IJAE
Vol. 123, n. 3: 282-287, 2018
ITALIAN JOURNAL OF ANATOMY AND EMBRYOLOGY

Research Article - Basic and Applied Anatomy

Do universal critical spine dimensions exist?

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Abstract

The effective spinal canal diameter is the fundamental index which will determine whether a patient of any compressive cervical spine pathology will get neurological deficit or not. So we analysed this index in our subset of population. 180 subjects with normal or near normal cervical spine magnetic resonance imaging were included. Antero-posterior diameter and transverse diameter of spinal canal from C3 to C7 was measured. Similarly spinal cord antero-posterior and transverse diameters were measured. Space available for cord was calculated at each of these levels in both sexes as the difference between the antero-posterior diameter of the spinal canal and that of the spinal cord. The mean value with standard deviation of cervical spinal canal diameter antero-posterior diameter at C3, C4, C5, C6 and C7 was 13.69±1.248, 13.34±1.186, 13.15±1.233, 13.12±1.275 and 13.73±1.226 mm respectively. The spinal cord antero-posterior diameter at the same level was 7.61±0.728, 7.58±0.677, 7.40±0.653, 7.12±0.657 and 6.69±0.622 mm respectively. The mean cervical spinal canal diameter of the local population in our region is different from the rest of the country. This has two implications; first the ancestral lineage is matching with some remote races of the world for which a detailed study may be needed. Secondly the dimension at which we call çritical stenosis may be different in the region as compared with the rest of the country.

Key words

Spine, diameter, cervical, magnetic resonance, NMR.

Introduction

Although spinal stenosis has been recognised for many years as a clinical diagnosis, it is yet to exactly defined and agreed upon. This lack of definition leads to difficulties in comparing and interpreting studies of the prevalence, incidence and treatment thereof (Jansson et al., 2003). This could be in part due to differences in spinal canal dimensions that exist between population groups as documented by various authors (Crock, 1981; Postacchini et al., 1981; Amono-Kuofi, 1982; Berry et al., 1987; Scoles et al., 1988)

Cervical spinal stenosis is a narrowing of the cervical spinal canal and is associated with compression of the spinal cord (Scoles et al., 1988). A midsagittal spinal canal diameter of less than 12 mm is believed to be indicative of cervical spinal stenosis (Inoue et al., 1996), and is observed frequently in patients experiencing neurological symptoms related to those of cervical spinal stenosis. Although spinal stenosis is mainly a disease associated with the elderly (Wunschmann et al., 2003; LaBan et al.,

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http://www.fupress.com/ijae
DOI: 10.13128/IJAE-25421

2004), cases of developmental cervical spinal stenosis, occurrence of stenosis in children (Starshak et al., 1987) and cervical stenosis associated with Down's syndrome (Frost et al., 1999) are also documented. Correct diagnosis of cervical spinal stenosis is greatly responsible for quick and accurate treatment of the associated pathology and to ensure optimal treatment and procedural outcome (Goldberg et al., 2002).

Magnetic resonance imaging (MRI) displays the bony architecture less well than computerized tomography (CT) but displays beautifully the contained bone marrow and often shows the ligaments and fascia. In addition, MRI provides information about the bone marrow not previously available by imaging. The size of the canal has also been reported to function as a diagnostic tool on the development of myelopathy, in patients with degenerative stenosis. This data could be useful for preoperative planning and surgical approach to the cervical spine. The present study was undertaken to determine the dimensions of cervical vertebral canal in Kashmiri adults as no reference levels for Kashmiris has been studied so far.

Material and methods

This was a hospital based Cross-Sectional observational study.

Examination was done using a Magnetom 3 tesla Skyra MRI Scanner (Siemens, Munich, Germany) at a high volume centre. The data was meticulously choosen by the radiologists. Only those MR images which were declared as 'normal' or 'near normal' by radiologists, of patients 18 to 40 years of age, were included in this study. The sagittal spinal canal diameter was measured as the shortest distance from vertebral bodies' superior and inferior endplates and middle of vertebral body to spinal laminar line. Three measurements were taken at each level and their mean was calculated. The transverse diameter was taken as maximum distance in millimetres at each level transversely. Each level was defined as including all sections through the associated vertebral body.

Space available for cord was calculated by subtracting sagittal diameter of spinal cord from sagittal diameter of spinal canal of the same vertebral level.

Statistical package for social sciences (SPSS) version 16 was used for data analysis. The data was first keyed in MS Excel before converting it into SPSS for analysis. The results were expressed as percentages, mean±SD, or median (IQR) as specified. Pearson's Chi square method was used for comparing proportions and percentages. ANOVA was used wherever needed.

Results

The total number of cervical spine MRI studied were 180. There were 72 male subjects (40%) and 108 females subjects (60%). A majority of the subjects (46.66%) were in the age group of 36-40 years whereas 21.22% were in the 31-35 age group and 16.11% were in the 18-25 years age group. The mean age was 33.29±6.24 years with a range of 18-40 years in males whereas it was 33.08±6.12 with a range of 22-40 years in females. This difference was statistically insignificant. The dimensions are tabulated in Tables 1 to 6.

Table 1. Sagittal (antero-posterior) diameter of cervical spinal canal (mm).

	C3 Mean ± SD	C4 Mean + SD	C5 Mean + SD	C6 Mean + SD	C7 Mean + SD
Male	13.70±1.20	13.38±1.15	13.18±1.22	13.13±1.24	13.75±1.18
Female	13.69±1.27	13.32±1.21	13.13±1.24	13.12±1.30	13.72±1.26
Total	13.69±1.24	13.34±1.18	13.15±1.23	13.12±1.27	13.73±1.22

Table 2. Transverse diameter of cervical spinal canals (mm).

	C3 Mean ± SD	C4 Mean + SD	C5 Mean + SD	C6 Mean + SD	C7 Mean + SD
Male	20.52±1.41	20.00±1.32	19.91±1.33	19.84±1.46	19.71±1.55
Female	20.55±1.48	20.10±1.42	20.053±1.39	19.96±1.60	19.78±1.68
Total	20.63±1.45	20.06±1.38	19.99±1.36	19.91±1.54	19.75±1.63

Table 3. Sagittal (antero-posterior) diameter of cervical spinal cord (mm).

	C3 Mean ± SD	C4 Mean + SD	C5 Mean + SD	C6 Mean + SD	C7 Mean + SD
Male	7.66±0.71	7.62±0.66	7.41±0.61	7.14±0.63	6.70±0.60
Female	7.58±0.73	7.55±0.68	7.39±0.68	7.11±0.67	6.685±0.63
Total	7.61±0.72	7.58±0.67	7.40±0.65	7.12±0.65	6.69±0.62

Table 4. Transverse diameter of cervical spinal cord (mm).

	C3 Mean ± SD	C4 Mean + SD	C5 Mean + SD	C6 Mean + SD	C7 Mean + SD
Male	12.73±1.08	13.37±1.06	13.42±0.98	13.22±0.93	12.47±1.24
Female	12.64±1.05	13.31±1.08	13.42±1.01	13.22±0.92	12.23±1.12
Total	12.67+1.06	13.34+1.07	13.42+0.99	13.22+0.92	12.33+1.17

Table 5. Space available for cord* (mm).

	C3 Mean ± SD	C4 Mean + SD	C5 Mean + SD	C6 Mean + SD	C7 Mean + SD
Male	6.04±1.08	5.75±0.95	5.76±1.00	5.99±1.13	7.04±1.30
Female	6.11±1.14	5.76±0.99	5.74±1.00	6.01±1.17	7.03±1.35
Total	6.08±1.11	5.75±0.97	5.75±1.00	6.00±1.15	7.04±1.32

* The space available for cord was calculated along the sagittal (antero-posterior) axis as the difference between the antero-posterior diameter of the spinal canal and that of the spinal cord.

Table 6. Comparison of mean antero-posterior spinal canal diameter (mm) in different ethnic populations with the results of present study.

		C3	C4	C5	C6
Indians	Male	17.07	16.59	16.65	16.73
	Female	16.13	15.6	15.72	15.54
Koreans	Male	12.80	13.00	13.20	13.40
	Female	12.90	13.00	13.10	13.40
Israelis	M/F	14.60	14.40	14.30	14.40
South African Blacks	Male	13.40	13.40	13.50	13.70
	Female	13.90	13.40	13.50	13.60
South African Whites	Male	13.90	14.20	14.40	14.40
	Female	16.90	13.70	13.80	13.40
Nepalese	Male	16.62	16.57	16.56	16.67
	Female	13.31	16.18	16.21	16.18
Greek	Male	12.94	13.05	13.43	13.28
	Female	13.70	12.49	12.66	12.52
Present study	Male	13.70	13.38	13.18	13.13
	Female	13.69	13.32	13.13	13.12

Discussion

The importance of measurement of anteroposterior diameter (saggital) of cervical spinal canal is well established. The exact dimensions of cervical spinal cord are important to be considered in the diagnosis, prognosis and treatment of diseases related to cervical spine and spinal cord such as spinal stenosis and intra-spinal tumors. Various investigations such as plain radiographs, myelographs, CT scan and MRI have been used for this purpose. We have used MRI for this purpose as MRI is widely used in diagnosis of cervical spine and cervical cord pathologies. Measurements on CT and MRI for spinal canal and thecal sac have been found to be comparable with mean measurement differences inferior to the degree of precision of the measurement technique itself (Malghem et al., 2009).

We took the dimensions from C3 to C7 levels because the atlas and axis have different shapes compared to other cervical levels and most cases of cervical stenosis or trauma of cervix vertebrae occurs at levels between C4 and C6. The antero-posterior diameter in both males and females showed a decreasing trend from C3-C6 but it was increasing at C7 level. The midsagittal diameter of cervical spinal canal was widest at C7 level, the same had been seen by Lee et al. (1994). The measured values were higher in males than in females. Similar observations were made by other studies (Duman et al., 2014; Evangelopoulos et al., 2012). The mean sagittal diameter of cervical spinal canal is shown in table 5, these diameters are somewhat similar to on MRI imaging in Australian population (Ulrich et al., 1980), and in Korean population (Lee et al., 1994),but is less than the values published for French and Indian populations (Gour et al., 2011; Katholi et al., 2012). However, the latter were measured in lateral radiographs which may explain the discrepancy, as the Povlav and Torg ratio (ratio of sagittal diameter of spinal canal to the sagittal diameter of the vertebral body at the same spinal level) is better representative of spinal canal diameter in lateral radiographs. Compared with radiography, MRI avoids magnification error, allowing for the direct measure of spinal cord (Tierney et al., 2002).

The transverse diameter showed a slightly decreasing trend from C3 to C7. The transverse diameter of cervical spinal canal is nearly twice the anterioposterior diameter, therefore there is more room for spinal canal to expand sideways and less space to expand in antero-posterior direction (Katholi et al., 2012).

The sagittal diameter of cervical spinal cord showed decreasing trend from C3 to C7 with slight male preponderance; a similar trend had been shown by Sherman et al. (1990).

The space available for the cord was narrowest at C4 followed closely by C5, C7 had the widest space available for cord. This trend and the average were similar to those shown in subjects from United States of America (Tierney et al., 2002) and in Macedonian population (Mataveeva et al., 2013).

A comparison of antero-posterior diameter of cervical spinal canal diameter among different ethnic populations, as presented in Table 6, has shown that Indian and Nepali populations have larger antero-posterior diameters than rest of the populations examined. However, in our study the mean antero-posterior diameter was less than the mean antero-posterior diameter of the rest of Indians and almost the same as that of Korean, South African black and Greek populations. It was slightly less than that of Israeli and South African white populations.

Subjects with limited space available for cord may be more susceptible to spinal cord compression even with less marked pathological changes, such as herniated discs, osteophytic spurs and hypertrophy of ligamentum flavum. Critical values of space available for cord may predict development of significant stenosis or increased risk of neurological injury. This is especially important for prevention and counselling on the possible risks for athletes or people with occupations that expose individuals to a greater risk of trauma to cervical spinal canal. Space available for cord is clinically important to decide on therapeutic treatment in traumatic, degenerative and inflammatory conditions of the cervical spine (Mataveeva et al., 2013). The space available for cord is larger in females at most levels so chances of spinal cord compromise are less in females as compared to males. We conclude from our study that universal dimensions for defining a critical diameter do not exist and need to be defined for the various populations.

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