Original Article

Indian Journal of Anatomy
Volume 2 Number 2, July - December 2013

Vertical Orientation of Cervical Part of Vertebral Canal in the Human Foetuses

Nidhi Sharma*, Nazim Nasir, Tarun Prakash Maheshwari*****

Abstract

In a morphometric study of normal human foetuses the size and shape of foetal spinal canal was evaluated to determine the reference values for the cervical part of vertebral canal. 30 human foetuses were dissected which were divided in five different groups I to V with gestational ages of less than 17, 17-20, 21-25, 26-30 and more than 30 weeks respectively. The foetuses were dissected and vertebral canal was exposed in coronal plane. Length of cervical part of vertebral canal and transverse diameters at different vertebral levels were recorded by the help of vernier caliper. The widest part of cervical vertebral canal was observed in the upper segment in first three groups, middle in group IV and in the lower part in foetuses of group V. Aforementioned parameters showed a steady but variable rate of growth with increasing gestational age.

Keywords: Cervical; Foetus; Morphometry; Vertebral canal.

Introduction

Although developmental process during first two months of intrauterine life i.e. embryogenesis, has been thoroughly investigated, features during postembryonic period i.e. foetal anatomy, has received very little attention. Detailed study on foetal anatomy by some of the investigators recently has proved that there are enormous facts of the subject yet to be explored.[1-3]

Foetal anatomy is the emerging specialty in itself, for the diagnosis and treatment of various neural tube defects. The prerequisite for the early diagnosis of disorders is the accurate knowledge of normal spine appearance at different gestational age. In humans, most foetal operations are performed between 18 and 30 weeks of gestation.[4]

Some workers gave a detailed account of foetal development of cervical spine and spinal cord by using different imaging techniques. Remes standardized the morphometry of cervical vertebral bodies in humans during postnatal period and found it to be reliable indicator to study the growth pattern.[5]

Different studies found direct correlation between cervical vertebral morphology of foetuses and newborns with gestational age.[6,7] Castellana and Kosa provided information about morphology of the cervical vertebrae in the foetal-neonatal human skeleton but their main focus was to highlight the ossification centres.[8] Bradley studied normal and abnormal cervical canal by using myelography.[9]

But none of the aforementioned workers provided accurate measurements of various parameters of cervical part of vertebral canal in different foetal age groups. In our study we have not only collected quantitative informations i.e. length and diameters, by

Author's Affiliation: *Assistant Professor, Department of Anatomy, TMMC, TMU, Moradabad, UP, India, **Assistant Professor, Department of Anatomy, King Khalid University, Abha, KSA, ***Demonstrator, Department of Anatomy, SHKM GMC, Nalhar, Mewat, Haryana, India.

Reprint's request: Dr. Nidhi Sharma, Assistant Professor, Department of Anatomy, TMMC, TMU, Moradabad, UP, India.

E-mail: drnidhivarshney@gmail.com & rohitmaxy@gmail.com

(Received on 23.07.2013, accepted on 02.08.2013)

Figure 1: Measuring length of cervical part of vertebral canal by vernier caliper

direct measurements of cervical canal but also highlighted changes in vertical shape of the same in coronal plane in different gestational age groups.

Materials and Methods

Thirty foetal cadavers comprising of equal males and females were collected from museum of Department of Anatomy, TMMC, TMU, Moradabad. Ethical clearance was obtained from Institutional Ethics Committee.

Gestational age was determined with the help of foetal foot length.[10] For the purpose of study 30 foetuses were divided into five groups I, II, III, IV and V with gestational age < 17, 17-20, 21-25, 26-30, >30 respectively, with six foetuses in each group.

A vertical cutaneous incision extending from external occipital protuberance to natal cleft was made on the back of the foetus. Vertebral canal was opened with the help of scissor which was introduced in sacral hiatus on either side of midline then continued upwards, till it reached the posterior arch of atlas. Spinal cord was removed before measuring the cervical part of canal with the help of Venire calipers. Length of the cervical part of vertebral canal was taken from upper border of posterior arch of atlas to lower border of seventh cervical vertebral body (Fig. 1). Transverse diameter of cervical vertebral body was measured at different vertebral levels. Readings were analyzed by using Students't test.

Results

Length of cervical part of vertebral canal showed steady growth with increasing gestational age (Table 1). The growth was statistically insignificant between group I and group II foetuses. Thereafter the growth was highly significant (p value <0.001) with percent change ranging from 14 to 24. O'Rahilly observed vertebral column of nine embryos of 8 postovulatory weeks and compared the lengths of different regions i.e. cervical, thoracic, lumbar, sacral and coccygeal without mentioning the length of cervical canal, though the total length of vertebral column (20-23 mm) was well documented.[11]

In our experiment we compared the transverse diameters of cervical spinal canal at different cervical vertebral levels in the same group of foetuses to determine the vertical shape of canal in coronal plane (Table2-6).

Transverse diameter of vertebral canal in first foetal group at the level of 1st cervical vertebra was 3.15 mm which is increased to 4.5 mm (p value < 0.001) at C_2 level (Table 2). Then upto C_4 there was no significant change but then there was reduction in diameter at the level of C_5 making it 3.43mm. It again increased significantly to reach the value of 4.15mm at the level of C-6 which continued upto C-7 without any change (Table 2).

In second foetal group the transverse

Table 1: Length of cervical part of vertebral canal (mm)

Groups	No. of cases (n)	Mean ± S.D.	Percent change	T value	P value
I	6	18.19 ± 2.87	_	_	_
II	6	19.98 ± 0.66	+10	0.17	Insignificant
III	6	24.85 ± 0.13	+24	6.9	<0.001
IV	6	28.28 ± 0.13	+14	6.78	<0.001
V	6	33.57 ± 0.06	+19	8.87	<0.001

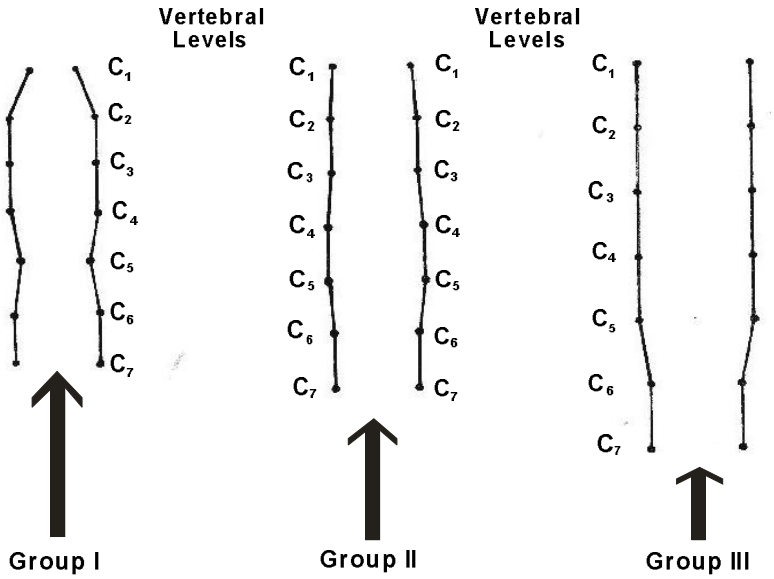
Table 2: Transverse diameter of cervical vertebral canal at different levels of cervical vertebrae in group I foetuses

Cervical vertebral level	Measurements (mm)	Per cent change	T value	P value
1st	3.15 ± 0.04	_	_	_
2nd	4.5 ± 0.06	+43	6.75	<0.001
3rd	4.23 ± 0.52	-6	0.23	Insignificant
4th	4.3 ± 0.13	+2	0.79	Insignificant
5th	3.43 ± 0.12	-20	2.66	<0.001
6th	4.15 ± 0.18	+21	8.46	<0.001
7th	4.13 ± 0.19	-0.5	0.82	Insignificant

Table 3: Transverse diameter of cervical vertebral canal at different levels of cervical vertebrae in group II foetuses

Cervical vertebral level	Measurements (mm)	Percent change	T value	P value
1st	4.1 ± 0.08	_	_	_
2nd	4.5 ± 0.06	+10	5.82	<0.001
3rd	4.5 ± 0.05	0	0.63	Insignificant
4th	4.7 ± 0.03	+4	4.14	<0.001
5th	4.3 ± 0.16	-9	0.004	Insignificant
6th	4.5 ± 0.04	+5	0.05	Insignificant
7th	4.5 ± 0.13	-0	0.67	Insignificant

Fig 2: Vertical orientation of cervical part of vertebral canal in coronal plane in groups I, II, III human foetuses



diameter of vertebral canal increased significantly between 1st and 2nd cervical levels and 3rd and 4th cervical vertebral levels only (Table 3). This made the cervical canal wider in lower part as compared to upper one (Fig 2), possibly to accommodate the cervical enlargement of spinal cord. This also highlighted the importance of upper limbs compared to head and neck in terms of innervations.

In third group transverse diameter of cervical vertebral canal showed a significant decrease only between 5th and 6th cervical vertebral levels making most of the upper cervical canal wider compared to lower one (Fig 2), possibly again to accommodate the cervical enlargement as well as nuclei of cervical plexus (Table 4).This highlighted the importance of both head and neck, upper limb in group III foetuses in terms of development.

The transverse diameter of 6.6 mm in group IV foetuses at 1st cervical vertebral level

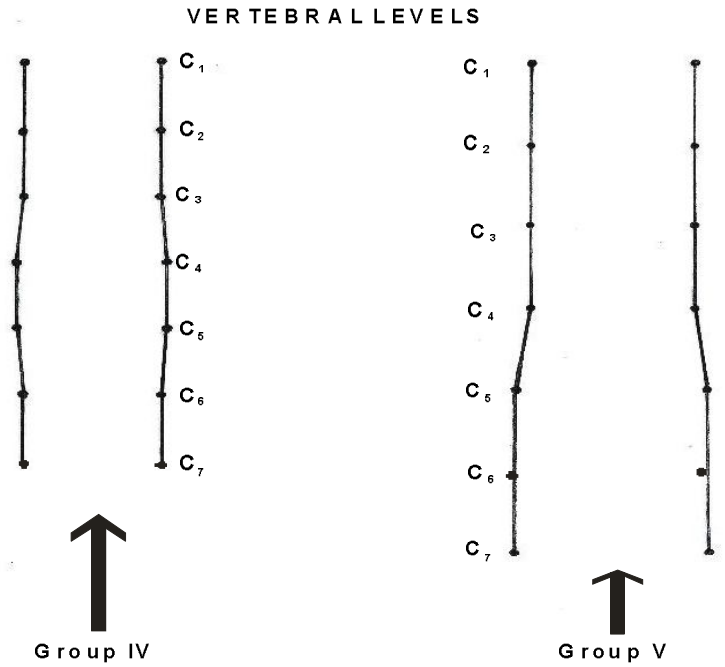
Table 4: Transverse diameter of cervical vertebral canal at different levels of cervical vertebrae in group III foetuses

Cervical vertebral level	Measurements (mm)	Percent change	T value	P value
1st	5.85 ± 0.05	_	_	_
2nd	5.53 ± 0.03	-5	1.37	Insignificant
3rd	5.59 ± 0.05	+1	0.02	Insignificant
4th	5.56 ± 0.04	-0.5	0.22	Insignificant
5th	6.3 ± 0.04	+13	1.23	Insignificant
6th	5.38 ± 0.25	-14	4.44	<0.001
7th	5.88 ± 0.14	+9	0.02	Insignificant

Table 5: Transverse diameter of cervical vertebral canal at different levels of cervical vertebrae in group IV foetuses

Cervical vertebral level	Measurements (mm)	Percent change	T value	P value
1st	6.6 ± 0.06	_	_	_
2nd	6.5 ± 0.02	-2	0.008	Insignificant
3rd	6.5 ± 0.09	0	0.68	Insignificant
4th	6.9 ± 0.03	+6	5.08	<0.001
5th	7.1 ± 0.1	+3	0.004	Insignificant
6th	6.6 ± 0.1	-7	8.12	<0.001
7th	6.5 ± 0.02	-2	0.24	Insignificant

Fig.3: Vertical orientation of cervical part of vertebral canal in coronal plane in groups IV and V human foetuses



showed no change upto 3rd cervical vertebra but the measurement significantly increased to 6.9 mm at C_4 level. It continued to C_5 without any change but then there was significant reduction to make the reading 6.6 mm only at C_6 level which continued upto C7 without any change (Table 5). The cervical canal therefore was widest between C-4 and C-5 vertebral levels located between upper and lower narrow segments (Fig 3). This might be due to fact that in foetal spinal cord, 5th segment was widest part of cervical enlargement as reported by Fountas *et al*[12] and Ko *et al*.[13]

The transverse diameter of spinal canal in V foetal group from level of C_1 to C_4 showed no significant change but at C_5 level it

Table 6: Transverse diameter of cervical vertebral canal at different levels of cervical vertebrae in group V foetuses

Cervical vertebral level	Measurements (mm)	Percent change	T value	P value
1st	7.6 ± 0.06	_	_	_
2nd	7.5 ± 0.03	-1	0.02	Insignificant
3rd	7.5 ± 0.05	0	0.34	Insignificant
4th	7.4 ± 0.03	-1	0.003	Insignificant
5th	7.8 ± 0.04	+5	2.93	<0.001
6th	7.5 ± 0.3	-4	0.02	Insignificant
7th	7.4 ± 0.09	-1	0.52	Insignificant

increased to 7.8 mm which remained the same at the lowest level of cervical spinal canal (Table 6). The wide lower segment again accommodated the cervical enlargement which increased in size due to well developed upper limbs in late foetuses.

Discussion

The most interesting finding in our study was the change in shape of vertical orientation of canal in coronal plane with gestational age. In early groups of foetuses the canal is wider in upper than the lower part. In group IV foetuses the canal was wider in the middle than its extremes i.e., at the upper and lower parts. The largest foetuses of V group showed lower half being wider than upper half. The latter was more like adult in which maximum transverse dimension was reported at the level of C6 and C7 vertebrae (Flyn).[14] Moreover the wider upper cervical spinal canal observed in small foetuses of earlier groups could be explained by the facts that in smaller foetuses head was relatively larger receiving innervations from upper cervical spinal segments. With the relatively faster growth of forelimbs in older foetuses, the cervical enlargement came into existence making the lower part of canal wider. The latter provided origin to roots of brachial plexus.

The knowledge of the parameters and shape of the vertebral canal at different gestational age will prove to be helpful in early diagnosis of the defect in embryological development. Some workers believe that congenital malformations follow two hit hypothesis.[15,16] According to this hypothesis the initial error is the defect in embryological development and secondary injury occurs throughout the gestation with continuous damage to exposed neural tissue. Intra-uterine repair may improve the neurologic outcome by decreasing the secondary damage.

Conclusion

With increasing interest in intrauterine foetal surgeries for corrective developmental defects, these parameters at different gestational age will prove to be helpful in early diagnosis of disease as well as in deciding the prognosis of disease. Besides this, parameters showing steady growth also seemed to be important in determination of gestational age and therefore of great medicolegal importance too.

References

1. Ghaus F, Faruqi NA. Morphometric analysis of developing maxillary sinuses in human foetuses. *Int J Morphol.* 2006; 24(3): 303-308.
2. Ghaus F, Faruqi NA. Morphometric analysis of infraorbital foramen in human foetuses. *Int J Morphol.* 2007; 25(2): 301-304.
3. Ghaus F, Faruqi NA. Bilateral variations and sexual dimorphism in morphometric analysis of infraorbital groove, canal and foramen in human foetuses. *Int J Morphol.* 2009; 27(2): 475-480.
4. Demirkan I, Cevik A. In utero foetal surgery. *Veteriner Cerrahi Dergisi.* 2004; 10(1-2): 66-74.
5. Remes VM. Reference values for radiological evaluations of cervical vertebral body shape and spinal canal. *World Wide Science Org.* 2000.

6. Marginean OM. Study of the correlation between newborn and foetus ages and some morphometric cervical vertebral arches indices. *Rom J Morphol Embryol.* 2008; 49(3): 387-390.
7. Fily RA. Foetal spine morphology and Maturation during the second trimester, Sonographic evaluation. *Journal of Ultrasound in Medicine.* 2002; 6(11): 631-636.
8. Castellana C, Kosa F. Morphology of the cervical vertebrae in the foetal neonatal human skeleton. *Journal of Anatomy.* 1999; 194: 147-152.
9. Bradley WG, Banna M. A study of the tight Dural canal and of syringomyelia by prone and supine myelography. *Br J Radiol.* 1968; 41: 608-614.
10. Streeter GL. Weight, sitting height, head size, foot length and menstrual age for human embryo. *Contrib Embryol.* 1920; 11: 14.
11. O' Rahilly R, Muller F, Meyer DB. The human vertebral column at the end of the embryonic period proper 1: the column as a whole. *Journal of Anatomy.* 1980; 131: 565-575.
12. Fountas KN. Cervical spinal cord- smaller than considered? *Spine Phila Pa.* 1998; 23: 1513-1516.
13. Ko HY, Park JH. Gross quantitative measurements of spinal cord segments in human. *Spinal Cord.* 2004; 42: 35-40.
14. Flynn. Measurement of the vertebral canal dimensions of the neck of the rat with a comparison to the human. *World Wide Science Org.* 2007.
15. Sutton LN, Adzick NS, Bilaniuk LT. Improvement in hindbrain herniation demonstrated by serial fetal magnetic resonance imaging following fetal surgery for myelomeningocele. *JAMA.* 1999; 282: 1826–1831.
16. Bruner JP, Tulipan N, Paschall RL. Fetal surgery for myelomeningocele and the incidence of shunt-dependent hydrocephalus. *JAMA.* 1999; 282: 1819–1825.