



## An Autopsy Study Of The Differences In The Level Of Termination Of Spinal Cord In Fetuses

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### Abstract

**INTRODUCTION:** The spinal cord extends the whole length of the vertebral canal during embryonic period. Then the conus medullaris of the spinal cord ascends gradually throughout the fetal life and reaches the level of L2/L3 vertebrae at the time of birth. Prenatal evaluation of the level of termination of spinal cord is mandatory in every routine antenatal examination. Knowledge of the level of termination of spinal cord is important for routine antenatal examination, when performing neuraxial procedures on premature and newborn babies. Prenatal evaluation of the level of termination of spinal cord is mandatory in every routine antenatal examination and for early diagnosis of tethered spinal cord and to avoid injury of the spinal cord during neuraxial procedures.

**OBJECTIVE:** To determine the level of termination of fetal spinal cord of different gestational age.

**MATERIALS AND METHOD:** The study was conducted among 32 human fetuses with their age ranging from 11 to 38 weeks of gestation. Fetuses were collected from the department of Obstetrics & Gynecology, RIMS, Imphal after taking permission from the concerned authority. Fetuses were divided into 6 clusters (Cluster 1:  $\leq 12$  weeks, Cluster 2: 13 to 18 weeks, Cluster 3: 19 to 24 weeks, Cluster 4: 25 to 30 weeks of gestation, Cluster 5: 31 to 35 weeks, Cluster 6:  $\geq 36$  weeks of gestation). After laminectomy, level of termination of the spinal cord was examined.

**RESULT:** The range of termination of spinal cord in Cluster 1 i.e.  $\leq 12$  weeks was between S5 and S4 vertebrae; in Cluster 2 i.e. from 13 to 18 weeks, between S4 and L4 vertebrae; in Cluster 3 i.e. 19 to 24 weeks, between the L3 and L4 vertebrae; in Cluster 4 i.e. from 25 to 30 weeks, at the level of L3 vertebra; in Cluster 5 i.e. from 31 to 35 weeks of gestation, at L3 vertebra; in Cluster 6 i.e.  $\geq 36$  weeks, at the level of L2 vertebra.

**CONCLUSION:** There was ascent of the level of termination of spinal cord from S5 at 11 weeks to L2 vertebra at 38 weeks of gestation. The normal level of termination of spinal cord is very important to diagnose the abnormal conditions like tethered spinal cord. If the level of termination of the spinal cord is found at the level below L3 to L4, a thorough evaluation will be necessary. In this case a multidisciplinary approach including pediatric neurosurgery is recommended for early prenatal diagnosis and treatment.

**Keywords:** Spinal cord, Conus medullaris

### Introduction

The spinal cord extends the whole length of the vertebral canal during embryonic period. Then the conus medullaris of the spinal cord ascends gradually throughout the fetal life and reaches the level of

L2/L3 vertebrae at the time of birth.<sup>1,2</sup> Neurological outcome following a neural tube defect is closely related to the level of the lesion. A low-lying conus medullaris, the most inferior point of the spinal cord at which it becomes the cauda equina, may be an

indicator of underlying spinal dysraphism, along with other cord abnormalities, or indicative of a tethered cord, which commonly presents with urinary symptoms.<sup>3</sup> Ultrasound Prenatal evaluation of the level of termination of spinal cord is mandatory in every routine antenatal examination. Knowledge of the level of termination of spinal cord is important for routine antenatal examination, when performing neuraxial procedures on premature and newborn babies. The level of termination of the spinal cord is important for early diagnosis of tethered spinal cord and to avoid injury of the spinal cord during neuraxial procedures. It was concluded that when conus medullaris was detected higher than L1-L2 vertebral space or lower than L3, it should prompt prenatal and postnatal surveillance.<sup>4</sup>

### MATERIALS AND METHOD

The cross-sectional study was undertaken at the Department of Anatomy, Regional Institute of Medical Sciences, Imphal, Manipur, using 32 human fetuses with ages ranging from 11 to 38 weeks of gestation, which were products of medical termination of pregnancy and stillbirths. Fetuses were collected after taking permission from the research ethics board. Sample size was calculated using

formula  $N=S^2/e^2$ . Fetuses with gross congenital anomaly were excluded. The fetus was placed in the prone position. A skin incision was made down the midline of the back of the fetus as shown in Fig.1.1, then muscles and ligaments were removed. The 12th thoracic vertebra was confirmed by its articulation with the 12th ribs. Pins were inserted to mark the vertebral levels from the level of the 12th thoracic vertebra to the 5th sacral vertebra. Laminectomy was performed by removing the vertebral lamina of each fetal cadaver (Fig.1.2). A longitudinal midline incision will be given in the posterior dura to expose the spinal cord. The lumbosacral enlargement and conus medullaris were clearly seen. The level of termination of the spinal cord was the level of the attachment of the lowest spinal nerve which coincides approximately with the level of the junction between the conus medullaris and filum terminale (Fig.1.2). The vertebral level of termination of the spinal cord was noted corresponding to the upper, middle and lower borders of the vertebral body. Fetuses were divided into 6 clusters (Cluster 1:  $\leq 12$  weeks, Cluster 2: 13 to 18 weeks, Cluster 3: 9 to 24 weeks, Cluster 4: 25 to 30 weeks of gestation, Cluster 5: 30 to 35 weeks, Cluster 6:  $\geq 36$  weeks of gestation.

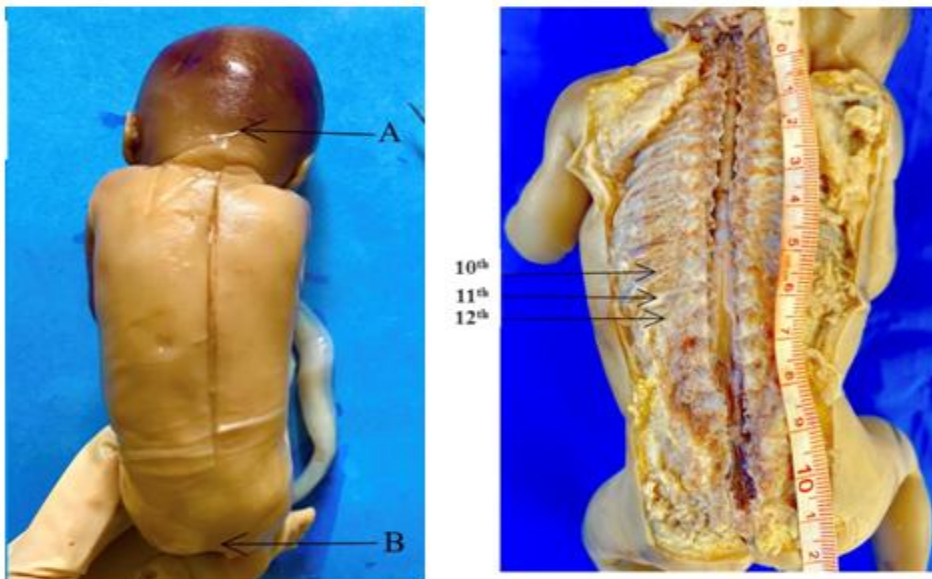


Figure. 1.1: Dissection of the spinal cord: giving a midline incision

A- External occipital protuberance

B- Coccyx

Figure 1.2: After removing skin, soft tissues, muscles and laminectomy (Arrow – level of ribs)

**RESULTS**

The conus medullaris was found at the level of S5 vertebra at 11 weeks of gestation (WOG), at S4 vertebrae at 12 WOG (Fig.2A). The spinal cord extended from the foramen magnum to sacrum till 14 weeks of gestation. The level of termination (LOT) reached the lumbar region at 15 weeks. The LOT was at the level of L4 vertebra at 18 weeks and reached L3 vertebra at 22 WOG (Fig.2B). There was a rapid ascent of the conus medullaris of the spinal cord till the 18 WOG in our study. The LOT was in the lower border of L5 vertebra at 15 WOG, reached L4 vertebral level at 20 WOG. By 33 weeks of gestation, LOT was at the level of the upper border of L3 vertebra. By the age of 37 weeks (at term), the spinal cord terminated at the level of L2 vertebra. The range of termination of spinal cord in Cluster 1 i.e.  $\leq 12$  weeks was between S5 and S4 vertebrae; in Cluster 2 i.e. from 13 to 18 weeks, between S4 and L4 vertebrae; in Cluster 3 i.e. 19 to 24 weeks, between the L3 and L4 vertebrae; in Cluster 4 i.e. from 25 to 30 weeks, at the level of L3 vertebra; in Cluster 5 i.e. from 31 to 35 weeks of gestation, at L3 vertebra; in Cluster 6 i.e.  $\geq 36$  weeks, at the level of L2 vertebra (Table1). There was linear relationship of the ascend of conus medullaris with the increased of gestational age as shown in Fig 3.

Table 1: Showing the differential level of termination of the spinal cord among the different clusters (N=32)

Clusters	GA (weeks)	LOT range	N	Weeks with LOT
1	< 12	S5UB-S4UB	2	11 -S5UB, 12-S4-UB
2	13-18	S4UB-L4LB	7	13-S4UB, 14-S3LB, 15-L5LB, 15-L5LB, 16-L5UB,18-L4LB, 18-L4LB
3	19-24	L4UB-L3MB	10	20- L4UB, 21-L4MB, 21-L4UB, 22-L4MB, 22-L4UB, 22-L3UB, 23-L5UB, 23-L3MB, 24-L3MB, 24-L3MB
4	25-30	L3LB-L3MB	4	26-L3MB, 27-L3MB, 29-L3MB, 30-L3LB
5	31-36	L3MB-L3UB	6	31-L3MB,33-L3UB, 33-L3UB, 34-L3MB, 34-L3UB, 35-L3LB
6	37&above	L2LB-L2MB	3	37-L3UB, 37-L2MB, 38-L2LB

\*UB- Upper border, MB-Middle of the body of the vertebrae, LB- Lower border

Fig.2: A. showing LOT at 12 weeks of gestation, B. LOT at 22 weeks of gestation

CM-Conus medullaris, FT- Filum terminale, LOT-Level of termination



Fig. 2A: Showing LOT at 12 weeks of gestation (LOT-Level of termination)

Fig.2B: Level of termination at 22 weeks of gestation CM-Conus medullaris, FT- Filum terminale

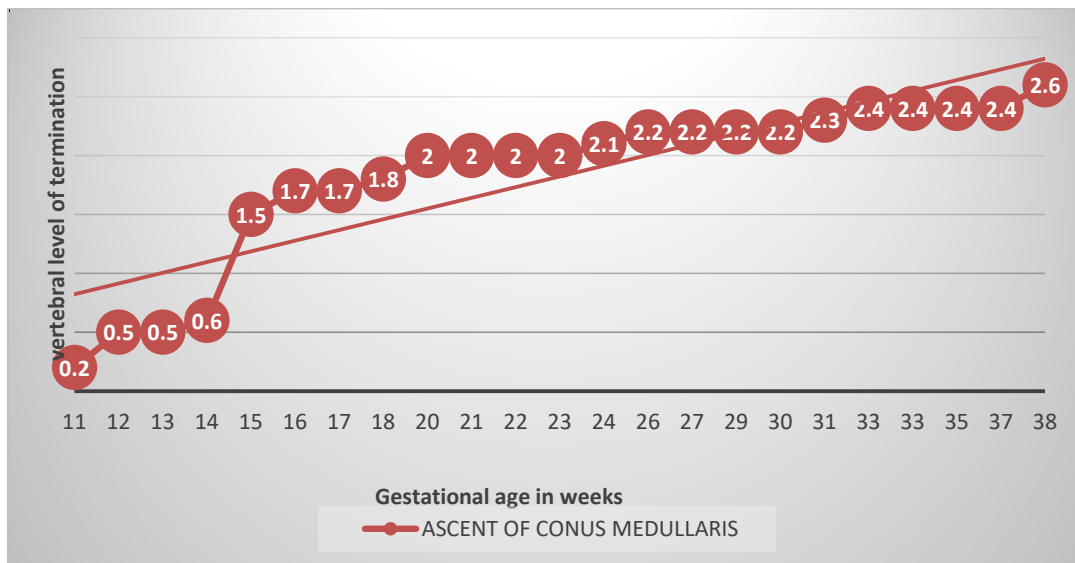


Fig. 3. Showing linear ascend of conus medullaris.

(UB-Upper border of the body of the vertebra, MB—Mid of the body of the vertebra, LB—Lower border of the body of the vertebra).

(S5: LB- 0, MB-0.1, UB-0.2), (S4: LB-0.4, MB-0.5, UB-0.6), (S3: LB-0.7, MB-0.8, UB-0.9), (S2: LB-1, MB-1.1, UB-1.2), (S1: LB-1.3, MB-1.4, UB-1.5), (L5: LB-1.6, MB-1.7, UB-1.8), (L4: LB-1.9, MB-2.0, UB-2.1), (L3:LB-2.2, MB-2.3, UB-2.4), (L2: LB-2.5, MB-2.6, UB-2.7)

**DISCUSSION**

In the present study, the spinal cord extended from the foramen magnum to sacrum till 14 weeks of gestation. The level of termination reached the lower

border of L5 vertebra at 15 WOG, L4 vertebra at 18 weeks and reached L3 vertebra at 22 WOG. There was a rapid ascent of the conus of the spinal cord till the 18th week of gestation in our study. In our study, the level of termination of the spinal cord at 20 weeks of gestational age reached L4 vertebral level. By 33 weeks of gestation LOT was at the level of the upper border of L3 vertebra. By the age of 37 weeks, the spinal cord terminated at the level of L2 vertebra. It reached up to the level of the lower border of L2 vertebra at term i.e. at 38 weeks of gestation. There was linear relationship of the ascend of conus medullaris with the increased gestational age.

Our finding was not lined with the findings of Manzone P et al<sup>5</sup>. In their cross-sectional study, the spinal cord extended from the foramen magnum to the sacrum in the human fetus at the beginning of the 2nd quarter of pregnancy. The level of termination at the 13th week of gestation was at the S2 vertebra in one fetus and at S1 in two fetuses of 13th-week and one fetus of 14th-week and also one 15th-week fetus. The spinal cord of three fetuses of 15th-weeks terminated at the level of L5 and reached at the level of L3 vertebra in the 18th week.

Zalel Y et al<sup>6</sup> observed the position of conus medullaris between L3 and L4 vertebrae in fetuses in the 13 to 18 weeks of gestation, L2 and L3 vertebrae in 19 and 24 weeks of fetuses respectively and at term, all fetuses showed the conus medullaris at L2 vertebra and higher. However, in the present study, the conus medullaris was located between S4 and L4 vertebrae in the fetuses between 13 and 18 weeks.

In our study, the level of termination of the spinal cord was between L4 to L3 vertebrae in 19 to 24 weeks of gestation wherein Perlitz y et al<sup>7</sup> found that in 20th and 24th weeks the conus medullaris ended adjacent to L2 vertebra, L2-L3 interspace and L3 vertebra (73/78, 93%).

Elvan O et al<sup>8</sup> observed the level of termination among 12 human fetuses between 25 and 32 weeks that the conus medullaris level was detected between L1 and L3 segments. Whereas, in the present study, the level of termination was within the body of L3 vertebra in the fetuses with age ranging between 25 and 32 weeks of gestation.

Arthus O et al<sup>9</sup> explained that at 20 weeks of gestation, an estimated 84.2% of fetuses had a conus position of L4/5 vertebra or higher, but only 22.8% at L3 vertebra or higher. By 26 weeks, an estimated 50.7% reached L3 vertebra, and 94.8% reached L3 vertebra by 40 weeks. Their study concluded that there was regular ascent of the conus throughout fetal life. Although growth for each individual fetus may be non-linear, most fetuses have a conus level within the normal adult range by 33 weeks gestation.

In the present study, the level of termination was found between L3 and L4 between 19 to 26 weeks of gestation, at the lower border of S3 in the fetus of 14 weeks of gestation (120 CRL stage). There was rapid ascent of conus medullaris up to 15 weeks of gestation (140 CRL stage). There was uniformly

gradual ascent of level of termination beyond L3 or L4 vertebra and the spinal cord terminated at the level of L2 at term. Our findings was in accordance with the findings of Vettivel S<sup>10</sup>. The author also reported that the conus medullaris was at the level between L3 and L4 vertebra in 111 to 160 CRL age, and reached L2 vertebrae in 161 to 330 CRL. There was rapid ascent of conus medullaris up to 120 mm CRL stage and when it reached L3 to L4 vertebrae, there was a fairly uniform rate of ascent up to 111-140 mm following which the rate decreased gradually. Beyond L3 or L4 vertebra the ascent of conus medullaris was uniformly gradual and the spinal cord terminated at the level of L1 and L2 vertebrae in full term neonates. Similar findings were observed by Malas MA et al<sup>11</sup> also determined the changes in the termination level of conus medullaris using ultrasonography in fetuses, premature babies, neonates and children. They explained that during fetal life the end of the conus medullaris altered its levels from S5 to L3 vertebrae. Foetal spine length grows linearly with increasing gestational age.<sup>12</sup> In an ultrasound study conducted by Hoopmann M et al<sup>13</sup> also found a linear relationship between conus distance and gestational age.

The term fetuses in the present study had their spinal cord terminated at the level of L2/L3 vertebrae. Similarly, Schoor AV et al<sup>14</sup> also determined the location of conus medullaris in the newborn and infant and the spinal cord terminated most frequently at the level of L2/L3 vertebrae. In our study, the level of termination of the spinal cord at term was at the level of L2 vertebra. In line with our study, Icten N et al<sup>15</sup> found that the termination of the spinal cord varied from the L1 to S2 vertebrae, with a mean level between L2 and L3 in the term babies. Similar finding was observed by Rozzelle et al<sup>16</sup> in a cross-sectional study by using ultrasound in fetuses and infants. They also found that the level of termination of spinal cord was at L2 in the newborn / infant group. Wolf S et al<sup>17</sup> reported that, the level of termination of spinal cord in premature and full term babies, the most caudal level of the conus medullaris in two cases were at the level of the middle third of L3 vertebra. 78% of the babies aged between the 30th and 39th postmenstrual weeks had the tip of the conus medullaris between L2 and L4 vertebrae.

## CONCLUSION

There was regular ascent of the level of termination of spinal cord from S5 at 11 weeks to L2 vertebra at 38 weeks of gestation. The normal level of termination of spinal cord is very important to diagnose the abnormal conditions like tethered spinal cord. If the level of termination of the spinal cord is found at the level below L3 to L4, a thorough evaluation will be necessary. In this case a multidisciplinary approach including pediatric neurosurgery is recommended for early prenatal diagnosis and treatment.

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