Original Research Article

A morphometric study of volume of caudal space and sacral canal in dry human sacra

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Abstract

Background: The sacral canal is formed by sacral vertebral foramina and is triangular in section. The volume of caudal space and sacral canal help to know the optimum volume of drugs required to reach the appropriate level in caudal epidural anaesthesia. **Aim:** The aim of this study is to measure volume of sacral canal and caudal space. **Material and Method:** This study was conducted on 109 dry human sacra, obtained from the bone library, Department of Anatomy of tertiary care teaching institutes. **Result:** Mean volume of sacral canal measured was 27.07 cm^3. Mean volume of caudal space measured was 16.02 cm^3. **Conclusion:** The techniques used for measuring volume of sacral canal and caudal space will help clinicians for giving a safe epidural anaesthesia using newer approaches.
Key Word: volume, sacral canal

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INTRODUCTION

The sacral canal is formed by sacral vertebral foramina and is triangular in section. Its upper opening, seen on the basal surface, appears to be set obliquely and its caudal opening is the sacral hiatus. Each lateral wall presents four intervertebral foramina, through which the canal is continuous with pelvic and dorsal sacral foramina. The canal contains the cauda equina, the filum terminale and spinal meninges[1]. During caudal epidural anaesthesia, the anaesthetic solution is injected into epidural cavity. It should reach the level of intervertebral foramina which transmit nerves and the area of distribution of which, needs to be anesthetized[2]. Hence, it is necessary to know the volume of the sacral canal.

The dural and arachnoid sheath of spinal cord terminates at the level of S2 vertebra (varies between the lower border of the S1 foramen in adults and the S3 in children.). The part of sacral canal, below the attachment of dural sheath at S2 is called as caudal epidural space or caudal space. It is filled with fats, venous plexus, filum terminale and coccygeal nerve. This caudal epidural space is utilized to deliver the local anaesthetic drug for caudal epidural block[3].

MATERIAL AND METHOD

This study was conducted on 109 dry human sacra, obtained from the Department of Anatomy of a tertiary care teaching institute. The sacra were of undetermined age and gender. Bones with lumbarization of first sacral vertebra and sacralization of fifth lumbar vertebra were excluded from the study.

The measurements were taken by using digital Vernier caliper (0-200 mm with precision of 0.01 mm), divider, ruler and thread.

The shape of sacral canal varies from the triangular pyramid to oval half cone. In the present study, the volume of sacral canal and caudal space was estimated by applying the mathematical formula of half cone.

Volume of sacral canal: It was measured with formula $\pi D^2H/24$ in which 'D' was transverse diameter at level of

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S1 between lateral margins of first sacral foramina and 'H' was height of sacral canal between upper border of S1 vertebra and sacral apex. 'D' was measured with digital Vernier caliper and 'H' was measured with divider and ruler.

Volume of caudal space: It was measured with formula $\pi d^2 h / 24$ in which 'd' was transverse diameter at level of S2 between lateral margins of second sacral foramina and 'h' was height of caudal space from sacral apex to level of S2 foramina. The 'd' was measured with digital Vernier caliper and 'h' was measured with divider and ruler.

Figure 1:

Figure 2:

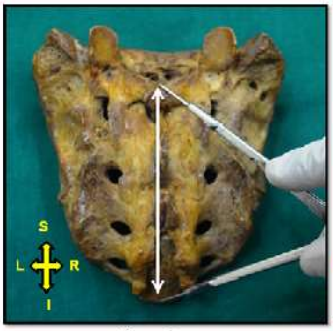

Figure 3:

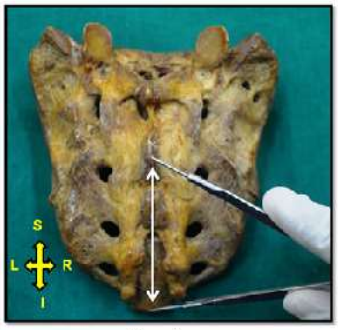

Figure 4:

Figure 1: - Illustration showing measurement of transverse diameter at level of first sacral foramina; **Figure 2:** Illustration showing measurement of transverse diameter at level second sacral foramina; **Figure 3:** Illustration showing measurement of height of sacral canal; **Figure 4:** Illustration showing measurement of height of caudal space

RESULT

Parameters related to sacral canal and caudal space were measured in 109 dry human sacra of undetermined age and gender. Measurements were mentioned in table 1 below.

Table 1: Volume of sacral canal and caudal space

	Minimum (cm^3)	Maximum (cm^3)	Mean (cm^3)	Standard deviation
Volume of sacral canal	14.66	46.78	**27.07**	6.50
Volume of caudal space	8.27	32.81	**16.02**	4.28

DISCUSSIONS

There are only few studies on dry bones in literature on volume of sacral canal and volume of caudal space. Hence, it is hoped that the present study will be useful for clinicians; especially anaesthetists as it is focused on the parameters related to sacral canal and caudal space. The height of caudal space which is the distance between the dural sac termination and the apex of the sacral hiatus is important because the risk of dural puncture is perceived to increase as this distance decreases[6]. It is important to know the volume of caudal space and sacral canal because optimum volume of drugs required to reach the appropriate level is needed in caudal epidural anaesthesia. The following tables (table 2 and table 3) shows the comparison of means of volumes of sacral canal and caudal space from previous studies; with that of the present study.

Table 2: Comparison of volume of sacral canal with previous studies

Study	Year	Country	Volume (cm^3)	Material of study	Range (cm^3)
Trotter M *et al* [2]	1947	Washington	White race: M – 35 F – 31 Negro race: M – 32 F - 28	Cadavers	12 - 65
Asghar A *et al* [3]	2013	India	38.26	Dry bones	23.76 - 62.78
Present study		**India**	**27.07 ± 6.50**	**Dry bones**	**14.66- 46.78**

In the present study, diameter of sacral canal was measured between lateral margins of first sacral foramina, which is same as in the study done by Asghar A *et al* [3]. But the volume of sacral canal is slightly higher in the study done by Asghar A *et al* [3] than the present study. Trotter M *et al* [2] measured sacral volume including the volume of intervertebral foramina by injecting fluids in sacral canal of cadaver. The volume measured by Trotter M *et al* [2] was also higher than the present study. This might be due to racial differences. According to Lanier V S *et al* [4], the levels reached by the constant amount of solution injected into epidural space through the hiatus of sacral canal varied throughout the extent of column.

Table 3: Comparison of volume of caudal space with previous studies

Study	Year	Country	Material for study	Volume (cm^3)	Range (cm^3)
Asghar A *et al* [3]	2013	India	Dry bones	14.25	6.67- 24
Crighton I M *et al* [5]	1997	Nottingham	MRI scans	14.40	9.5 - 26.6
Present study		**India**	**Dry bones**	**16.02±4.28**	**8.27- 32.81**

In the present study, the volume of caudal space was almost similar to the value obtained in the study done by Asghar A *et al*[3]. The volume of caudal space measured by Crighton I M *et al*[5]; by using MRI scans, almost resembled with that the present study.

CONCLUSION

Thus, the volume of sacral canal or caudal space can be calculated by using the formula of volume of half cone and this technique used for measuring volume of sacral canal and caudal space will help anaesthetists for giving a safe epidural anaesthesia using newer approaches.

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