Original Article

DOI: 10.7860/IJARS/2016/16825:2091

Anatomy Section

A Morphometric Study of Sacral Hiatus and its Importance in Caudal Epidural Anaesthesia

MD. JAWED AKHTAR, NASREEN FATIMA, RITU, AVANISH KUMAR, VINOD KUMAR

ABSTRACT

Introduction : The caudal epidural anaesthesia is a process in which medications are injected into epidural space to provide analgesia and anaesthesia in various clinical procedures. The technique of caudal epidural block entirely depends upon exact localization of sacral hiatus through which clinicians access the epidural space. The precise knowledge about different anatomical variations related to the sacral hiatus increase its success rate.

Aim: To study the different anatomical variations and morphometry of the sacral hiatus in the population of Bihar that is useful in caudal epidural anaesthesia.

Materials and Methods: The present study has been carried out on 124 undamaged adult human sacra of which age and sex were not predetermined. Only fully ossified, dried, macerated and thoroughly cleaned sacra which were complete in all respects, in order to give the correct observations, were included in the study while the sacra having any deformity or pathology were excluded. The different metric parameters were measured with the help of digital vernier caliper. The various shapes of sacral hiatus was also observed. The software GRAPH PAD PRISM version 4.03 is used for statistical analysis of data.

Results : The most common shape of sacral hiatus recorded in the present study is Inverted U (44.36%) followed by Inverted V (35.48%). The least common shape is bifid (4.03%). In 2.42% cases sacral hiatus is absent. Apex of the sacral hiatus is mostly seen at the level of 4th sacral vertebra (71.77%), while base is commonly located at the level of 5th sacral vertebra (79.84%). The mean length of sacral hiatus is 26.92 ± 12.91 mm. The mean transverse width and mean anteroposterior diameter of SH at the apex are 12.14 ± 3.89 mm and 5.39 ± 1.96 mm respectively.

Conclusion : The different variation of shape and size of sacral hiatus should always kept in mind while giving caudal epidural anaesthesia and analgesia. These variations may occur due to different genetic and racial factors.

Keywords: Anatomical variations, Sacrum, Sacral canal, Sacral cornua

INTRODUCTION

Sacrum is a wedged shaped bone which is formed by the fusion of five sacral vertebrae, present at the caudal region of the vertebral column [1]. Usually the sacrum is the last bone of a buried body to rot due to its large size. Sacral hiatus is an opening at the caudal end of sacral canal, which is formed due to failure of fusion of laminae of the 5th (or sometimes 4th) sacral vertebra or lower end of median sacral crest. The hiatus is covered by the superficial and deep posterior sacro coccygeal ligaments along with subcutaneous fatty tissue and skin. The sacral canal contains cauda equina along with filum terminale and spinal meninges. The dura and arachnoid mater ends at the middle of sacrum while pia mater continues as filum terminale up to the coccyx. On the surface of our body, the hiatus can be felt beneath the skin of natal cleft just two inches above the tip of coccyx [2]. Alternately, it may be located by drawing an equilateral triangle on a line joining the posterior superior iliac spines, the inferior angle of this triangle lies on the sacral hiatus. The caudal epidural anaesthesia (CEA) is a process in which medications are injected into epidural space to provide analgesia and anaesthesia in various clinical procedures, which was first of all performed in 1900. In the field of obstetrics, Edward and Hingson introduced continuous caudal analgesia in 1942. This procedure drawn attention of the clinicians and anatomists to make detailed study about the sacral region. In urology, orthopaedics, proctology and general surgery it is also widely used. The technique of CEA entirely depends upon exact localization of sacral hiatus through which clinicians access the epidural space. The absence of sacral hiatus is one of the important anatomical reason of failure of CEA. Hence, a thorough knowledge about different anatomical features of sacral hiatus leads to reduction in the failures of administration of CEA. Various studies were conducted on morphometry of sacral hiatus in

different parts of our country. But, still no data were available on morphometry of human sacral hiatus in Bihar region hence the necessity of the present study arose.

AIM

To study the different anatomical variation and morphometry of the sacral hiatus in the population of Bihar that is useful in caudal epidural anaesthesia.

MATERIALS AND METHODS

The present study is a cross sectional study which has been carried out on 124 undamaged adult human sacra, which were collected from the students of the 1st year MBBS and Department of Anatomy and Department of Forensic Medicine and Toxicology of Indira Gandhi Institute of Medical Sciences, Patna Medical College and Nalanda Medical College of Bihar state of India. This study was conducted in June 2015. The age and gender of the bones used in the study was not predetermined. Only fully ossified dried, macerated and thoroughly cleaned sacra which were complete in all respects, in order to give the correct observations, were included in the study while the sacra having any deformity or pathology were excluded. All parameters were measured by using digital vernier caliper (accuracy: 0.01mm).

The following parameters were studied:-

(A) Nonmetric Parameters:-

1. Shapes of the sacral hiatus.
2. Level of apex of sacral hiatus with respect to sacral vertebrae.
3. Level of base of sacral hiatus with respect to sacral vertebrae.

(B) Metric Parameters:-

1. The length of the sacral hiatus [Table/Fig-1a].
2. The anteroposterior diameter of sacral hiatus: At the apex [Table/Fig-1b].
3. The transverse width of sacral hiatus: At the base i.e. intercornual distance [Table/Fig-1a].

The software GraphPad Prism version 4.03 is used for statistical analysis of data. Continuous variables are expressed in term of mean and standard deviation while categorical variables are expressed in term of percentage.

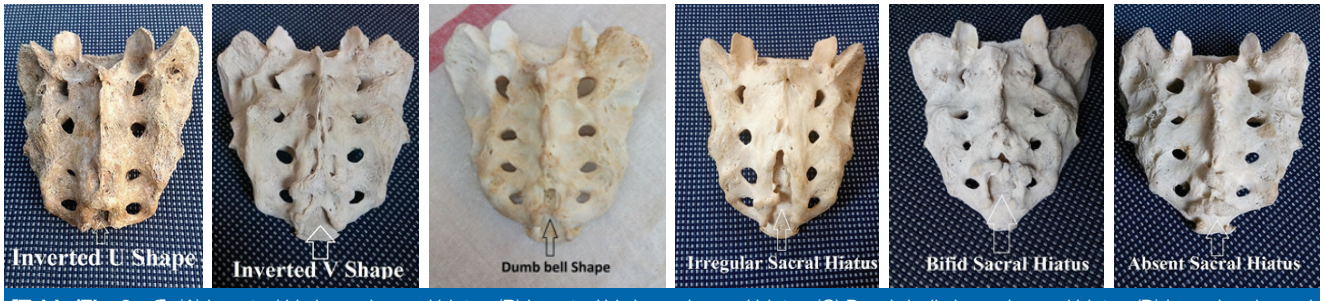
RESULTS

The most common shape of sacral hiatus (SH) recorded in the present study is Inverted U (44.36%) followed by Inverted V (35.48%). The least common shape is bifid (4.03%). In 2.42% cases SH is absent [Table/Fig-2a-f and 3]. Apex of the SH is mostly seen at the level of 4th sacral vertebra (71.77%), while base is commonly located at the level of 5th Sacral Vertebra (79.84%) [Table/Fig-4 and 5]. The mean length of SH is 26.92 ± 12.91 mm. The mean transverse width and mean anteroposterior diameter of SH at the apex are 12.14 ± 3.89 mm and 5.39 ± 1.96 mm respectively [Table/Fig-6 and 7].

[Table/Fig-1a-b]: Morphometric measurements of the sacral hiatus (1a) 1. Height of the sacral hiatus, 2. Width of the sacral hiatus at the level of sacral cornua (1b) 3. The anteroposterior diameter of the sacral hiatus at the apex.

Sr. No.	Shape of Sacral Hiatus	No.	Percentage (%)
1.	Inverted U shaped	55	44.36
2.	Inverted V shaped	44	35.48
3.	Dumb bell shaped	6	4.84
4.	Irregular	11	8.87
5.	Bifid	5	4.03
6.	Absent	3	2.42
Total		124	100

[Table/Fig-3]: Distribution of different shapes of sacral hiatus.



[Table/Fig-2a-f]: (A) Inverted U shaped sacral hiatus (B) Inverted V shaped sacral hiatus (C) Dumb bell shaped sacral hiatus (D) Irregular shaped sacral hiatus (E) Bifid sacral hiatus (F) Absent sacral hiatus.

Sr. No.	Location of Apex	No.	Percentage (%)
1.	2nd Sacral Vertebra	3	2.42
2.	3rd Sacral Vertebra	26	20.97
3.	4th Sacral Vertebra	89	71.77
4.	5th Sacral Vertebra	6	4.84
Total		124	100

[Table/Fig-4]: Different levels of apex of the sacral hiatus with respect to sacral vertebrae.

Sr. No.	Location of Base	No.	Percentage (%)
1.	4th Sacral Vertebra	15	12.10
2.	5th Sacral Vertebra	99	79.84
3.	Coccygeal Vertebra	10	8.06
Total		124	100

[Table/Fig-5]: Different levels of base of the sacral hiatus with respect to sacral vertebrae.

	Length of SH from apex to the midpoint of the base		Transverse width of SH at the base		AP diameter of SH at the apex	
Sr. No.	Length (in mm)	No. (percentage)	Distance (in mm)	No. (percentage)	Distance (in mm)	No. (percentage)
1.	0-10	10 (8.06%)	0–5	3 (2.42%)	0–3	12 (9.68%)
2.	10.01-20	31 (25%)	5.01–10	38 (30.64%)	3.01–6	67 (54.03%)
3.	20.01-30	41 (33.07%)	10.01–15	60 (48.39%)	6.01–9	37 (29.84%)
4.	30.01-40	26 (20.97%)	≥ 15.01	23 (18.55%)	≥ 9.1	8 (6.45%)
5.	40.01-50	10 (8.06%)	Total	124 (100%)	Total	124 (100%)
6.	≥ 50.01	6 (4.84%)				
Total		124 (100%)				

[Table/Fig-6]: Length, transverse width and AP diameter of the sacral hiatus.

Variables (in mm)	Mean ± SD	Median	Range
Length	26.92 ± 12.91	26.65	7.12 - 59.93
Transverse Width	12.14 ± 3.89	11.82	4.25 - 19.58
Anteroposterior Diameter	5.39 ± 1.96	5.17	2.1 - 10.87

[Table/Fig-7]: Length, transverse width and anteroposterior diameter of the sacral hiatus (expressed in term of mean, standard deviation, median and range).

DISCUSSION

The precise knowledge of different anatomical variations related to the sacral hiatus increase the success rate of the caudal epidural anaesthesia. Tsui BC et al.,, [3] reported 25% failure rate in caudal epidural block in 1999. The common cause of failure was various anatomical variations in sacral hiatus. This route is also frequently used in different therapeutic as well as diagnostic procedures in orthopaedics [4]. Corticosteroid injections are also given through this route in sciatica [5]. Contrast dye is injected in the caudal space through a epidural catheter via SH in epidurography [6]. In the process of spinal endoscopy this route is also used [7].

Shape of Sacral Hiatus

As in our standard text books SH is triangular or inverted U shaped and is bounded laterally by sacral cornua [1,2]. In the present study we also observed inverted U shape (44.36 %) is most common followed by inverted V shape (35.48 %). The results are similar to studies by Nagar S K [8], Seema et al., [9], Sinha M B et al., [10], Nadeem G [11] and Ukokha U U et al., [12] which are compared in [Table/Fig-8]. But Kumar V et al., [13] and Chhabra N [14] observed Inverted V shape is more common than inverted U shape. In our study sacral hiatus is absent in 2.42% cases which is most likely due to bony overgrowth. Similar results also reported by Seema et al., [9] i.e. 2.51%. While Kumar V et al., [13], Nagar S K [8] and Ukokha U U reported less cases of absent sacral hiatus.But Senoglu N et al., [15] found absent sacral hiatus in 4% cases which is higher than our findings. The absent SH obstruct the needle insertion during CEB and may causes needle breakage.

Apex of Sacral Hiatus

The level of apex of SH shows considerable variation which ranges from S2 to S5. The precise knowledge about level of apex

SHAPE	Kumar V et al., [13]	Seema et al., [9]	Seema et al., [9] (2013)	Sinha M B et al., [10]	Nadeem G [11] (2014)	Ukokha U U et al., [12]	Present study (2015)
Inverted U shaped	29.70%	41.50%	42.95%	35.93%	56%	48.20%	44.36%
Inverted V shaped	46.53%	27%	27.51%	17.18%	14%	34.90%	35.48%
Dumb bell shaped	7.43%	13.30%	13.41%	7.81%	10%	4.80%	4.84%
Irregular	-	14.10%	16.10%	15.62%	16%	4.80%	8.87%
Bifid	-	-	-	7.81%	2%	4.80%	4.03%
Absent	0.99%	0.70%	2.51%	3.12%	-	1.20%	2.42%

[Table/Fig-8]: Incidence of various shapes of sacral hiatus recorded by different workers.

Previous workers	Level of Apex				Level of Base		
	S2	S3	S4	S5	S4	S5	Coccyx
Nagar S K [8] (2004)	3.40%	37.30%	55.90%	3.40%	11.10%	72.60%	16.30%
Seema et al., [9] (2013)	4.03%	35.57%	56.37%	4.03%	13.42%	70.46%	16.10%
Chhabra N [14] (2014)	6.67%	33.33%	60%	-	20%	63.33%	16.67%
Sinha M B et al., [10] (2014)	-	25%	70.86%	6.45%	6.45%	88.71%	4.83%
Nadeem G [11] (2014)	2%	62%	34%	2%	24%	62%	14%
Ukokha U U et al., [12] (2014)	2.40%	20.50%	69.90%	4.80%	2.40%	88%	7.20%
Present study (2015)	2.42%	20.97%	71.77%	4.84%	12.10%	79.84%	8.06%

[Table/Fig-9]: Incidence of level of apex and base of the sacral hiatus recorded by different workers.

becomes important when it is located at the level of S2 or S3 because of more chances of puncture of dural sac during CEA as apex is very close to the lower limit of dural sac. In case of higher apex, more precaution is needed while deciding the length of the spinal needle which has to be introduced into the sacral canal. In our study in 71.77% cases, the apex of hiatus is located at the level of S4 vertebra while in 2.42 % cases it is at S2 level [Table/Fig-4]. Sinha M B et al., [10] , Ukokha U U et al., [12], Chhabra N [14], Seema et al., [9] and Nagar S K [8] also reported apex most commonly at the level of S4 [Table/Fig-9]. But, Nadeem G [11] found apex most commonly lies at the level of S3 in his study on german bones.

Base of Sacral Hiatus

The location of the base of SH also shows variation which ranges from the lower end of S4 vertebra to the coccyx. In our study it is most commonly at the level of S5 vertebra (79.84 %) [Table/Fig-5]. The findings of our study are more or less in agreement with findings of other authors namely Sinha M B et al., [10], Ukokha U U et al., [12], Nagar S K [8], Seema et al., [9]], Chhabra N [14] and Nadeem G [11] [Table/Fig-9]. In 8.06% cases base is at the level of coccygeal vertebra. However, when the base of SH is situated at the level of coccyx it is slightly narrower as compared to that of sacral level. Coccygeal ankylosis is found in those sacra.

Length of Sacral Hiatus

In the present study the length of SH varied from 7.12 mm to 59.93 mm with a mean of 26.92 ± 12.91 mm [Table/Fig-7]. In 58 % cases, length of SH varied between 10.01 to 30 mm [Table/Fig-6]. Nagar S K [8] also reported most common range was 11 to 20 mm in which 35 % cases belongs followed by 21 to 30 mm to which 30.08 % cases belongs. While Chhabra N [14] observed mean length of SH was 25.05 ± 10.96 mm which varied from 9.98 mm to 61.98 mm which is very nearer to our observation. Ukokha U U et al., [12] reported mean length of SH 20.05 ± 9.22 mm which varied from 6.10 mm to 57 mm. Seema et al., [9] as well as Nadeem G [11] also observed length of SH was in between 11 to 30 mm in about two third of cases. While Kumar V et al., [13] in 1992 observed mean length in males were 20 mm and in female were 18.9 mm. Nadeem G [11] observed two third of cases i.e. in 57 % sacra length was in between 11 - 30 mm which varied from 5 to 50mm during study of German sacra. Sinha M B et al., [10] found in 44% cases length of SH lies in between 10.01 to 20 mm. In 1945, Trotter and Leanier [16] also observed a mean length of SH was 24.8 mm and 19.8 mm in American male and females respectively. While Mustafa MS et al., [17] reported mean length of SH 2.1 ± 0.80 cm in Egyptian sacra, which was also nearer to our observations.

Transverse Width of Sacral Hiatus at the Base

In the present study the transverse width of SH varied from 4.25 mm to 19.58 mm with a mean of 12.14 ± 3.89 mm [Table/Fig-7]. In 48.39% cases transverse width of SH varied in between 10.01 to 15 mm [Table/Fig-6]. Our findings coincided with the observations of Kumar V et al., [13] who reported mean transverse width of SH of 13mm with range of 5 to 20 mm. Nagar S K [8] also reported the transverse width of SH were in between 10 - 15 mm in 54% cases. Chhabra N [14] observed mean transverse width of SH at the base was 12.84 mm with range of 6.53 to 16.9 mm. While Ukoha U U et al., [12] found mean transverse width of SH at the base was 12.35 ± 3.12 mm with range of 5 to 20.50 mm which is also very near to our findings. Kumar V et al., [9] reported width at the base of SH varied between 0.3 to 18 mm, in which more than half i.e. 52 % cases was in between 11 - 15 mm. Nadeem G [11] observed width at the base of SH varied between 3 to 25 mm, in which 52 % cases it was more than 15 mm and in 46 % cases it varied between 6 to 15 mm with mean of 19.5mm. Sinha M B et al., [10] found intercornual distance at the base in between 10.1 to 15mm in 41.93 % cases followed by 5.1 to 10 mm in 35.48 % cases. While Mustafa MS et al., [17] reported the mean transverse width of SH at its base was 1.7 ± 0.26 cm in Egyptian sacra.

Anteroposterior diameter of sacral hiatus at the apex

The anteroposterior diameter of sacral canal at the apex of SH is important because it helps in decision of accurate needle usage in CEB. It must be adequately large to admit a needle. Subcutaneous deposition of anesthetic drugs may occur due to variation in diameter. In our study the anteroposterior diameter ranged from 2.1 to 10.87 mm with a mean of 5.39 ± 1.96 [Table/Fig-7]. The observations of our study concur with the studies done by Nadeem G [11] and Ukoha U U et al.,, [12] where they noted a mean anteroposterior diameter of 5.53mm and 5.52 ± 1.89 mm respectively. While mean anteroposterior diameter reported by Seema et al., [9] was 4.7mm, Nagar S K [8] was 4.88mm, Chhabra N [14] was 6.30 ± 1.39 mm and Lanier et al.,, [18] was 6.0 ± 1.9 mm. While Mustafa MS et al., [17] observed the anteroposterior diameter of sacral canal at the apex of SH was 0.48 ± 0.19 cm in Egyptian sacra, which was also nearer to our findings. They reported narrower sacral hiatus apex in female sacra in comparison to male.

CONCLUSION

The different variation of shape and size of SH should always keep in mind while giving caudal epidural anaesthesia and analgesia. Exact location of SH in CEB determine its success rate. These variations may occur due to different genetic and racial factors. The different observations of the study are helpful to clinicians in minimizing the complications during surgeries. However, in the field of spinal surgery with advancement in different surgical methods and instrumentation there is continued need about better understanding of anatomy around this region, as this route is widely used in diagnosis along with treatment of different lumbar spinal diseases in the field of orthopaedics.

ACKNOWLEDGEMENT

We sincerely thank the Dr. Arvind Prasad, HOD of Department of Forensic Medicine and Toxicology, IGIMS Patna for granting the permission to carry out the study in his department.

Abbreviations

CEA: Caudal epidural anaesthesia

CEB: Caudal epidural block

SH: Sacral hiatus

REFERENCES

[1] Standring S, "The Back" in Gray's Anatomy: The Anatomical Basis of Clinical Practices, Standring S, Ellis H, Healy JC et al., Grays Anatomy. 40th Edition. Elsevier. Churchill Livingstone. New York, NY, USA, 2008; 724-28.
[2] Keith L. Moore, "Back" in clinically oriented anatomy. 7th Edition. Lipincott, Williams Wilkins. Philadelpia. 2014;451-54.
[3] Tsui BC, Tarkkila P, Gupta S, Kearney R. Confirmation of caudal needle placement using nerve stimulation. *Anaesthesiology*. 1999(2);91:374-78.
[4] Sekiguchi M, Yabuki S, Satoh k , Kikuchi S. An Anatomic study of the sacral Hiatus: A Basis for successful caudal epidural Block. *Clin J Pain*. 2004;20(1):51-54.
[5] Czarski Z. Treatment of sciatica with hydrocortisone and novocaine injection into the sacral hiatus. *Przegl Lek*. 1965;21(7):511-13.
[6] Devulder J, Bogaert L, Castille F, Moerman A, Rolly G. Relevance of epidurography and epiduralysis in chronic failed back surgery patients. *Clin J Pain*. 1995;11(2):147-50.
[7] Helm Sznd, Gross JD, Varley K.G. Mini surgical approach for spinal endoscopy in the presence of stenosis of the sacral hiatus. *Pain Physician*. 2004;7(3):323-25.
[8] Nagar SK. A study of sacral hiatus in dry human sacra. *J Anat Soc India*. 2004;3(2):18-21.
[9] Seema, Singh M, Mahajan A. An anatomical study of variations of sacral hiatus in sacra of north indian origin and its clinical significance. *Int J Morphol.* 2013;31(1):110-14.
[10] Sinha M B, Rathore M, Sinha H R. A study of variation of sacral hiatus in dry bone in central Indian region. *Int J of Healthcare and Biomedical Research.* 2014; 2(4):46-52.
[11] Nadeem G. Importance of knowing the level of sacral hiatus for caudal epidural anaesthesia. *Int J Morphol*. 2014;31(1):9-13.
[12] Ukoha UU, Okafor JI, Anyabolu AE, Ndukwe GU, Eteudo AN, Okwudiba N J. Morphometric study of the sacral hiatus in nigerian dry human sacral bones. *Int J Med Res Health Sci*. 2014;3(1):115-19.
[13] Kumar V, Pandey SN, Bajpai RN, Jain PN, Longia GS. Morphometrical study of sacral hiatus. *J Anat Soc India*. 1992;41(1):7-13.
[14] Chhabra N. An anatomical study of size and position of sacral hiatus; its importance in caudal epidural block. *Int J of Health Sciences andResearch*. 2014;4(12):189-96.

[15] Senoglu N, Senoglu M, Oksuz H. Landmarks of the sacral hiatus for caudal epidural block: an anatomical study. *British J of Anaesthesia*. 2005;95(5):692-95.
[16] Trotter M and Lanier PF. Hiatus canalis sacralis in American whites and Negroes. *Hum Biol*. 1945;17:368-81.
[17] Mustafa MS, Mahmoud OM, El Raouf HH, Atef HM. Morphometric study of sacral hiatus in adult human Egyptian sacra: Their significance in caudal epidural anaesthesia. *Saudi J Anaesth*. 2012;6:350-57.
[18] Lanier VS, Mc knight HE and Trotter M. Caudal analgesia: an experimental and anatomical study. *Am J Obstet Gynaecol*. 1944;47(5):633-41.

AUTHOR(S):
1. Dr. Md. Jawed Akhtar
2. Dr. Nasreen Fatima
3. Dr. Ritu
4. Dr. Avanish Kumar
5. Dr. Vinod Kumar

PARTICULARS OF CONTRIBUTORS:
1. Senior Resident, Department of Anatomy, Indira Gandhi Institute of Medical Sciences, Sheikhpura, Patna, Bihar (India).
2. Senior Resident, Department of Anaesthesiology, All India Institute of Medical Sciences, Patna, Bihar (India).
3. Senior Resident, Department of Forensic Medicine and Toxicology, Indira Gandhi Institute of Medical Sciences, Sheikhpura, Patna, Bihar (India).
4. Additional Professor, Department of Anatomy, Indira Gandhi Institute of Medical Sciences, Sheikhpura, Patna, Bihar (India).
5. Professor and HOD, Department of Anatomy, Indira Gandhi Institute of Medical Sciences, Sheikhpura, Patna, Bihar (India).

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Md. Jawed Akhtar,
Senior Resident, Department of Anatomy,
Indira Gandhi Institute of Medical Sciences, Sheikhpura, Patna-800014, Bihar, India.
E-mail: drjawedakhtarpmch@gmail.com

FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Publishing: **Jan 05, 2016**