar vertebra to become displaced forwards more or less, so that it projects beyond the sacrum. In the interarticular fibro-cartilage between it and the sacrum there is formed a large articular cavity, and from the front of the upper piece of the sacrum is formed a projecting shelf of bone which helps to support the displaced vertebra. The articular cavity is the result of the considerable restitution after the weight pressing on it has been removed.

The laminæ of the fifth lumbar are closely approximated to the posterior margin of the body of the first sacral vertebræ diminishing considerably the calibre of the spinal canal, and interfering in the same way with the size of the intervertebral foramina between the sacrum and fifth lumbar. The form and position of the articular processes and laminæ are naturally much altered by the prolonged pressure.

I do not find the least indication of any congenital deficiency of the laminæ or articular processes, nor any sign of any previous injury or fracture. I refer to this particularly, as Neugebauer, in his article on spondylolisthesis,

takes rather an opposite view.¹ I see no reason to suppose that in the production of spondylolisthesis in this form of spinal deformity it is necessary to suppose the existence of anything beyond great pressure acting at a great mechanical advantage upon the articulation. Criticising Neugebauer, I think that he has erred in regarding the displacement of the fifth lumbar as *something quite peculiar and local and not as part of a general change in the spinal column*. I do not think that in any of the examples he describes he has given us any account of the condition of the rest of the column.

The pressure of the weight is also transmitted to the neck partly directly and partly indirectly through tension exerted on the head by the tarpaulin cap, or other means of support used by this class of labourer. This renders the cervical spine more convex forwards, and causes pressure changes in the lower cervical vertebræ and fibrocartilages.

Fig. 2 is a drawing of the spine of a middle-aged man. He was powerfully built. I was unable to discover his occupation. The deformity it exhibits corresponds to those I have just described. The intervertebral substances between the fifth, sixth, and seventh cervical vertebræ have become thinned, and have developed articular cavities in their centres. The bodies of these vertebræ are diminished in depth, and their lipped margins project forwards, and backwards into the spinal canal.

The odontoid process presents marked signs of the pressure that has been exerted on it by the anterior arch of the atlas. Its facet is much increased in size, and from its upper margin there is an outgrowth of bone to strengthen the articulation, and increasing the height of the process. Owing to the removal of bone from its anterior surface, the antero-posterior diameter of the process is diminished. The arch of the atlas presents

¹ 'Zur Entwicklungsgeschichte des spondylolisthetischen Beckens und seiner Diagnose,' von Franz Ludwig Neugebauer.

FIG. 2.

corresponding changes. Two out of the thirty-five male subjects possessed spinal columns which presented the above conditions.

While watching labourers carrying heavy weights on their heads, I have often speculated as to what changes one would expect to find in their bodies as the result of this form of pressure. These men, when bearing a load (which is often a very heavy one), allow the head to sink somewhat downwards towards the shoulders and do not keep the cervical spine extended.

They keep the load in position by one or both hands. I concluded that the cervical spine would present a well-marked lateral curve, with the accompanying destruction of cartilage and bone on the concave side. Below this large cervical curve one or two compensatory lateral curves occupying the dorsal region, the extent of deflection of the curves from the median line diminishing as they descend.

I was some time before I discovered a subject in which the spine presented changes similar to those I expected to find. Fig. 3 is a drawing of the first one, and I will now describe it in detail.

The articulations between the atlas and occiput and atlas and axis present but a slight deviation from the normal condition, and this was limited to slight asymmetry of the articular facets. The axis and third cervical vertebræ are fused together, the fusing being more complete on the left side. This causes a slight lateral displacement of the atlas. Below this there is a large lateral curve with its convexity to the right, the body of the sixth cervical forming the centre of the arc. The vertebræ are here very dense. The left halves of the bodies are much diminished in depth, being rendered somewhat wedge-shaped. The fibro-cartilages, especially in the concavity of the curve, are much destroyed, more so between the upper than the lower cervical vertebræ. In fact, as the fibro-cartilages ascend they diminish in thickness, being almost completely absent between the third and fourth

vertebræ, so that one sees a regular gradation from normal fibro-cartilage below, to osseous union of the vertebræ above. Fig. 4 is a vertical section through the 2nd, 3rd, 4th, 5th, 6th, 7th, and 8th cervical vertebræ, and shows these changes. The articular processes are also altered in form by the pressure. Below the cervical curve there is a compensatory curve with its convexity to the left, and again below this there is less marked curve to the right. Later I found another example of this deformity among the thirty-five male subjects before referred to.

In the museum of Guy's Hospital I find many specimens of fusion of the atlas and axis, but without the remainder of the spine. As in the case I have just described, the bones are unequally fused so that union is more complete and advanced on the left side than on the other. This obliquity of union alone indicates that there must have been a compensatory curve lower down. I have no doubt that this was due to the same cause that produced similar osseous ankylosis in my case, and which I believe is force transmitted through the occiput.

I think that there will be found many other distinct forms of deformity besides those I have described, also modifications of those three forms due to individual differences in the method of carrying and supporting the loads.

There is another condition to which I would like to have paid more attention, and that is the fusion of the occiput and atlas, and sometimes also the axis as well. There are many examples of these in our museum. Unfortunately this portion only of the column is present, so that one cannot venture any definite hypothesis as to the particular means by which force is transmitted in this case, as I believe it must be the cause here also of the fusion.

I have for a long time looked in the dissecting room for a spine showing this abnormality, but have as yet failed to find one.

I also believe that many museum specimens put up as examples of rheumatic arthritis, osteophytic growth, and

congenital deformities of the bodies of the vertebræ are merely changes produced as a result of pressure.

That there is a greater tendency to the formation of compensatory bony outgrowth and lipping of the vertebræ if the man is also affected by rheumatic arthritis is probable, but I have not yet been quite able to satisfy myself on this point. At the same time, I believe that the irritant poison in rheumatoid arthritis can of itself produce destruction of cartilage and osseous ankylosis in articulations kept perfectly at rest, as in those of the tarsus. This I have referred to elsewhere (*Mollities ossium*;—Charcot's disease;—Rheumatoid arthritis, 'Trans. Path. Soc.,' 1884).

I am sure, however, that many spines are said to present rheumatoid change when it is simply the result of a physiological and healthy process.

That changes from the normal curvatures of the spine are by no means uncommon in the bodies of hardworked labourers is shown by the fact that in thirty-five male subjects dissected consecutively, I found five well-marked examples of the first class of deformity, two of the second class, two of the third, and besides these four species presenting changes which did not belong to either of these classes. In all there were thirteen deformed spinal columns in thirty-five subjects.