# SOME EXAMPLES OF DISEASE OF THE VERTEBRAL COLUMN FOUND IN SKELETONS OF ANCIENT EGYPT

## A CONTRIBUTION TO PALÆOPATHOLOGY

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IN this paper it is proposed to offer descriptions of a few specimens which show different types of disease in the vertebral column. All the specimens to be described are contained in a collection of vertebral columns at Cambridge derived from excavations at Hierakonpolis, and are attributed to the Predynastic Epoch. The material includes about 4100 vertebræ, being the remains of 274 columns. The degree of damage or loss that has occurred will be appreciated from the statement that no more than eight columns are complete or capable of being reconstructed.

The term 'palæopathology' was coined by Sir Armand Ruffer to indicate that branch of scientific inquiry which is concerned with the pathological processes which affected the human body in the remote past. Obviously the material available for such inquiry is mainly limited to bones, except where exceptional circumstances and a high standard of the arts and crafts, as in Egypt, extended the field for research. Ruffer himself described the lesions of bilharzia, of arterial disease, and even of variola in tissues derived from mummies, in the collection of writings which have been published under the title *Studies in the Palæopathology of Egypt.* From dolls, bas-reliefs, and other sculptures Ruffer has given an account of dwarfs and deformities from which fairly exact diagnosis can be made. The same book contains a paper on "Arthritis Deformans and Spondylitis in Ancient Egypt". Having had a field for observation that ranged from archaic Nubians through Predynastic, Dynastic, and Ptolemaic Egyptians to the Greek and Roman periods and even to the Copts of early Christian times, Ruffer[1] formed an opinion that may well be stated in his own words :—

> The pathological anatomy of spondylitis did not vary during this period of eight thousand years. Further, it is clear that geographical distribution did not influence the course or incidence of the disease, since specimens from Lower Egypt, Upper Egypt, and Nubia showed that the frequency, nature, and severity of the lesions were unaffected by varying climatic conditions.

The present paper is written in the hope of presenting some matter of interest though based upon nothing but dried and macerated bones. Probably no specimen will be described which might not be found in a modern skeleton in a modern museum of pathology. It is the presence of similar lesions in the vertebral columns of ancient Egyptians that constitutes their chief claim to interest.

All the specimens to be described have one feature in common, namely, ankylosis of certain members of the vertebral column. Closer examination of the specimens shows the presence of different causative processes bringing about this common effect.

It may perhaps be of service to recall in brief terms the more important mechanisms by which the units of the vertebral column are united in the natural state. Anterior to the spinal canal, the bodies of the vertebræ, by their cartilage-covered upper and lower surfaces, make contacts with the intervertebral discs, structures which possess central nuclei of a highly expansive nature restrained by layers of tough fibrous tissue. Short ligaments extending from vertebral body to vertebral body lie outside the intervertebral discs. Enclosing the vertebral bodies and the tissues between them around their circuit for the whole length of the column lies a fibrous envelope of which the well-known anterior and posterior common ligaments are specialized thickenings. Posterior to the spinal canal, the dorsal arches, by contact of each with its upper and lower neighbour, make a series of dorsal diarthrodial joints. In addition, the dorsal arches are connected by a series of powerful interlaminar ligaments (ligamenta subflava) and by the interspinous ligaments.

It follows, therefore, that when the perivertebral fibrous sheath is ossified a layer of new bone will be found to hide the normal superficial texture of the vertebral bodies. If sufficiently extensive, this new bone surrounds the site of the intervertebral disc, which is represented in a macerated specimen by an intervertebral space. When the deeper ligaments, those of no more than intervertebral length, are ossified, the normal appearance of the vertebral bodies is not lost at the bases of the osteophytes which are marginal in their place of origin.

The capsular ligaments of the dorsal intervertebral joints in an ossified state may enclose a joint either patent or obliterated by bony invasion; it is only by section that it can be determined which condition obtains.

Ossified interlaminar ligaments are recognized by their anatomical position.

## SPECIMEN I.—ANKYLOSIS OF THE SECOND AND THIRD LUMBAR VERTEBRÆ

(*Figs.* 189, 190)

The anterior view in *Fig.* 189 shows that the normal superficial texture of the vertebral bodies is lost. A superficial sheet of new bone, of a texture smoother than normal though porous here and there, somewhat raised and, as it were, *appliqué*, envelops the vertebral bodies and encloses the intervertebral space. It seems, therefore, that new bone has been laid down in the perivertebral fibrous sheath. On the right side this bony sheet is complete as far back as the intervertebral or neural foramen; on the left side and in front it is partly deficient and the normal surface of a vertebral body may be seen. A marked prominence over the intervertebral union projects towards the right side and makes the specimen asymmetrical.

The dorsal arches are not united: no ossific process has invaded the interlaminar ligaments, the capsular ligaments of the dorsal intervertebral joints, or the joint cavities themselves. *Fig.* 190 is a photograph of a section made in a coronal plane and traversing the prominence on the right side. This prominence is shown to be a bridge of cancellous bone; the intervertebral space is not invaded; the lower (3rd lumbar) vertebral body is somewhat wedge-shaped, with the narrow edge towards the right.

It is certain that ankylosis is of long standing, for marrow spaces have penetrated the bony bridge of union from end to end. The texture of both bones is less compact than normal, and is certainly disorganized in the neighbourhood of the connecting bridge. Degeneration of the 3rd lumbar body is shown in its partial collapse into a wedge shape.

The agent which brought about the degenerative process probably was a microbic invasion—almost certainly blood-borne; otherwise it is difficult to account for the degenerative process being so generalized through the two vertebræ. One of the effects of this agent has been an intense stimulation towards new bone formation in the fibrous envelope of the two vertebræ.

FIG. 189.

FIG. 190.

FIG. 189.—*Specimen I.* Ankylosis of the 2nd and 3rd lumbar vertebræ. The specimen is viewed from the front. A sheet of superficial bone, of texture smoother than normal, covers the two vertebral bodies and the intervertebral space except for a gap on the left front. A break in the superficial sheet extends from this gap towards the right; this break was the result of a mischance in handling the specimen, but it follows the intervertebral space. The new superficial bone corresponds to the superficial fibrous sheath of the vertebral column.

FIG. 190.—*Specimen I.* This photograph shows the appearance of a coronal section through the ankylosed 2nd and 3rd lumbar vertebræ. The intervertebral space is patent; the lower vertebral body is somewhat wedge-shaped, with the thin edge towards the right, and is also slightly hollowed. The texture of both bones is less compact than is normal. Cancellous bone is continuous in the bony bridge which connects the two vertebral bodies and corresponds to the prominence on the right side seen in the last figure.

The intervertebral space, so far from being reduced, is rather enlarged, for the lower vertebral body is slightly hollowed on its upper surface. This suggests that the normally expansive intervertebral disc met with decreasing resistance as the bone became softened by disease. Also it is shown that the intervertebral disc retained its turgor and therefore was not diseased. This conclusion goes far to negative the infecting organism as *Bacillus typhosus*, which, being generally credited with a predilection for the tissues of the intervertebral discs, leads to their early collapse in typhoid infections of the spine.

Except for arthritis this specimen goes far to reproduce the picture of ' spondylitis ossificans ligamentosa ' described by Lawford Knaggs,[2] showing, as it does, superficial ossification of ligaments, preservation of the intervertebral space, and rarefaction of bone. Lawford Knaggs insists that these features, with arthritis, represent a vertebral manifestation of an infective or ' rheumatoid ' process in the body elsewhere. Perhaps we are viewing a specimen which attained spontaneous cure, possibly after formation of the envelope of new bone which answered as a splint and secured immobility of the inflamed parts.

## SPECIMENS II, III, AND IV.—ANKYLOSIS OF THE SECOND AND THIRD THORACIC, SIXTH AND SEVENTH THORACIC, AND THIRD AND FOURTH LUMBAR VERTEBRÆ

(*Figs.* 191, 192)

In one vertebral column bony ankylosis has occurred between three pairs of vertebræ, the 2nd and 3rd thoracic, the 6th and 7th thoracic, and the 3rd and 4th lumbar.

All three specimens are extraordinarily light to handle and very fragile; they have been so considerably damaged that certain of the superficial details are uncertain. The left lateral appearances of these three pairs of vertebræ are shown in *Fig.* 191.

The mechanism of union seems to be much the same for each pair of vertebræ. The dorsal arches are firmly united by bone and so also are the vertebral bodies. While it is easy to define the mechanism of union of the former, it is not at all easy to state by what means the vertebral bodies are joined.

In these specimens there is no obvious sheet of superficial bone such as was seen in *Specimen I*; it seems rather that vertebral body has formed direct union with vertebral body, because the vertebral bodies have an almost normal superficial texture.

**Specimen II—2nd and 3rd Thoracic Vertebræ.**—The surfaces of the two vertebral bodies show light superficial striation as is found normally. The position of the intervertebral joint is quite apparent, being marked by a ridge which bears upon it a transverse line with here and there a short linear gap. Part of the same gap is to be seen on both sides in the area for articulation of the head of the 3rd rib. This articular area, and the intervertebral interval, are shown in *Fig.* 191, ringed in white chalk upon the specimen before it was photographed.

From the side view it is evident that the vertical depth of the 2nd thoracic vertebra is much less than that of the 3rd, and the section in *Fig.* 192 shows the same difference. That compression and distortion of the same vertebra have taken place is shown by two further findings in *Fig.* 191: first, the upper vertebral body bulges while the other is slightly hollowed; secondly, the 3rd costo-central joint is out of alinement with the 2nd and 4th, being situated in a more posterior plane.

**Specimen III—6th and 7th Thoracic Vertebræ.**—These two vertebræ are joined into a curve of slight anterior concavity, corresponding to the normal curve of the thoracic column. The surface of the two vertebral bodies is striated, scarcely different from the normal, but is continued below into a flange which projects about 2 mm.

The position of the intervertebral joint is indicated on the right side by a line about 4 mm. long, and on both sides by gaps in the areas for articulation with the heads of the 7th ribs. The vertebral bodies are not hollowed, therefore no ridge marks the union, and the incidence of disease upon these two vertebræ does not seem to have been unequal. The transverse processes have been broken off, and so it is impossible to report on the condition of the costo-transverse joints. The three costo-central and dorsal intervertebral joints above and below the place of ankylosis show no signs of disease.

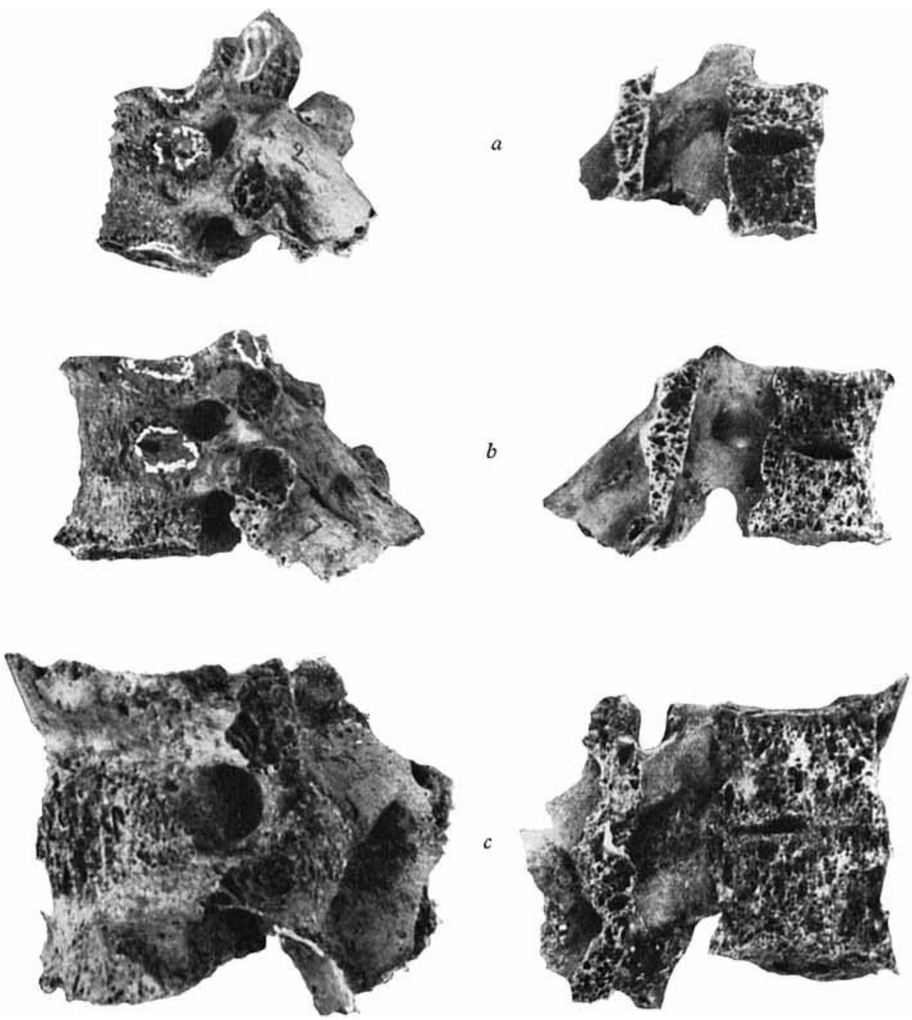


FIG. 191. FIG. 192.

**Specimen IV—3rd and 4th Lumbar Vertebræ.**—*Fig.* 191 shows that these two vertebræ have been considerably damaged; the transverse processes have been lost, and the ridge that covered the intervertebral union has been largely broken away.

In this specimen, near the upper and lower margins, the surface of the bone is smoother and less obviously striated than in the others, also it is somewhat bulky and punctured with small foramina. This appearance, together with its continuation into flanges of bone which project from each of the upper and lower edges of the specimen, suggests some ossification in superficial ligaments.

Both vertebral bodies are hollowed to a very considerable degree, and it seems that a conspicuous ridge, now broken away for the most part, must have marked their place of union. The dorsal end of this ridge partly occludes the intervertebral foramen. Where the intervertebral union has been exposed by superficial breakage no intervertebral space is to be seen—only bone of a very porous texture.

*Fig.* 192 shows photographs of the three pairs of vertebræ after section. In each specimen the plane of the cut through the vertebral bodies is true sagittal, but that through the dorsal arches passes to the right of the middle line.

FIG. 191.—*Specimens II, III, and IV.* A photograph of three pairs of ankylosed vertebræ derived from the same column and viewed from the left side. *a*, Th. 2–3 : *b*, Th. 6–7 ; *c*, L. 3–4.

*a*. Th. 2–3 shows the articular surfaces, picked out in white chalk, for the heads of three ribs and for the 2nd costo-transverse joint ; the 3rd costo-transverse joint has been lost with the 3rd transverse process. The 3rd costo-central joint shows a trace of the intervertebral space in the form of a narrow gap. This joint is in a plane posterior to that for the heads of the 2nd and 4th ribs, thus showing evidence of distortion. The 2nd vertebral body bulges somewhat, while the 3rd retains its normal slight hollow. The union of the two vertebral bodies is marked by a slight ridge, which bears traces of a line upon it. The general surface of the vertebral bodies is almost normal.

*b*. Th. 6–7. These two vertebræ are united in a curve which is nearly normal for this part of the vertebral column. The position of the intervertebral union is clearest in the area for articulation with the head of the 7th rib. No ridge marks the union, and the vertebral bodies are not distorted. Both transverse processes with their costo-transverse joints have been lost, but the costo-central and the dorsal joints above and below appear to be normal.

*c*. L. 3–4. These two vertebræ have been much damaged, having lost both transverse processes and the surface of the ridge that marked the union between the two bodies. Both vertebral bodies are hollowed, and the ridge that marked the union at the dorsal end considerably obstructs the intervertebral foramen. Where the ridge of union has been broken no intervertebral space is to be seen, only very porous bone. At the upper and the lower margins of the specimen flanges of bone project. These flanges are of smoother texture, and pierced by a few small foramina. The dorsal intervertebral joints above and below are normal.

FIG. 192.—*Specimens II, III, and IV.* This photograph shows the three pairs of ankylosed vertebræ after section. The plane of the section through the vertebral bodies is true sagittal ; that through the dorsal arches traverses the sites of the dorsal intervertebral joints. In all these specimens the dorsal joints have been completely obliterated, and cancellous bone occupies the former joint sites. Union of the dorsal arches is also effected by ossification of the interspinous ligaments, best seen in Th. 6–7, and by ossification of the interlaminar ligaments, which is best seen in the upper and the lower specimens. The texture of the bones both in the vertebral bodies and in the dorsal arches is greatly rarefied. Compression of the 2nd thoracic body, previously remarked, is seen again. The intervertebral spaces are progressively invaded from the periphery, most conspicuously in the lowest, and least in the highest of the three specimens.

The figure shows that in each specimen the vertebral bodies are joined across the intervertebral space—very extensively in the lowest, less so in the middle, and least in the uppermost pair.

Bony invasion of the intervertebral space probably commenced circumferentially and spread inwards into the intervertebral discs. In the 3rd and 4th lumbar vertebræ, the site of the most advanced and therefore the oldest pathological change, even the central parts of the intervertebral space have been invaded by new bone.

In each specimen the dorsal intervertebral joints are completely obliterated, and cancellous bone, i.e., marrow, is continuous from dorsal arch to dorsal arch across the former site of the joint. Not only the bone of the dorsal arches, but also the new bone which occupies the joint sites, is very porous. It is perhaps surprising that the costal joints, so far as they have been preserved, are normal.

The sections of the vertebral bodies show a texture which is very porous or spongy. It may be a matter of wonder that they are not hollow on their upper and lower opposed surfaces in response to the expansive pressure exercised by the intervertebral discs. The explanation probably lies in the loss of this expansive quality of the discs from disease, of which most ample evidence lies in their invasion by bone, the presumed effect of an inflammatory process spread from the vertebral bodies. That pressure was exerted by the intervertebral discs at some stage is shown by the section of the 2nd and 3rd thoracic vertebræ, which shows at once slight hollowing and the least degree of invasion of the disc. It follows, therefore, that softening of the vertebral bodies preceded bony invasion of the intervertebral discs.

The following are the outstanding features of *Specimens II, III, and IV*: ossification of the ligaments of the dorsal arches; arthritis of the dorsal intervertebral joints, evidenced by obliteration of the joint cavities; invasion of the intervertebral discs; and rarefaction of bone. Perhaps the processes which led to these results were something as follows.

Invading microbes, almost certainly blood-borne, settled in the bone of the vertebral bodies and of the dorsal arches, and in the dorsal intervertebral joints.

In the joints microbic activity led to destruction of cartilages and their substitution by granulation tissue. Fibrous adhesions prepared the way for osteogenetic cells to invade the former joint cavities from both of the articulating bones, and the result is osseous union by bone formation in fibrous adhesions. Bone formation in the interlaminar and the interspinous ligaments must have been initiated from the same source.

In the vertebral bodies microbic activity has manifested itself by bone destruction. Bony invasion of the intervertebral discs, as met with in these specimens, is somewhat uncommon, but must have spread from the vertebral bodies. *Specimen II* (Th. 2–3) shows that bone formation in the intervertebral disc is a later process than invasion of the vertebral bodies; direct spread is possibly delayed by the sheets of cartilage which intervene between the vertebral bodies and the intervertebral discs.

It might reasonably be held that the dorsal vertebral arches were the earliest site of infection. In his account of acute pyogenic osteomyelitis of the spine, Steindler[3] expresses the view that the dorsal arches and the transverse processes are the commoner site of election for the pyogenic organisms, and points a contrast with the vertebral body which is preferred by the *Bacillus tuberculosis*. From time to time medical literature contains reports of cases which seem to resemble the three specimens here described. A recent report by Flemming[4] contains a radiogram which presents an appearance very like *Specimen III*, and also situated in the thoracic column. In Flemming's case, and also in the opinion of Steindler, *Staphylococcus pyogenes aureus* is considered the causative organism. General opinion seems to be that typhoid has a predilection for the intervertebral discs and for the superficial investing ligaments, though rarefaction of bone may also occur. The deformity in these specimens is not of the kind to be expected from collapse of the intervertebral discs; indeed, we know that in *Specimen II*, at least, nothing of the sort occurred. It is unlikely that these three specimens are examples of the 'typhoid spine'.

## SPECIMEN V.—ANKYLOSIS OF THE THIRD, FOURTH, AND FIFTH THORACIC VERTEBRÆ

(*Figs.* 193, 194)

This specimen consists of the 3rd, 4th, and 5th thoracic vertebræ ankylosed into a formation which, from the side view in *Fig.* 193, has an appearance very suggestive of Pott's disease on account of the ventral compression of the vertebral bodies and of the dorsal separation of the spinous processes.

*Fig.* 193 shows contact surfaces for the heads of four ribs on the vertebral bodies, and for the tubercles of three on the transverse processes. The fused mass is considerably hollowed, and the pedicle of the middle vertebral arch, projecting forwards, fails to make contact with the vertebral body, but ends in a blunt, rough stump.

FIG. 193.

FIG. 194.

FIG. 193.—*Specimen V.* In this figure is shown a photograph taken from the right side of the ankylosed 3rd, 4th, and 5th thoracic vertebræ. The vertebral bodies have assumed a wedge formation. The bodies are compressed together in front, while the spinous processes are splayed and separated to a corresponding degree. The pedicle of the middle vertebra is separated from the fused mass of the vertebral bodies in front. On the vertebral bodies and situated rather posteriorly can be seen four articular areas which correspond to the joints of four ribs which normally articulate with three thoracic vertebræ. The mass of vertebral bodies is distinctly hollowed, but there is no surface indication of the intervertebral spaces.

FIG. 194.—*Specimen V.* In this figure is shown a photograph of the right half of the specimen after sagittal section. It can be seen that the three dorsal arches are united by a continuous sheet of bone which corresponds to the ossified interlaminar ligaments and the ventral surfaces of the laminæ. The separation of the middle dorsal arch from its body is seen in the stump of its pedicle. In the fused mass of vertebral bodies can be seen a space which is nearly central and elongated in the horizontal plane. This is the intervertebral space, which communicated with the exterior on the left side by a sinus. The bone above and below this space presents an orifice which comes to the surface in the neural canal. Each of these orifices contains the vena basis vertebræ and is a normal feature of a vertebral body. It seems, therefore, that two vertebral bodies lie on either side of the central gap, which must have contained the middle vertebra before it was broken down by disease and extruded through the sinus on the left side.

From the dorsum the outlines of the dorsal intervertebral joints are obscured by ossified capsular ligaments, but section has shown that the joint cavities are patent and the articular surfaces are normal. The interlaminar ligaments are extensively ossified.

In *Fig.* 194 is shown the right half of the fused mass after sagittal section. The dorsal arches with the ossified interlaminar ligaments, as well as the stump of the pedicle of the middle arch, can be seen. Anteriorly lies the mass of the vertebral bodies. In the middle lies a cavity elongated fore-and-aft and closed by a bridge of bone in front and behind. On either side of the gap lies a vertebral body which, though rather dense, seems very near to normal in the regular striation and in the presence of some part of a canal which communicates with the surface posteriorly. Such a canal in a fresh specimen transmits the vena basis vertebræ and is a normal feature of a sagittal section of a vertebral body. Therefore each canal indicates that a vertebral body does indeed lie on either side of the central gap. The central gap communicates with the exterior by a hole on the left side. Unfortunately it was not possible to obtain a satisfactory photograph of the specimen from the left side because it is too severely eroded and discoloured.

The inference is that the body of the third vertebra, which lay in the middle, has been destroyed by disease, and that two practically intact bodies are left above and below bearing between them on their dorsal arches that of the missing member.

Probably the 4th thoracic vertebra was destroyed by tuberculous disease, and extruded through the sinus on the left side. A slow process of destruction by an organism of low virulence rather than an acute osteomyelitis is probable. In this case the disease has been limited to a single vertebral body in a manner which contrasts with the specimens just described.

In this specimen the disease seems to have healed, to judge from secondary effects found in the column, and this again suggests tuberculosis.

These secondary or compensatory changes include extensive ossification of ligaments, particularly those of the dorsal joints and the interlaminar ligaments of the three fused dorsal arches. Further, no doubt as a response to the requirements of a new balance to the whole column, osteo-arthritic changes are present in the dorsal joints of the three vertebræ above and below the site of ankylosis.

## SPECIMEN VI.—ANKYLOSIS OF THE SECOND AND THIRD LUMBAR VERTEBRÆ

(*Figs.* 195, 196.)

In a right anterior view, *Fig.* 195 shows the two vertebral bodies united by an extensive sheet of smooth superficial bone which covers the bodies and the intervertebral space in an almost complete circuit, and therefore must correspond to the perivertebral fibrous sheath ossified. This sheet is complete except for one small gap in front and for a second on the right and behind, into which the pointer is inserted.

The dorsal intervertebral joints show some osteo-arthritis. The dorsal ligaments, except the interlaminar to a slight degree, are unossified. Sections of this specimen, shown in *Fig.* 196, display two cavities surrounded by bone and lying between the two vertebral bodies. One cavity is the intervertebral space, and extends fore-and-aft as far as the hinder and front surfaces of the vertebral bodies, where it is limited by ossified posterior and anterior ligaments. It was into this cavity that the pointer shown in *Fig.* 195 was inserted. The other cavity is situated within the body of the 2nd lumbar vertebra, and is completely closed, being separated from the intervertebral space by a wall of thin but dense bone which can be seen best on the left-hand side in *Fig.* 196.

This cavity in the vertebral body is not quite central, being nearer to the posterior than to the anterior surface. It measures 1 cm. vertically and 1·7 cm. horizontally. The intervertebral space is encroached upon by the wall of the small

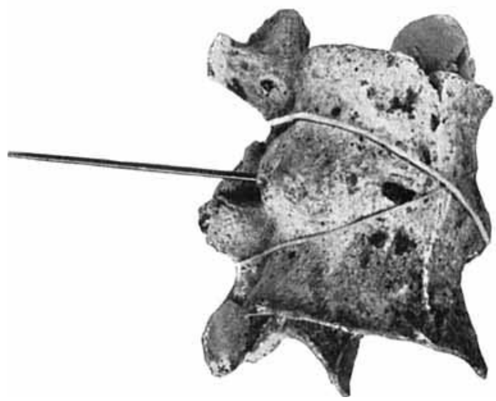

FIG. 195.—*Specimen VI.* This photograph is a right anterior view of the 2nd and 3rd lumbar vertebræ united by a superficial sheet of smooth new bone. This new bone is complete except for the gap which can be seen in front and for a second gap in a right posterior position in which the pointer is inserted. The photograph was taken after section in a sagittal plane, and shows the line of section along the front of the specimen. The two halves are retained in position by two crossing rubber bands.

cavity, which is protruded almost to meet the other vertebral body. The interior is smooth and the wall is highly compact in texture; except for some increased density in the immediate vicinity of the cavity the texture of both bones is normal.

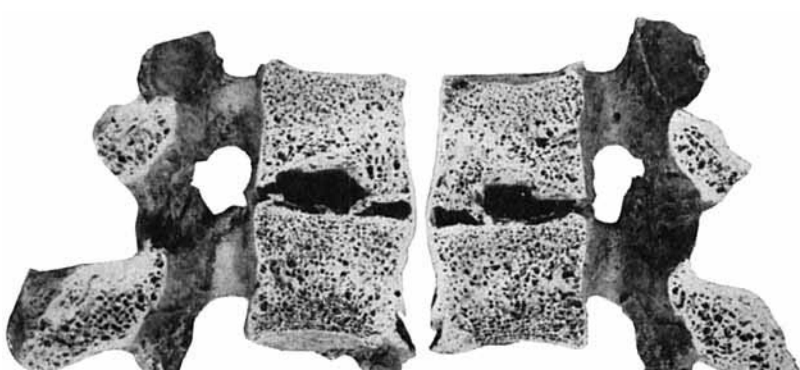

FIG. 196.—*Specimen VI.* This photograph presents the appearances after the fused vertebral bodies had been cut in the sagittal plane. It is to be noted that two cavities lie between the two vertebral bodies. One cavity—the larger and the lower—is limited by thin bone lying in the plane of the fronts and the backs of the vertebral bodies, and corresponds to the space formerly occupied by the intervertebral disc. A smaller cavity, rather oval in section, lies in the body of the 2nd lumbar vertebra and protrudes into the intervertebral space. This smaller cavity is completely enclosed in bone, and is shut off from the intervertebral space by a plate of thin but compact bone which is best seen on the left-hand side.

During life the small cavity must have contained a tissue which exerted pressure during its growth, for it formed a compact wall and encroached upon the space occupied by the normally expansive intervertebral disc. It is easy to surmise that in consequence the ligaments that ensheathed the two vertebral bodies were subjected to high tension, which induced the process of ossification in them.

Had the small cavity contained an abscess, collapse rather than expansion would have been expected ; the wall would be rough and shaggy rather than smooth, condensed, and sharply delimited. The findings rather suggest the past presence of a tumour, non-infiltrating in character, perhaps a myeloma.

Other pathological findings in the same column include osteo-arthritis of the dorsal intervertebral joints from the 12th thoracic to the 4th lumbar and from the 3rd cervical to the 3rd thoracic. Fixation of the 2nd and 3rd lumbar vertebræ sets abnormal demands on the dorsal intervertebral joints elsewhere in the column in response to the needs of adjustment to a new balance, with the result of osteo-arthritis. These changes may be regarded as an indication of chronicity in the initial lesion.

## SPECIMEN VII.—ANKYLOSIS OF THE THIRD AND FOURTH LUMBAR VERTEBRÆ

(*Figs.* 197, 198.)

It is unfortunate that this specimen was not photographed from the side before section ; only the line drawing reproduced in *Fig.* 197 is available. In contrast with the last specimen the two vertebral bodies are ankylosed on each other with some degree of anterior angulation. No extensive sheet of bone such as was found in *Specimens I* and *VI* is present.

The intervertebral space is open at the sides and back and is covered in front only to a limited extent. The uniting bone is smooth and raised, but arises from no more than the margins of the vertebral bodies ; elsewhere the surfaces of the bodies are normal. A large left and a smaller right anterior bridge of bone comprise the means of union.

*Fig.* 198 presents a photograph of the specimen after it had been cut with a fret-saw in the sagittal plane. It can be seen that the 3rd lumbar vertebra has an excavation in the postero-inferior part of its body. This excavation is evenly rounded, but its surface is rough and porous. The bone around the hollow is somewhat condensed, but no wall of compact bone has been formed.

During the partial destruction of the vertebral body and under weight-bearing there may well have been approximation of the dorsal elements of the two vertebræ. It will be remembered that in a normal column the 3rd and 4th lumbar vertebræ are dorsiflexed upon each other, as in this specimen, and this dorsiflexion may have been accentuated. Dorsiflexion is limited posteriorly by the dorsal intervertebral joints, and anteriorly by intervertebral ligaments.

It is upon these mechanisms that the brunt of the secondary pathological changes seems to have fallen. The dorsal joint between the 3rd and 4th lumbar vertebræ is markedly affected with osteo-arthritis, and the new bone in front suggests ossification in the fibres of the short intervertebral ligaments.

If the contours of the intervertebral space are followed from behind forwards, the following changes can be seen. Behind is the hollow of the site of the primary pathological process ; next, for a distance, the two vertebral bodies have parallel surfaces ; in front, the intervertebral space widens just where it is enclosed by the new bone. It must be supposed that these changes in bone record changes in the intervertebral disc, and this structure, we must infer, bulged in front and gave a certain shape to bone formed in ligaments which are immediately adjacent.

These features—namely, bulging of the intervertebral disc, ossification of the short intervertebral ligaments which lie immediately outside them, and a marginal origin for new bone—are characteristic of the condition the morbid anatomy of

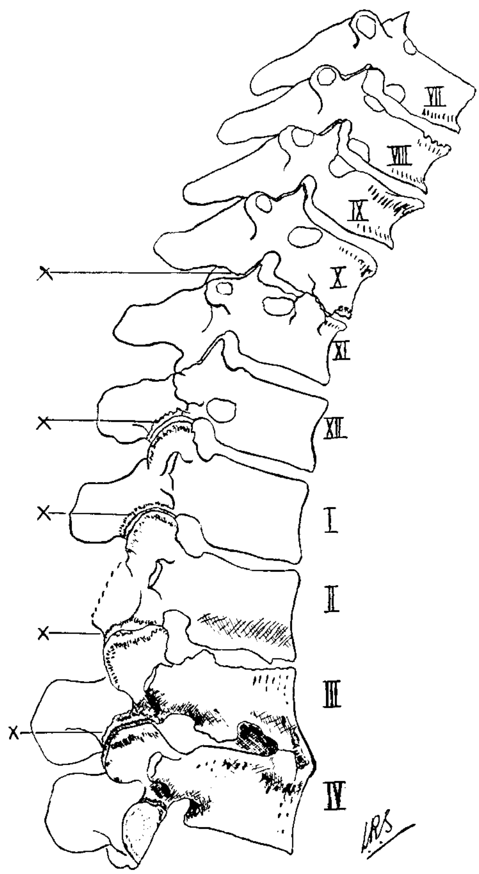


FIG. 197.—*Specimen VII.* This is a line drawing from the right side of part of the column containing the ankylosed 3rd and 4th lumbar vertebræ after reconstruction. There is some anterior angulation of the two ankylosed vertebral bodies in exaggeration of the dorsiflexion normal for the lumbar column. The union between the 3rd and 4th lumbar units is effected by osteophytes which only incompletely hide the intervertebral space. These osteophytes arise from the margins of the vertebral bodies, which for the greater part present a normal texture. Reconstruction shows that the vertebræ above the place of ankylosis are set in a uniform curve of ventriflexion, and that there is no differentiation between the thoracic and the lumbar curves. Such a contour implies general kyphosis of the spine. The dorsal intervertebral joints marked X are the seat of osteo-arthritis.

which has been described under the name ‘ polyspondylitis marginalis osteophytica ’.[5] More commonly this condition is called ‘ spondylitis ’, perhaps with the epithet ‘ deformans ’, ‘ spondylitis osteo-arthritica ’, ‘ spondylosis ’, or ‘ osteo-arthritis of the spine ’. In this specimen and in *Fig.* 198 it can be seen how the lines of condensation of bone radiate into the substance of each vertebral body from the compact new bone at each vertebral margin, where are attached the short intervertebral ligaments.

The nature of the pathological process which eroded the body of the 3rd lumbar vertebra and gave rise to these changes must be a matter of conjecture. An excavation of the size could scarcely have been caused by a meningeal tumour without erosion of the other vertebra. For the same reason a tumour arising in the intervertebral disc would scarcely explain the findings. A chondroma would have caused considerable distortion of the vertebral body in which it arose, and have left traces of expansion of the bone. It is perhaps most likely that we are examining the effects of tuberculous disease of the body of the 3rd lumbar vertebra.

FIG. 198.—*Specimen VII.* A photograph of the left half of the ankylosed 3rd and 4th lumbar vertebræ after sagittal section. There is an excavation in the posterior part of the body of the 3rd lumbar vertebra. The excavation is uniformly curved, and though the bone around it is somewhat condensed, the surface is porous and not compressed into a firm lamina as in *Specimen VI.* It can be seen that at the seat of ankylosis in front of the vertebral bodies, where the bridge of union broke in handling, the bone is very dense. From the two points of union compact bone spreads into the two vertebral bodies. The intervertebral space in front of the hollow excavation has parallel walls which expand just where the compact bone begins. It must be inferred that the intervertebral disc bulged anteriorly, and it is probable that the new bone is formed in the short intervertebral ligaments.

The presence of changes in the dorsal intervertebral joints elsewhere in the column suggests that there was time for the column to become adjusted to new strains, and therefore that the process, whatever it was, was not rapidly fatal. Osteo-arthritis in the dorsal joints is shown in the lateral drawing in *Fig.* 197 affecting all the joints below the 10th thoracic. The interlaminar ligaments from the 9th to the 11th arches are ossified. The only part of the column available for reconstruction is shown in *Fig.* 197, from which it seems that the normal thoracico-lumbar curve has been straightened out and even reversed. There probably was a kyphotic curve to the whole vertebral column.

## DISCUSSION

The specimens described illustrate the following diseases of the vertebral column to which ankylosis is a concomitant.

*Specimen I.*—Primary disease, probably microbic infection. Ankylosis is effected by ossification of the perivertebral fibrous sheath.

*Specimens II, III, and IV.*—Primary disease, probably staphylococcal infection. Ankylosis is brought about by obliteration of the joints, by ossification of the interlaminar ligaments and by bony invasion of the intervertebral discs.

*Specimen V.*—Tuberculous disease. Extrusion of a diseased vertebral body, and healing by ossification of ligaments.

*Specimen VI.*—Primary disease, a tumour of the vertebral body, probably a myeloma. Secondary ankylosis is brought about by ossification of the perivertebral fibrous sheath.

*Specimen VII.*—Primary disease uncertain, probably tuberculosis of the vertebral body. Ankylosis is caused by ossification of the short intervertebral ligaments.

In Ruffer's book are figured specimens which resemble *Specimens I* to *IV*, though the author does not subject them to very close analysis or to section. *Specimens I* to *IV* are all regarded as illustrating the effects of microbic infection, though these effects are much slighter in the first than in the others. Reasons for taking this view have been given already.

A feature common to these four specimens is rarefaction of bone. An obvious question arises: Is rarefaction of bone a sequel to ankylosis comparable with the atrophy of disuse? This question is not easily answered; but a limited experience, so far as it goes, does not suggest to me that rarefaction necessarily follows ankylosis. There is no rarefaction of bone in *Specimens V* and *VI*, though ankylosis is firm enough. It might be objected that there is no information available as to the relative chronicity of the pathological processes in *Specimens II, III*, and *IV* on the one hand, or in *V* and *VI* on the other. *Specimens V* and *VI* were ankylosed long enough for osteo-arthritic changes to develop in the dorsal intervertebral joints near the site of ankylosis in response, as it is surmised, to disturbances in balance of the whole column following on ankylosis.

In another place[6] I have described a specimen of developmental sacro-iliac synostosis and compared it with synostosis of infective origin. The internal structure of the first was perfectly normal; it was in the second that alteration of bone structure with patches of rarefaction were found. It does not seem from this that ankylosis *per se* brings about absorption or rarefaction of bone; rather is this effect to be attributed to diffuse inflammation or osteomyelitis.

The infective nature of *Specimens II, III*, and *IV* would be very probable from the ankylosis and obliteration of the dorsal joints, apart from rarefaction of bone and invasion of the intervertebral discs.

The term 'rhizomelic spondylitis' has been used to include those cases of ankylosis brought about by an extensive superficial sheet of new bone. This term, derived from the Greek ῥίζα spine, and μέλος membrane, is sufficiently descriptive of ossification of the perivertebral fibrous sheath. Rhizomelic spondylitis, as usually understood, corresponds to 'spondylitis ossificans ligamentosa' of Lawford Knaggs, and is distinguished by extensive ossification of the perivertebral sheath, but includes in addition ossification of the interlaminar ligaments, ankylosis of the small vertebral joints, and rarefaction of bone. An infective or 'rheumatoid' origin is the opinion almost universally held. There does not seem to be any justification for applying the term 'rhizomelic spondylitis' to *Specimens II, III*, and *IV*.

So far as external appearances go, *Specimen VI* might have been assigned to the category of rhizomelic spondylitis. Further examination shows that the perivertebral ligaments are more probably ossified as the result of mechanical strain than as a consequence of 'rheumatoid' infection. A tumour encroached upon the intervertebral disc, which is normally expansive; hence excessive strain was set upon all of the ligaments which surround the disc and hold vertebral body to vertebral body, and that strain induced ossification in them.

That abnormal strain in ligament is sufficient cause for ossification is probably generally assumed, and the mechanism described below in the words of Macewen[7] explaining the process of ossification in tendon probably represents a general principle which covers this theorem.

> Tendons which are directly inserted into bone, without the intermediary of the periosteum, are, under exceptional circumstances, liable to osseous infiltration . . . mechanical irritation causes a proliferation of osteoblasts which penetrate the . . . fibres of the tendon and set up ossification in their midst. Some of the fibres . . . may retract into the tendon, carrying osteoblasts from their point of insertion. Rider's bone results in this way.

In another place[8] I have tentatively explained the very common finding of ossified interlaminar ligaments as the result of strain or trauma following on ventriflexion of the vertebral column, and commonest in the thoracic region because the thoracic units are normally ventriflexed on each other and supported in that position by the interlaminar ligaments. This might be held to illustrate the principle set out above. Vertebræ with the interlaminar ligaments ossified to a greater or lesser extent are very common in Egyptian columns, and this makes the finding of Ruffer on this point the more remarkable. Writing on 'spondylitis deformans' in Egyptian skeletons, he states: "On the other hand the ligamenta subflava (interlaminar ligaments) composed of yellow elastic tissue always remained free from ossification".[9] I strongly dissent from this opinion.

In *Specimen III* ankylosis is brought about by direct bony union of two vertebral bodies after extrusion of a diseased intermediate member. The interlaminar ligaments are completely ossified, it may be suggested, because they were subjected to strain in resisting separation of the dorsal arches in the position of extreme ventriflexion which followed collapse of the intermediate vertebral body. In the stages prior to healing, these ligaments must have been the chief local support of the three acutely flexed vertebræ, and probably represent the earliest site of new or reparative ossification.

In one of his papers Ruffer[10] interprets two tomb carvings of the XI–XIIth and of the XVIIIth Dynasties as examples of Pott's disease of the spine, and states that he knows of no others in Egypt. His collection of bones apparently did not contain an example like *Specimen III.*

In several places reference has been made to concomitant osteo-arthritis in the dorsal intervertebral joints, and this finding has been adduced as evidence of chronicity. Timbrell Fisher defines osteo-arthritis as "the series of physiological or pathological changes that occur in a joint when it is subjected to oft-repeated injury, either mechanical or toxic, but of a moderate degree of intensity".[11] Pointing out that osteo-arthritis may be an expression of abnormal stresses laid upon a joint, Fisher gives among the causes of "traumatic or localized" osteo-arthritis this example: "a localized increase of articular stress of an occupational nature or caused by . . . ankylosis of an adjacent joint".

Ankylosis of two or more vertebræ may be supposed to cause an unusual stress to fall upon the dorsal intervertebral joints above and below the site of union, and therefore to render those joints prone to the development of osteo-arthritis. This inference follows from Fisher's theorem, and also the further inference that in those specimens in which osteo-arthritis is an apparent concomitant of ankylosis the main pathological lesion must be of longer duration than is necessary to bring about the development of osteo-arthritis.

In his account of pathological lesions of the vertebral column Ruffer describes and figures specimens of ankylosis brought about, as it seems, by ossification of the perivertebral fibrous sheath, and a much larger number exhibiting osteophytes of the type that causes the familiar ' lipping ' of the vertebral bodies. This type of osteophyte Ruffer considers to be that most characteristic of ' spondylitis '. Lipping, or polyspondylitis marginalis osteophytica, I believe to be the result of bone formation in the short intervertebral ligaments, brought about by strain when vertebra slips or rotates upon vertebra as a consequence of change in the intervertebral disc. Though this condition is the commonest of pathological changes in Egyptian vertebral columns, I have not obtained a specimen in which ankylosis had resulted except *Specimen VII*, and in this the initial lesion is highly unusual.

Ruffer makes an interesting deduction as to the development of the social sense in the communities of ancient Egypt. The individuals with the pathological lesions described in this paper must have been crippled and for a long time unable to exist by their own efforts, or to bear a share in the communal life of a primitive people. It is inferred that the care of the sick was a duty even in Predynastic times in ancient Egypt. *Specimen V*, healed tuberculosis of the spine, points in this direction, and even more strongly *Specimen VII* (if it is tuberculous), because diagnosis must have been much more difficult, and healing has taken place at a much earlier stage.

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