THE SAGITTAL DIAMETER OF THE CERVICAL SPINAL CANAL

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SYNOPSIS

The sagittal diameter of the cervical spinal canal was measured from radiographs of 400 subjects. Standardised techniques, as described below, were used. The subjects comprising an equal number of both sexes, were normal in the sense that those with clinical features suggestive of cervical spondylosis or spondylotic myelopathy were excluded. The results indicate that local individuals had, on an average, a narrower antero-posterior diameter of the cervical spinal canal compared with Western subjects. Workers in this field have shown that a narrow spinal canal predisposes to spondylotic myelopathy. Though the cross-sectional diameters of the spinal cord have not been determined in a large sample of the local people, the finding suggests that a narrow cervical spinal canal constitutes a definite handicap and that local subjects are probably more prone to myelopathic changes.

Apart from the sella turcica and the obstetric pelvis, probably no other anatomical structure has been measured more extensively by X-ray methods than the bony canal of the cervical spine. As many as seven groups of workers have recorded measurements of its anteroposterior diameters in adults (Boijsen, 1954; Wolf *et al*, 1956; Payne and Spillane, 1957; Wholey *et al*, 1958; Burrows, 1963; Crandall and Hanafee, 1964; Sachdev and Soo, 1970) and many other investigators have also determined its transverse diameters (Elsberg and Dyke, 1934; Landmesser and Heublein, 1953; Simril and Thurston, 1955; Schwartz, 1956; Hinck *et al*, 1966). Mensuration of the canal of the cervical spine has also been made in children.

Interest stems mainly from a high frequency of cervical spondylosis and spondylotic myelopathy seen in the ageing community. It is widely believed that the dimensions of the cervical spinal canal, particularly the antero-posterior diameter, play an important contributory role in the causation of spondylotic myelopathy.

The paper records the antero-posterior diameter of the cervical spinal canal, segment by segment, in a relatively large group of local adults. Certain interesting observations arising from this study are also noted and discussed.

MATERIAL AND METHOD

A total of 400 subjects comprising an equal number of both sexes was studied. Their ages ranged from 20 to 80. No selection was made except that cases referred for radiography with complaints suggestive of cervical spondylosis and/or myelopathy were excluded. Most patients in the study group had lateral neck X-rays because of trauma to the cervical spine, suspected foreign body in the throat and for the investigation of nasopharyngeal carcinoma. The breakdown of the series into ethnic groups is shown in Table I.

TABLE I

Ethnic Group	Males	Females
Chinese	157	171
Malays	16	14
Indians	22	12
Others	5	3
TOTAL	200	200

A conventional method of radiography was adopted. The subject was X-rayed in a true lateral position with his right shoulder pressed against the cassette holder. Of importance was the fact that the focus-film distance of 72 inches (183 cm.) was employed. Teleradiography minimised object magnification and was particularly useful as the object-film distance varied slightly with the shoulder width of the subject.

The method of measuring the antero-posterior diameter of the canal in each cervical vertebra is shown in Fig. 1. This was the method of Boijsen (1954) and was employed by most workers. The antero-posterior diameter of the spinal canal was defined as the distance from the midpoint on the posterior border of the body to the nearest point on the lamina of the respective vertebra. In the case of the atlas, the measurement was taken

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TABLE II

MEASUREMENTS IN FOUR HUNDRED NORMALS

	Millimetres	11·5	12	12·5	13	13·5	14	14·5	15	15·5	16	16·5	17	17·5	18	18·5	19	19·5	20	20·5	21	21·5	22	22·5	23	23·5	24	24·5	25	25·5	26	26·5	27
200 MALES	C.1											2	3	7	13	9	13	18	21	12	16	24	13	16	14	5	4	4	3	1	1	—	1
	C.2									5	6	6	13	13	20	22	24	22	19	15	15	9	4	5	1	1							
	C.3			2	1	6	13	16	22	38	30	24	18	14	7	4	3	—	1	—	—	—	1										
	C.4		2	4	6	9	19	19	38	32	26	20	7	9	7	—	2																
	C.5			2	6	6	13	21	28	35	35	20	11	7	6	6	3	1															
	C.6			1	2	10	11	15	27	22	32	28	16	16	7	5	3	3	2														
	C.7				2	6	14	20	24	30	30	25	15	16	10	3	2	1	1	—	1												
200 FEMALES	C.1								1	3	2	3	6	7	13	22	25	23	19	20	18	14	12	6	4	—	—	1	—	1			
	C.2								4	8	9	16	24	21	29	36	22	16	8	3	3	1											
	C.3		1	—	13	16	19	32	32	34	23	13	9	6	1	1																	
	C.4		3	9	14	25	32	30	30	26	12	9	9	1																			
	C.5		1	5	10	18	34	43	26	25	16	11	7	3	1																		
	C.6			3	6	16	25	42	33	26	25	13	7	1	1	2																	
	C.7	1	1	1	9	15	31	42	35	34	16	7	6	1	—	1																	

TABLE III

NORMAL RANGE OF VARIATION IN VARIOUS SERIES

Series	Focus-film distance	Number of Cases	Measurement (in mm.)													
			C.1		C.2		C.3		C.4		C.5		C.6		C.7	
			Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Boijsen (1954)	1·5 m (59 in.)	200	19-32	—	16-27	—	15-25	—	14-24	—	14-23	—	14-23	—	14-23	—
Wolf, Khilnani and Malis (1956)	72 in.	200	16-30	—	15-27	—	13-22	—	13-22	—	12-21	—	13-22	—	12-22	—
Payne and Spillane (1957)	72 in.	90	16-26	—	15-23		12·5-22	—	12-20	—	12-22	—	11-20	—	11-20	—
Wholey, Bruwer and Baker (1958)	60 in.	480	16-30	21·4	16-28	19·2	14-25	19·1	—	—	14-25	18·5	—	—	13-24	17·5
Burrows (1963)	72 in.	300	16-27	22·9	15-25	20·3	12-23	18·5	12-22	17·7	12-22	17·7	12-21	17·5	12-21	17·3
Sachdev and Soo (1970)	72 in.	98	—	—	13-32	20	13-20	17·5	12-20	17	12-20	15·5	12-18	16	12-18	15
Oon (1974)	72 in.	400	15-27	20·3	15-23·5	18·5	12-22	15·5	12-19	14·9	12-19·5	15·2	12-20	15·5	11·5-21	15·4

Fig. 1: The endpoints for determining the sagittal diameter of the cervical spinal canal are shown. This is in accordance with the method of Boijsen (1954).

from the posterior surface of the atlanto-axial joint to the nearest point where the two limbs of the posterior arch of C1 unite.

In most cases, the posterior border of the vertebral body was shown by a single cortical line. When double lines were visualised on a proper lateral view, the anterior one was taken to represent the posterior surface of the vertebral body in the midplane (Burrows, 1963). This point is best illustrated graphically in Fig. 2.

RESULTS

Details of the measurements made from radiographs of 200 males and 200 females are given in Table II. A comparison of the range of variation present is made with that recorded by previous workers in Table III.

The analysis confirms the result of previous studies that there was a gradual diminution in the sagittal diameter of the spinal canal from the foramen manum to the level of the fourth cervical vertebra. Beyond this level as far as the upper thoracic spine, it had been shown that the measurement remained constant. Our study however indicates that the fourth cervical vertebra had a significantly narrower antero-posterior diameter than that for the rest of the lower cervical vertebrae.

Another interesting finding arising from the exercise is that the sagittal diameter of the cervical spinal canal in the local population was, on the average, 2 to 3 mm shorter than that found in Western subjects. Sachdev and Soo (1970) who made a study of 98 normal Malaysian subjects found their measurements were much lower than those of the European population. However the differences noted were not as marked when compared with figures derived from the present study. The lower mean values of the sagittal diameters were ascribed to the fact that while the lower limits of the normal range corresponded to figures found in the European population, the upper limits were much reduced.

Another feature worthwhile noting is that the antero-posterior diameter of the cervical spinal canal in local females was narrower than those in the local males by about 1 to 1·5 mm (Table IV). This confirms the finding of previous investigators.

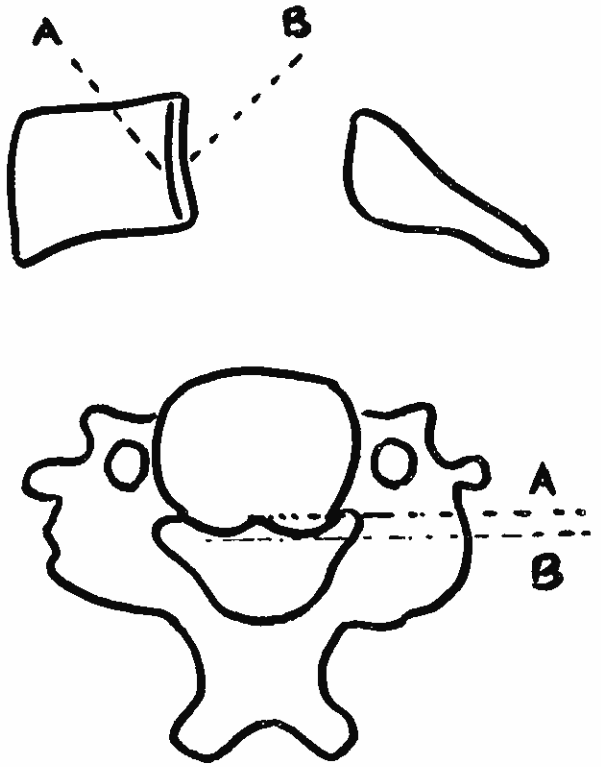

Fig. 2: Occasionally, on a well taken lateral view of the cervical spine (upper diagram), double cortical lines are seen on the posterior aspect of the vertebral body. In such a situation, the anterior line represents the midline posterior limit of the vertebral body, as demonstrated in the lower diagram. (After Burrows, 1963).

DISCUSSION

The canal of each cervical vertebra, except for the atlas and axis is three-sided, with the triangular base formed by the posterior surface of the body. The cross-section of the spinal cord which lies within the canal is, on the other hand, ellipsoidal. As the interpedicular or side-to-side distance is nearly twice the sagittal diameter of the canal, there is more room for the cord to expand sideways and less in the antero-posterior direction. For this reason, the antero-posterior diameter of the cervical spinal canal is considered the most useful measurement (Young, 1967).

The available space in the spinal canal is reduced by the presence of spondylotic bars, herniation of intervertebral discs, hypertrophy of the ligamentum flavum and vertebral subluxation. Spondylotic bars may be formed at the neurocentral joints of Luschka. These consist of hypertrophic bony and cartilaginous spurs which project posteriorly into the spinal canal or postero-laterally into the intervertebral foramina. The occurrence of cervical disc prolapse is uncommon and usually follows acute trauma. Hypertrophy of the ligamentum flavum which lines the cervical canal dorsal to the cord may result from degenerative swelling. Vertebral subluxation secondary to ligamentous laxity gives rise to disalignment of the cervical vertebrae especially on movement.

The spondylotic bars, in particular, may indent on the spinal cord (Wilkinson, 1960) and may also compromise the circulation to the cord (Brain, 1956). The ligamentum flavum wrinkles and becomes folded with the neck in full extension and may press directly on the dorsal aspect of the cord (Taylor, 1953; McRae, 1956). In view of these changes, Arnold (1955) and Mayfield (1955) postulated that subjects with constitutionally small cervical spinal canal would be predisposed to spondylotic myelopathy.

Boijsen (1954) is probably the first to record measurements of the sagittal diameter of the cervical spinal canal from radiographs. His method has been widely adopted by other workers. Wolf *et al* (1956) introduced a regrettable variation in the technique of measurement. These investigators estimated the sagittal diameters from the upper or lower corners of the vertebral body to the nearest point of the corresponding lamina. Though it is appreciated that this method takes into account the narrowest sagittal diameter, the measurement is subject to variation when osteophytes are present at the posterior corners of the body. Boijsen's method, on the other hand, gives a truer picture of the basic or initial sagittal diameter of the spinal canal.

The measurements in a sample of local population are compared with those made by previous workers of Western subjects, predominantly of Caucasian stock. In our study, the vast majority were Chinese. Patients examined for neck pain or upper limb pain of the radicular type were not considered as it was thought that inclusion of these patients might influence or distort the results. It is interesting to note that such cases were included in many previous series and made up the majority of some groups (Payne and Spillane, 1957; Burrows, 1963).

It has been noted that the sagittal diameter of the cervical spinal canal of local subjects was smaller than that found in Western subjects. This is a significant finding as the radiographic study and measurement were made using comparable techniques. The result is corroborated by another study of a group of 98 normal volunteers in Malaysia (Sachdev and Soo, 1970).

It is of importance to the discussion to distinguish cervical spondylosis from spondylotic myelopathy. Cervical spondylosis refers to degenerative changes, mainly of osteocartilaginous or ligamentous origin, occurring in the spine. Spondylotic myelopathy, on the other hand, relates to pathological changes taking place in the spinal cord as a result of pressure or ischaemia. These manifest clinically as neurological deficits.

The local incidence of cervical spondylosis and myelopathy has not been worked out. However, the impression of experienced observers is that while cervical spondylosis is common during and after middle age, this condition is not as widespread as in Western communities (Seah, 1973; Tham, 1973). The difference in incidence is probably due to the fact that ageing members form a larger proportion in the Western population. It is possible, however, the necks of Western individuals are subject to greater stress and strain. One cause worth looking into is minor repeated traumata human necks are exposed to as a result of extensive motorisation.

Cervical spondylosis in turn produces myelopathic changes in a proportion of patients. Investigators in this field have demonstrated that a narrower spinal canal predisposes to spondylotic myelopathy and there has been no reason to question this hypothesis. Work has not been done to measure the cross-sectional diameters and area of the spinal cord of local subjects. Until this vital piece of information is available, it is difficult to evaluate the significance of a narrower cervical spinal canal found in the local people. Nevertheless, the fact suggests that a

narrow cervical spinal canal constitutes a definite handicap and that the local subjects are probably more prone to myelopathic changes.

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