THE IMPORTANCE OF THE SAGITTAL DIAMETERS OF THE CERVICAL SPINAL CANAL IN RELATION TO SPONDYLOSIS AND MYELOPATHY

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It is well known that subjects with all the radiological features of cervical spondylosis may be symptom-free (Brooker and Barter 1965). On the other hand, manifest cervical myelopathy may occur in the presence of modest radiological changes. This discrepancy between symptoms and radiological findings seems to be attributable mainly to differences in the initial size of the cervical spinal canal.

![Graph](image_url)

**Fig. 1**
A graph compiled from radiological measurements of the antero-posterior diameters of the cervical spinal canal in the neutral position, showing the range and average at each level in twenty Japanese men with no spondylosis (Group 1).

**MATERIAL AND METHODS**

In fifty-one adult Japanese men the antero-posterior diameter of the cervical spinal canal was determined in the neutral position. These men fell into three groups: Group 1, twenty with normal cervical spines; Group 2, eleven with cervical spondylosis but without neurological symptoms; and Group 3, twenty with both cervical spondylosis and myelopathy.

Of radiological methods of measuring the size of the spinal canal, that of Payne and Spillane (1957), modified from Wolf, Khilnami and Malis (1956), seems to be the most easily carried out, and was used in this study. Standard lateral radiographs were taken in the neutral position of the cervical spine with a tube distance of 140 centimetres and the factors 55 kilovolts and 100 mA. The antero-posterior diameter (O) was measured between the posterior border of each vertebral body and the anterior border of the corresponding lamina. In this way the basic size was obtained for each of the three groups.

In spondylosis the canal diameter is of course reduced. This measurement of the decreased diameter (S) was made between the postero-inferior limit of a vertebra and the lamina below (Cailliet 1962) (see inset Fig. 4). The method of the measurement of the decreased diameter was examined in two necropsy cases of cervical myelopathy.
RESULTS

Normal Japanese men (Group 1)—Figure 1 shows the mean and the range of the antero-posterior diameter (O) at the several levels from C.1 to C.7 in the twenty normal subjects. The variation ranges from 5 millimetres at C.1 to 10 millimetres at C.3-4. The mean diameter becomes physiologically reduced between C.3 and C.6 and at C.5-6 is the least (15 millimetres).

![Graph](image1)

**Fig. 2**
A graph to compare the antero-posterior diameters recorded in twenty normal Japanese men (---) and twenty Japanese men with cervical spondylosis (———) with the findings of Payne and Spillane in adult European subjects, either normal (---) or with spondylosis (———).

![Graph](image2)

**Fig. 3**
Two graphs obtained from measurement of the initial (O) and reduced (S) diameters in eleven Japanese men with spondylosis but no neurological symptoms (Group 2).

The antero-posterior diameter of the cervical spinal canal of normal Japanese men would appear to be smaller by 1·3 to 3 millimetres than was found by Payne and Spillane in Europeans (Fig. 2). Thus it may be concluded that measurements of the normal cervical canal in English and American subjects do not apply to Japanese.

Cervical spondylosis without neurological symptoms (Group 2)—Figure 3 shows the antero-posterior diameters of Group 2. These values were larger by 0·2 to 2·3 millimetres than those
of Groups 1 and 3. At C.5 and at C.6 they were larger by 2.3 millimetres and 1.1 millimetres. Moreover, the decreased diameter (S) of the narrowest canal was 14 millimetres at C.4 to C.6. Such a size seems to be too large for compression. **Cervical spondylosis with myelopathy (Group 3)**—Figure 4 shows that the mean size was 19 millimetres at C.1 and 12.4 to 12.6 millimetres at C.4 to C.7. These values were smaller by 2.4 to 2.6 millimetres than for the control group. Regarding the decreased diameter (S), the mean values proved to be reduced at all levels. The tendency was especially distinct at C.4 to C.6, where the values were 11 to 12 millimetres.

These findings suggested that cord compression may occur when the diameter is between 11 and 12 millimetres in the neutral position.

**NECROPSY STUDIES**

Evaluation of the decreased diameter of the cervical spinal canal was done in two cases of cervical myelopathy examined at necropsy.

**CASE REPORTS**

Case 1—A man aged forty-three was admitted to the Niigata University Hospital on July 20, 1964, and died five weeks later. He had first noticed numbness of the fingers of the left hand in December 1963. In May 1964 he became aware of progressive weakness of both upper limbs and of the left lower limb. Cutaneous sensibility was impaired below the level of the third cervical dermatome, more marked distally. All tendon reflexes were exaggerated but pathological reflexes were not seen. Simple radiographs showed narrowing of the intervertebral disc space at C.2-3 and osteophytes at C.2-3 and C.3-4. Myelography showed an H-shaped deformation at C.2-3 (Figs. 5 and 6).

**Summary of necropsy findings**—There was a disc protrusion at C.2-3 (Fig. 7). Osteophyte formation and thickening both of the dura and of the posterior longitudinal ligament were seen at C.2-3-4. The spinal cord at C.2-3 was markedly compressed by the protruded disc (by 4 to 5 millimetres). The antero-posterior diameter of the cord was reduced to 6 millimetres, the transverse diameter being 12 millimetres.

In this case the antero-posterior diameter (O) of the spinal canal and the decreased diameter (S) had been measured (Fig. 8). Regarding the decreased diameter, the size of the narrowest, at C.2-3, was 13 millimetres. This value seemed to indicate enough space for the spinal cord not to be compressed, but myelography showed the indentation at C.2-3. This discrepancy was attributed to the technical limitation by which the encroachment of a disc protrusion cannot be assessed on radiographs.
The importance of the sagittal diameters of the cervical spinal canal

FIG. 5
Case 1. Figure 5—A lateral myelograph taken after cisternal puncture showing a block about the level of C2.

FIG. 6
Figure 6—The antero-posterior myelograph showing an H-shaped deformation of the column of medium at the level of C2-3.

FIG. 7
Case 1. Figure 7—Section showing the disc protrusion encroaching upon the spinal canal.

FIG. 8
Figure 8—A graph showing the initial (-----) and decreased (---) diameters of the bony spinal canal in this male patient with spondylosis and myelopathy. The arrow indicates the site of block, at the level of C2-3, where the cord measured only 6 millimetres in the antero-posterior direction and 12 millimetres transversely.
Case 2—A man aged forty-eight was admitted to the Niigata University Hospital on December 12, 1962, and died six weeks later. At the age of twenty-one he had first noticed weakness of the lower limbs and impaired sensibility in the right upper and lower limbs. In May 1960 he developed weakness of the lower limbs and became aware of difficulty in walking. The impairment of cutaneous sensation spread to the level of the third dermatome. Sphincter control was disturbed. On examination the muscles of both hands were markedly wasted. All tendon reflexes were markedly exaggerated. Babinski and Rossolimo reflexes were present. Plain radiographs revealed posterior osteophytes at the level of C.4-5 and C.5-6 and thickening and calcification of the posterior longitudinal ligament at all levels (Fig. 9). Myelography showed a block at the level of C.4.

Summary of necropsy findings—There were disc protrusions at the C.4-5, C.5-6 and C.6-7 levels, and fibrosis with marked calcification involving the dura, the posterior longitudinal ligament and the ligamenta flava over all the cervical region. Compression atrophy of the cord was recognised at almost all levels, the greatest degree being at C.4-5, where the antero-posterior diameter was 4 millimetres and the transverse 10 millimetres. In such a case the decreased antero-posterior diameter of the canal has to be measured radiographically from the posterior border of the longitudinal ligament (Fig. 10).

DISCUSSION

In general the diagnosis of cervical spondylosis is made by the findings in plain radiographs, which show narrowing of the disc spaces and osteophyte formation on the vertebral bodies. If neurological symptoms occur in addition, they may be attributed to the spondylotic lesion. On the other hand, as has already been related, such symptoms when associated with minimal radiological changes of cervical spondylosis may be mistaken for other space-occupying lesions or for motor neurone diseases. In order to avoid such a wrong diagnosis, the size of the cervical spinal canal must be measured. Whether the cord is compressed or not depends on the mutual relationship between the size of the canal and the amount of encroachment of the disc protrusion or osteophyte.

As Hinck and Sachdev (1966) pointed out, the antero-posterior diameter is the best guide for detecting stenosis produced by cervical spondylosis. The sagittal diameters of the normal
cervical canal in relation to spondylosis have been reported on by Wolf et al. in 1956 and by Payne and Spillane in 1957, but most of their normal controls were of European stock. This value in Japanese adults is smaller by 2-25 millimetres. If the incidence of cervical spondylosis and the size of the spinal cord were equal in the two races, it could be concluded from the above finding that the Japanese would sustain spondylotic myelopathy more easily.

The average antero-posterior diameter of the cervical spinal canal at the C.4-7 levels in cervical myelopathy was smaller by 3 millimetres than in the control group. This shows that the initial size of the cervical spinal canal is a determining factor in the development of cervical myelopathy. Generally speaking, cord compression may occur if the initial diameter is 10 millimetres or less, but it is unlikely to occur if the diameter of the spinal canal is 13 millimetres or more (Wolf et al. 1956, Cailliet 1962). The range of the antero-posterior diameter of the normal spinal cord of Japanese is from 8·2 to 9·8 millimetres at C.5-7 and 10·3 millimetres at C.1-3 (Tokieda 1959). Nevertheless, the decreased diameter (S) of Group 2 showed that the cervical cord might be compressed if the diameter is on average 11 to 12 millimetres in the neutral position. Moreover, extension and full flexion of the neck may alter the diameter by 2 millimetres. Especially in hyperextension the ligamenta flava are relaxed and bulge forwards to reduce the diameter of the canal (Taylor 1953). It is inferred from these facts that cord compression may occur if the diameter is reduced to about 12 millimetres.

Despite marked changes of spondylosis, cord compression did not occur in some cases. In these the average antero-posterior diameter was 16·2 millimetres at C.4-7, slightly greater by about 0·7 millimetre than in the control group at C.3-7. As has already been pointed out, the mean antero-posterior diameter of the canal in spondylosis without neurological symptoms was the largest of the three groups. As the average value of the decreased diameter (S) was about 15 millimetres, it was demonstrated that the canal was too large for compression to occur.

Hinck and Sachdev (1966) related that the sagittal diameter of the cervical spinal canal was the best guide for detecting a stenosis. However, because this method is applicable only for measurement of the initial size of the canal, the decreased diameter must also be measured in order to know the size after encroachment by osteophytes. But encroachment by a disc protrusion is not always detectable in the standard lateral radiograph, and in such cases the real size of the narrowed canal can seldom be measured. For example, in the first case report the disc protrusion at C.2-3 could not be identified on lateral radiographs, whereas myelography suggested the disc protrusion found at necropsy.

As already mentioned, there are other factors contributing to stenosis of the cervical canal besides disc protrusion, such as hypertrophy of the soft tissues around the cord which cannot be clearly seen on radiographs unless there is marked calcification. As the second case showed, however, hypertrophy of the posterior longitudinal ligament is often seen on the radiograph as a calcified shadow. In such cases the diameter of the cervical canal must be measured from the posterior border of the ligament.

**SUMMARY**

1. The antero-posterior or sagittal diameter of the cervical spine has been measured radiographically in fifty-one Japanese men who fell into three groups—twenty with normal cervical spines, eleven with spondylosis but no neurological symptoms, and twenty with spondylosis and myelopathy.
2. The average normal diameter was found smaller by 2·25 millimetres in Japanese men than in European adults examined by other authors.
3. The average initial diameter in cases of spondylosis without neurological symptoms was found to be greater than normal, which suggests that the increased space round the cord helps to avoid compression.
4. The average initial diameter in cases of spondylosis with myelopathy was found to be less
than normal, which suggests that compression may be determined by moderate osteophyte formation or disc protrusion.

5. The risk of myelopathy would appear to be high when the average diameter is 12 millimetres or less.

6. The difficulty with such radiological measurements is that standard lateral films cannot always record the degree of encroachment by disc protrusion or by hypertrophy of the soft tissues.

REFERENCES


