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Sacral hiatus anatomical variations and clinical relevance in caudal epidural block

Shweta Solan

Associate Professor, Department of Anatomy, Kalinga Institute of Medical Sciences, Patia, Bhubaneswar, Odisha, India

Manoja Kumar Muni

Associate Professor, Department of Anaesthesiology, Kalinga Institute of Medical Sciences, Patia, Bhubaneswar, Odisha, India

Sudeepa Das*

Associate Professor, Department of Anatomy, Kalinga Institute of Medical Sciences, Patia, Bhubaneswar, Odisha, India

* Corresponding Author

Abstract---Objective: For the management of perioperative pain control during procedures like genitourinary surgery and labor pain instances when the sacral epidural space technique is utilized for the application of analgesia, caudal epidural anesthesia (CEB) is frequently used. CEB is an anesthetic that is injected through the sacral hiatus (SH) into the sacral canal. Anatomical features of sacral hiatus that are in-depth are needed for the best possible access to the sacral epidural area. By employing the sacral bone as a point of reference to failure parameters for evaluating caudal epidural anesthesia and refining the success factors in practice, this study intends to explore the anatomical structures and variations of the Sacral hiatus. Material and methods: 85 sacral bones had their alignment points measured precisely morphometrically. Virtual calipers were used to take the readings were used to evaluate those utilizing photogrammetric techniques. Results: Inverted U was the most frequent sacral hiatus form reported (33.32%), although bifida and 6.8% 3.44% of cases frequently missing sacral hiatus were also seen. The mean Sacral hiatus length was 28.67.0 mm, the mean intracorneal distance was 13.472.68 mm, and the mean gap between the apex of the Sacral hiatus and S2 sacral foramen was 34.677.08 mm. In terms of bilateral measurements, there was no statistically significant variation found ($p>0.04$). Very frequently, the S4 and S5 vertebrae were found to be the sacral hiatus's peak and base. S3 had a peak curvature of 62.06% and S4 had a peak curvature of 28.7%. Spina bifida was detected 16.12% frequently in the L5-S1 region.

In 55.25% of instances, the sacral cornua were bilaterally present, and in 21.04% of patients, they were immobile. The shortest path of 7.24 mm between both the S2 and the peak of the Sacral hiatus showed that it would not be appropriate to insert the syringe further into the sacral canal than 6 mm in order to prevent dural puncture. The hiatus level has been less than 2 mm in 8.76% of patients. Conclusion: Due to anatomical differences, a particular bony feature is ineffective for finding the sacral hiatus. Specific anatomical features of the CEB include the sacral cornu, lateral sacral crests, pinnacle and summit, of the Sacral hiatus, top of the central sacral crest, anteroposterior range of the sacral canal, intracorneal distance, and the proximity from the apex of the Sacral hiatus to the S2 foramina. One of the reasons why syringe insertion failed could be a profundity of pause that was lower than 2 mm.

Keywords---sacrum, sacral canal, sacral hiatus, caudal epidura block, sacral cornu.

Introduction

In order to manage persistent back pain, cure lumbar spinal diseases, and ensure pain reduction and anesthesia during procedures like genitourinary surgery and labor discomfort, caudal epidural block (CEB) has been performed frequently (1,2,3). Precise identification of the sacral hiatus (SH), via which entrance to the sacral epidural area is achieved, is essential for the CEB procedure (4,5). The end of the sacral canal is represented by Sacral hiatus, which has an approximately triangular form (6,7). It happens when the lamina of the S4 or S5 vertebrae fails to fuse (6-10). Skin, subcutaneous fat, and sacrococcygeal membrane all surround the Sacral hiatus. End of dural sac rests on S2 vertebra. Regarding dural activity, the gap between the apex of the Sacral hiatus and the margin of the dural sac is approximately 4.5 cm (11,12). The components going through the Sacral hiatus are the coccygeal nerve, filum terminale, the S5 spinal nerve, and fibro-fatty tissue (10, 13-16). Doctors must be familiar with the anatomy of the Sacral hiatus and sacral bone in order to perform an effective CEB procedure. However, there are significant anatomical variances in this region, which lead to differences in the Sacral hiatus's size and form and may make diagnosis challenging (4,7,15,16). Direct syringe injury to the spinal cord or spinal nerve, significant subdural spread, inadvertent dural tear, epidural hematoma, epidural abscess, anterior spinal anterior syndrome, and ischemia are among the problems, both of anatomical and technical origin (17,18). It may not always be possible to place the needle into the sacral canal (19). For the doctors, identifying pauses continues to be difficult. For this aim, nearby bone structures are typically taken into account. The efficacy of the CEB depends on the verification of bone features [20].

If the application is approved, the patients will experience comfortable anesthesia and soon be able to resume their active lifestyles. It's critical to have a thorough grasp of the Sacral hiatus position in order to lower perioperative risk and damage to key structures. The current work intends to quantify Sacral hiatus

distances and identify positional differences. This study's objectives were to identify the Sacral hiatus landmark points, perform thorough and consistent morphometric measurements, and compute the Sacral hiatus's safe zones for the use of the CEB.

Materials and Methods

For this research, a total of 80 adults dried human sacrum bones have been used. A morphometric investigation was performed on freshly acquired uncertain age and gender bones. The study was conducted in two stages:

Non-metric evaluation

Using a macroscopic examination, the hiatus' shape was categorised as an inverted "U," inverted "V," irregular, dumbbell-shaped, bifida-shaped, "M," and without SH. The level of the sacral hiatus (points of the sacral cornu) was examined in respect to the sacral and coccygeal vertebra as S4, S5, and coccyx 1, and the level of the hiatus' apex was evaluated in relation to the vertebra level as S2, S3, S4, and S5. Highest sacral curvature was assessed in relation to the sacral vertebrae at the S2, S3, and S4 levels. Spina bifida cases had defects in the dorsal wall of the sacrum that were assessed at the vertebral level. Sacral cornu is present or absent; sacral cornu smaller than 2 mm was regarded as nonexistent.

Metric evaluation

The same researcher used a dial indicator digital calliper with 0.02 mm precision to measure all characteristics twice. The following variables were assessed: How long the break was, The SH's breadth (intercornual distance), the average distance between the SH's apex and the bottom edge of the S2 foramen, the distance between the posterior margin of the S2 foramen and the SH's peak the separation between the S2 foramen and the SH's base midway point, the distance between the posterior margin of the S1 foramen and the apex of SH the separation of the lateral sacral crests. The triangle's angles were measured and assessed. Right lateral sacral crest to the apex of hiatus range; left lateral sacral crest to peak of hiatus distance; anteroposterior diameter of the hiatus (profundity of hiatus) at the peak of the SH distance; and posterior end of average sacral crest to apex of SH range. In order to calculate the angle of the ring formed by the lateral sacral crest and SH's apex, the bones were imaged.

Statistical analysis

The mean (SD) and range were used to express all data. The link between the variables was examined using the Pearson correlation coefficient.

Results

Non-metric evaluation

- a. Hiatus shape: The S5 and occasionally S4 laminae that did not fuse together generated a space at the posterior wall of the sacrum, giving rise to

the pattern of the hiatus SH. The gap generally took the form of an inverted U (33.2%) or V (19.3%). Table 1 shows the percentages of irregular shape (19.4%), dumbbell shape (6.8%), absence of SH (6.8%), and bifida form (3.44%).

Table 1: Occurrences of Hiatal shapes

S.No.	Shape	Number (%)
1.	M Shaped	8-10.34
2.	Dumbbell shape	5-6.8
3.	Bifid	2-3.44
4.	Irregular	16-19.44
5.	Inverted V	16-19.44
6.	Inverted U	28-33.34
7.	Absent	5-6.8

- b. Abnormalities in the dorsal wall of sacral canal
7.88% of sacral tissue showed the failure of the neighboring sacral lamina to fuse. The prevalence of spina bifida, which causes the SH structure, was highest at the S1-S5 level (18%).
- c. Whether the sacral cornu is present or not
55.25% of the time, the sacral cornu was large sufficient to be felt bilaterally, 23.68% of the time, unilaterally, and 21.04% of the time, it was immovable bilaterally. In 13% of cases, the tendon between the sacral cornu and the coccyx became osseous, flattening the cornual protrusion. 8.6% of the sacral bones had accessory bony projections from the lateral/medial boundary of the gap.
- d. Height of the hiatus peak
The SH's apex levels ranged from S2 to S5. It was most frequently found against S4 in 70.0% of instances, however, it was as high as S1 in 1.0% of cases and as low as S5 in 11.4% of cases (Table 2). 6.8% of instances did not have SH.
- e. Base level of the hiatus
The level of the hiatus base that was most frequently seen was S5 (82.6%). The absence of the SH with a prevalence of 6.8% prevented the base location from being identified (Table 2).

Table 2: level of the hiatus peak and base, as well as its maximal curvature in relation to the sacral bones

Criteria	Coccyx (%)	S2 (%)	S3 (%)	S4 (%)	S5 (%)	Absent hiatus
Peak hiatus	-	1.0 (1.14)		60 (70.0)	9 (11.48)	6 (6.8)
Base hiatus	6 (8.04)	-	-	2 (2.2)	71 (82.6)	6 (6.8)
Highest curvature	-	8 (9.1)	53 (62.06)	24 (28.77)	-	-

f. The sacrum highest curvature

In 62.0% of instances, the sacrum's highest level of curvature was at the level of S3.

Metric Evaluation

The parameters were evaluated and the average and standard deviation were computed. Certain factors, including the length of the SH, the distance between the average sacral crest's caudal end and the peak of the hiatus, and the average distance between S2 and the apex, revealed a wide variation (Table 3).

Table 3: values for measurements relating to the bony markers of the hiatus

Criteria	Mean \pm SD	Range-mm
Distance between apex and S1 foramen	72.84 \pm 10.98	94-48
Distance between basis and S2 foramen	63.1 \pm 7.6	82-45
Distance between the apex and S2 foramen	34.67 \pm 7.08	48-8
Distance interlateral sacral crests	64.78 \pm 4.64	74-52
Distance between left lateral sacral crest and apex (left border)	70.3 \pm 9.58	92-43
Distance between right lateral sacral crest and apex (right border)	69.48 \pm 9.68	92-43
Left angle of triangle	61.43 \pm 5.49	69-49
Right angle of triangle	62.81 \pm 5.57	69-49
Length of hiatus	28.06 \pm 7.0	49-11
Intercornual distance	13.47 \pm 2.68	21-8

In 61.39% of instances, the intercornual distance was between 5 and 14 mm, with 5.9 mm being the smallest measurement. Similarly, 3.1 to 6 mm of anteroposterior depth at the hiatus's peak were typically identified. The lowest depth that was measured was 1.9 mm. Approximately 44% of the sacral bones showed equilateral triangle formation by the SH's apex, the right and left lateral sacral tubercles, and the remaining sacral bones.

Statistical Analysis

Using Pearson's correlation, it was proven that the triangle's base had a substantial positive statistical relationship with both its right and left margins (right 0.393 and left 0.985; correlation significant at 0.02 level two-tailed). The length of the SH also shown a positive link with the triangle's base, right, and left margins (base 0.300, left 0.263, and right 0.207; significant at 0.02 level two-tailed).

Discussion

Many factors influence the use of CEB, including its affordability, effectiveness in postoperative analgesia, rapid recovery, early bowel movement initiation, reduction in venous-arterial thrombosis, and speedy release [20]. In order to

successfully access the caudal epidural gap, it is necessary to understand the anatomical anatomy of the SH [6,21,22]. Making SH explicit by palpating the sacral cornu and inserting a needle into the sacrococcygeal membrane is the major method of intervention to the caudal epidural p [2,13,14,20]. According to clinical investigations, 82% of patients with CEB applications reported having backaches the day after the application [7,16].

Congenital and geometrical anomalies, obesity, ageing, metastatic bone involvement of the sacrum, and other factors can sometimes make CEB complicated [3,16,23]. The variances in the SH's anatomical structure, its narrowness or partial obstruction, the lack of the posterior wall of the sacral canal, and the variations in the SH's shape are listed as the primary issues with the CEB in published publications [2,24–25]. Only a small number of cases reporting the lack of SH were found in literature studies that were gathered as case studies. Sekiguchi et al. and Nagar discovered that SH was absent in 4 and 0.7% of cases, respectively (16-26)

Both ultrasonography and fluoroscopy are used to successfully enter the needle into the SH. Due to the expense, limited time, and a shortage of qualified and knowledgeable professionals, using ultrasound and fluoroscopy during the CEB may not be as advantageous (15, 11, 20, 21, 27, 28). Consequently, it is crucial to understand the SH's anatomical anatomy in order to prevent interference. For CEB, a thorough understanding of the SH's dimensions and anatomy is necessary. In the CEB technique, the intracorneal distance and the most often utilised markers for the profundity of the sacral canal at the peak are also listed. Complicated and smaller than 1 mm landmarks pose common issues in their recognition. Operation further than a range of less than 9 mm with 5% is linked to a higher risk of inserting catheter the SH, the contents of which should be scoped, when utilising the intracorneal distance as a navigational waypoint. The depth of the hiatus was less than 2 mm in 8% of cases. This indicates that it will be challenging to place the syringe in 14% of situations. A 4 mm maximum to the canal should be used for needle placement. No more than the S3 foramen should the syringe tip be. In 62.0% of cases, the level of the sacrum's maximum curvature was at S3.

Conclusion

The SH is virtually completely silent. The mean proportions that we have given in this research may all be used as anatomical guides for the CEB. It is insufficient to use a single bone as a landmark. For anaesthetists operating on the sensitive SH, orientation waypoints are invaluable. It is undeniable that the anaesthetists' familiarity with the SH's landmarks, ability to correctly align the sacral bone, ability to insert a catheter into the SH, ability to reduce surgery time, and ability to avoid complications are key factors in facilitating easier access to the SH and increasing the success rate of the CEB.

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