The spinal canal in cervical spondylosis

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Cervical spondylosis was defined by Brain (1948), by Brain, Northfield, and Wilkinson (1952), and by Frykholm (1951). Its essential features are protrusion of the annulus fibrosus and changes in the adjacent vertebral margins. The size of the cervical spinal canal may play a major part in the neurological manifestations of cervical spondylosis.

The antero-posterior diameters of the cervical canal in 200 normal adults were measured by Boijesen (1954). Wolf, Khilnani, and Malis (1956) in a similar study found that the antero-posterior diameter at the first cervical vertebra varied from 16 mm. to more than 30 mm. and from C.4 to C.7 varied from 12 mm. to 22 mm. The average antero-posterior diameter from C.4 downwards was 17 mm.

Payne and Spillane (1957) recorded the antero-posterior diameters of the spinal canal in routine lateral radiographs in 90 adults. Measurements were from the posterior border of each vertebral body to the anterior border of the junction of the corresponding lamina. At C.1 the measurement was taken from the posterior border of the odontoid to the anterior edge of the posterior arch of the atlas. They used standard lateral radiographs at a tube distance of 6 ft. with the patient against the film. The patients fell into three groups: 1 Normal, 2 cervical spondylosis without paraplegia, and 3 cervical spondylosis with paraplegia (myelopathy). In spondylotic spines the antero-posterior diameter tended to be less than the normal range. In those with myelopathy the reduced diameters were found throughout the cervical spine.

There are possible disadvantages in assessing the significance of the size of the cervical canal in this way. Only the antero-posterior measurements are obtained, thus neglecting possible changes in the length of the canal. Precise points must be used for each measurement. For clinical purposes these measurements must be compared with a 'normal' group. The ranges of normal and the overlap of abnormal and normal are considerable.

We have attempted to measure the cervical spine in such a way as to take into account both the length and all the antero-posterior diameters of the canal. In order to avoid having to make comparisons with normal ranges of measurement we have compared

the canal size with one of the patient's own parameters in the region, namely, the size of the bodies of the cervical vertebrae. This method eliminates geometrical errors of radiographic projection and avoids the difficulties in measuring the varying antero-posterior diameters of the irregular canal.

METHOD

The routinely taken lateral radiograph of the cervical spine to be examined is placed on a horizontally positioned viewing box. A piece of blank developed x-ray film is then placed over the radiograph. A careful tracing using a sharp film-marking pencil is then made. The area covered by this tracing is shown in Fig. 1. It includes the spinal canal from the arch of C.2 to a line across the canal immediately below the body of C.6, the vertebral bodies of C.3 to C.6 (including osteophytes), the body of C.2 (excluding the odontoid), and the disc spaces between adjacent vertebral end plates. The posterior limits of the spinal canal were, for this purpose, taken to be the line joining the most anterior points of the junctions of the laminae forming the posterior arches. The anterior limits were taken to be the posterior outlines of vertebral bodies and lines joining adjacent bodies or osteophytes at the most posterior points.

FIG. 1. Radiograph of the cervical spine showing a piece of x-ray film in position and tracing made.

FIG. 2. Tracing before being cut.

FIG. 3. Tracing cut into 'canal', 'vertebrae', and 'discs'. The patient (not included in this series) has disseminated sclerosis and Reiter's syndrome. Weight of 'canal' 0.43 g., weight of 'vertebrae' 0.32 g., ratio 134%.

FIG. 3

The tracing was then carefully cut out in one piece (Fig. 2) and was weighed on a very accurate balance. It was then cut again, separating the 'spinal canal' from the 'bodies' and 'discs'. The 'canal' was then weighed and the 'vertebral bodies' were weighed together (Fig. 3).

The weights used were those of the canal and the five vertebral bodies. From these the ratio of canal to vertebral bodies was calculated as a percentage. The following is an example:—

Spinal canal weight	0.34 g.
Vertebral bodies' weight.....	0.51 g.
Ratio of spinal canal to vertebral bodies.....	67%

A film which is satisfactory for tracing is essential. We have chosen radiographs in which the neck was in a position intermediate between the extremes of flexion and extension. Errors are possible in the tracing and cutting

but are probably small. Weighings were very accurate and speedily made on an automatic balance. The reason for choosing the upper limit of the tracing was that the arch and the body of C.2 are well defined and easily drawn. The lower limit was taken at the level of C.6 because the C.7 vertebra is sometimes incompletely seen on radiographs of the cervical spine.

MATERIAL EXAMINED

GROUP I This group consisted of 46 consecutive and unselected patients all of whom had had cervical myelograms. Radiographs of the cervical spine were examined as described above. In no cases was the diagnosis known when the tracings and weighings were made and ratios calculated. The case notes were then examined and the diagnosis was ascertained without knowledge of the previous results. The diagnosis was doubtful in three cases which were eliminated from the study. This was quite unbiased as the results of the measurements were not known. This group of cases was chosen for study because of the greater certainty of accurate and complete diagnosis.

There were 15 cases of disseminated sclerosis. Seven of the 15 had some radiographic evidence of cervical spondylosis. In one case the second and third cervical vertebral bodies were fused.

Thirteen had various lesions which will be analysed later. Five of the 13 had some radiographic features of cervical spondylosis.

There were 14 cases of cervical spondylosis with the signs of myelopathy in the long tracts.

Four had cervical spondylosis without evidence of myelopathy.

GROUP II This group consisted of 21 consecutive cases of cervical spondylosis. Symptoms and signs were confined to the neck and upper limbs. The diagnosis was based on clinical observation and examination of plain radiographs. None had a myelogram. The radiographs were examined as in group I.

RESULTS

These have been graphically recorded in Fig. 4.

All 15 cases of disseminated sclerosis showed a ratio of spinal canal to vertebral bodies greater than 85%.

The ratios for patients included under the heading of 'other conditions' were the following:—

One case of neurofibroma without meningocele, 96%; one case of congenital anomalies of the cervical vertebrae, 77%; two cases with normal cervical spine but with disease in a lower part of the spine, 95% and 128%; three cases with normal myelograms diagnosed as having functional disease, 94%, 119%, and 117%; three cases of cervical syringomyelia, 90%, 98%, and 88%; one case of cervical meningioma, 97%; one case of ankylosing spondylitis with cauda equina lesion, 87%; one case of vascular malformation in the cervical spine, 86%.

Only two patients with cervical spondylosis who

FIG. 4. The vertical axis in each of the four sections represents the ratio of the spinal canal to the vertebral body expressed as a percentage. Each point represents one patient. The horizontal line is drawn at the level of 85%. The ratios of the patients with cervical spondylosis and myelopathy (top right hand) are nearly all less than 85% in contrast to the other three groups.

had myelopathy showed a ratio of more than 85%, and these were 88% and 90%.

Of 21 patients who had cervical spondylosis without myelopathy, four had ratios below 85%.

Four patients who had myelograms are not included in the results. These were patients with cervical spondylosis without signs in the long tracts. The ratios in these cases were 88%, 86%, 95%, and 98%.

DISCUSSION

The weights of the x-ray film tracings of the spinal canal and vertebral bodies are approximately equivalent to a very thin mid-line sagittal section.

From the theoretical standpoint the ratio of canal to vertebral bodies may be increased or decreased. For example, an increase in the ratio could be caused by an increase in the size of the canal or a decrease in the size of the bones. If an equivalent change occurred in the canal and bone then the ratio would be unchanged.

In cervical spondylosis with myelopathy we have

shown that the ratio of canal size to vertebral body size is low compared with the ratios in nearly all the other patients. The cause of the low ratio could be a decrease in canal size, an increase in bone size, or both changes together.

The size of the canal could be reduced in two ways. First, there could be a decrease in the antero-posterior diameter of the canal. Secondly, there could be a decrease in the length of the canal as a result of narrowing of disc spaces and possibly a decrease in height of the vertebral bodies.

Increase in the size of the vertebra could be produced by the formation of osteophytes and new bone. Further study is required to determine whether other changes might occur.

The importance of the size of the spinal canal has been stressed by Pallis, Jones, and Spillane (1954), by Wolf, Khilnani, and Malis (1956), and by Payne and Spillane (1957).

The method we have described emphasizes the differences between the spinal changes in cervical spondylosis with myelopathy and other conditions

by taking into account the factors mentioned. Simple antero-posterior measurements of the canal, although showing the same trends, are not quite so conclusive. It is difficult to compare the size of the spinal canal of one person with that of another. Actual measurements have a limited value because of variations in size from one person to another. A small spinal canal is only to be expected in a small person, but it might well be expected that such a person would also have small vertebral bodies. The problems inherent in comparing actual measurements in an individual patient with a range of 'normal' or 'average' measurements have been avoided by the method we have used.

It has been suggested that a small spinal canal in cervical spondylosis might be congenitally determined (Clarke and Little, 1955). If this were so then one would expect not only small spinal canals to be found in the normal population but also low ratios of canal size to vertebral body size. Yet, in our groups of patients with disseminated sclerosis and with miscellaneous disorders, and in most of the cases of spondylosis without myelopathy, the ratios were not low. Only one patient in the 'miscellaneous' group and none at all in the disseminated sclerosis group had low ratios. It seems possible that the phenomenon of a low ratio is acquired. Further study is required to elucidate this point. However, an individual with a relatively small canal might be predisposed to myelopathy should he develop spondylosis. It is also possible that a relatively large canal might allow an individual to escape myelopathy in similar circumstances.

The spinal cord lies within the confines of the spinal canal, anchored by the ligamentum denticulatum and nerve roots. Reductions in the width or the length of the canal reduce the space available for the cord, and in spondylosis protrusions of tissue into the canal reduce the available space still further. In these circumstances the cord is vulnerable. A number of mechanisms have been held to be responsible for damage to the cord. Taylor (1953) invoked bulging of the ligamentum flavum into the spinal canal posteriorly. Tethering of the cord by the dentate ligament was thought to be important by Kahn (1947). Damage to the cord by interference with arterial blood supply was postulated by Mair and Druckman (1953) but recent work by Wilkinson (1960) gives no support to this concept. O'Connell (1955) stated: 'Osteophytes projecting posteriorly impinge upon the cord and subject it to recurring trauma during neck movement—especially flexion'. Damage from any of these causes would seem more likely to occur if there were a reduction in the space available.

A decrease in length of the spinal canal might tend

to minimize trauma by slackening the cord and allowing a concertina effect during movements of flexion and extension. This theoretical advantage may be completely offset by the associated decrease in volume of the canal.

Twenty-one of the 25 cases of cervical spondylosis without signs in the long tracts with symptoms confined to the neck and upper limbs had ratios above 85%. Four cases had ratios below 85%. It is tempting to postulate that the cases with low ratios might well be those which will eventually develop signs in the long tracts. This requires further study.

In this investigation we have not attempted to match the patients for age in the four groups. Patients with spondylosis tend to be in an older age group than those with disseminated sclerosis. However, there was a great overlap in all four groups. We do not know whether the ratios change with age in patients with or without spondylosis. Further studies are required to elucidate this point.

CLINICAL APPLICATIONS

The radiographic changes of cervical spondylosis are commonly seen in patients with neurological disorders and it is often difficult to assess the significance of such radiological findings. In a patient with signs in the long tracts and with a high ratio of spinal canal to vertebral bodies it would seem unlikely that the long tract signs were being produced by spondylosis. In such cases it follows that one should suspect a lesion other than that of spondylotic myelopathy. In a patient with cervical spondylosis who is found to have a low ratio of spinal canal to vertebral bodies the possibility that the myelopathy is of spondylotic origin is much greater than if the ratio were high. It is likely that ratios in the region of 85% will not be of value in the assessment of a case. The method may have no value in the assessment of a patient with a traumatic disc protrusion. Such an accurate method of measuring by weight the area of an irregular radiographic outline may be of great value in the investigation of other aspects of spondylosis.

SUMMARY

A new method of measuring the cervical spine is described. The principle used is that of tracing the radiographic outlines of spinal canal and vertebral bodies on x-ray film and weighing the cut-out tracings. The size of the spinal canal is compared with that of the vertebral bodies and a ratio calculated. Such ratios were obtained in 67 patients with and without radiographic evidence of cervical spondylosis. Patients who had cervical spondylosis with myelopathy were found to have a low ratio of

spinal canal to vertebral bodies compared with those in other diagnostic groups. The reasons for the association of low ratios with spondylotic myelopathy are discussed. The possible clinical application of the method, its value as a research technique, and its advantages over other ways of measuring the cervical spine are considered.

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