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Original Article

Study of Sacral Hiatus and its Implication in Caudal Epidural Block

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Abstract

Background: Morphological variations occur frequently in the lower region of the vertebral column, and sacrum is the most variable portion. The present study was undertaken to analyze the morphometric characteristics of the sacral hiatus and its sex differences to provide baseline data for the northern region of variation.

Materials and Methods: A cross-sectional observational study was conducted among 100 dry adult human sacra collected from the Development of Anatomy, TMSS Medical College and Shaheed Ziaur Rahman Medical College, Bogura. Data were recorded using a pre-designed questionnaire prepared for the study. Sex determination was done by using discriminant function analysis (DFA) and found 43 male and 57 female sacra. Location and shape of sacral hiatus was observed and noted. With the help of digital slide calipers different measurements of sacral hiatus were recorded to the nearest millimeter.

Results: The most common shape of sacral hiatus was found as inverted U shaped in both sexes and it was 48.84% in male and 44.83% in female. The second common type was inverted V shaped, and the frequency was 23.26% and 25.86% in male and female respectively. Location of apex of sacral hiatus at the level of 4th sacral vertebra was found most commonly 67.44% in male and 56.90% in females. In most of the sacra, location of base of the sacral hiatus was found at the level of 5th sacral vertebra; 95.35% in male and 91.38% in female. Regarding different other parameters of sacral hiatus there was no statistically significant difference between male and female sacra.

Conclusion: Though findings of present study regarding different parameters of sacral hiatus were not statistically different between male and female; it can provide a baseline data associated with clinical application in caudal epidural block.

Keywords: Human sacrum, Sacral hiatus, Sex variation, Caudal epidural block.

Introduction

The sacral hiatus is the terminal part of the sacral canal as well as the vertebral canal that transmits the fifth pair of sacral spinal nerves and coccygeal nerves. It is produced by the non-fusion of the laminae of the fifth sacral vertebra to meet in the median plane and as a result the posterior surface of the body of that vertebra is exposed on the dorsal surface of the sacrum. The inferior articular processes of the fifth sacral vertebra are free and project downwards at the sides of the sacral hiatus as sacral cornua.

The variation in anatomical features of sacra and the dorsal wall of sacral canal is associated with clinical application in caudal epidural anesthesia. Through the sacral hiatus caudal anesthesia is introduced in operation of the anal region, the external genital organs, as well as cystoscopy examination of male. It is also used in obstetrics during parturition for better cervical dilatation and shortening of the first stage of labor.[1]

Metrical study of sacral hiatus done by various authors revealed that mean value may be significantly different in bones from different zones even within the same general population.[2,3] Anatomical abnormalities of the sacral hiatus include upward and downward displacement of sacral hiatus, narrowing or partial obliteration of the sacral canal, ossification of the

sacrococcygeal membrane, absence of bony posterior wall of the sacral canal and variation of shape of sacral hiatus[4,5] studied that caudal epidural block has 25% failure rate.

The reliability and success of caudal epidural anesthesia depends upon the knowledge of anatomical variations of sacral hiatus. Depth, surrounding bony irregularities, different shapes and defects in dorsal wall of sacral canal and hiatus may cause failure of needle insertion. The present study was undertaken to study the morphometric analysis of sacral hiatus and also their sex differences to provide a baseline data for the northern region of Bangladesh.

Materials and Methods

This study was conducted on dry human sacra taken from the Department of Anatomy, TMSS Medical College and Shaheed Ziaur Rahman Medical College, Bogura. Data were collected by using a pre-designed questionnaire prepared for the study during the period from January 2023 to June 2024. Grossly malformed sacrum or incomplete sacrum were excluded. Lumbarization and sacralization would affect the measurements of normal sacra, so they are excluded too. Location and shape of sacral hiatus was carefully observed and noted. With the help of digital slide calipers different measurements were done and recorded to the nearest millimeter.

Measurement of the length of the sacral hiatus: Length of hiatus was measured from apex of the sacral hiatus to midpoint of base at the level of the cornu.[6]

Measurement of the transverse diameter of the sacral hiatus at the base: Transverse diameter of sacral hiatus at the base was measured between the inner aspects of inferior limit of sacral cornua by the digital slide calipers.[6]

Measurement of the antero-posterior diameter of the sacral hiatus at the apex: Anteroposterior diameter of sacral hiatus at the apex was measured by digital slide calipers [6]. For this purpose, a flat metallic structure was introduced vertically through the hiatus at the level of the apex and the point was marked and measured.

Observation of the level of position of the apex of sacral hiatus: Position of the apex of sacral hiatus situated at the level of which vertebra was observed and recorded. For this purpose, a stick was placed transversely at the level of the apex of hiatus on its dorsal surface and its position on which sacral vertebra was observed on the ventral surface and recorded.

Observation of the level of position of the base of sacral hiatus: Position of the base of sacral hiatus situated at the level of which vertebra was observed and recorded. For this purpose, a stick was placed transversely at the level of the base of hiatus on its dorsal surface and its position on which sacral vertebra was observed on the ventral surface and recorded.

Results

Results are shown as frequency and percentage

Table – I: Shape of the sacral hiatus (n=100)

Shape of the sacral hiatus	Number	Percentage (%)
Inverted U	47	47
Inverted V	25	25
Irregular	24	24
Dumbbell	2	2
Bifid	2	2

Table I shows the percentage of different types of shape sacral hiatus of total 100 sacra. The most common shape of the sacral hiatus was inverted U (47%) in both male and female.

Table II: Shape of the sacral hiatus in male and female

Shape of the sacral hiatus	Male (n=43)		Female (n=57)	
	No	%	No	%
Inverted U	40	48.84	52	44.83
Inverted V	33	23.26	29	25.86
Irregular	10	25.58	12	24.14
Dumbbell	0	0	7	3.45
Bifid	1	2.33	1	1.72

Again Table - II reveals most common shape of the sacral hiatus in male was inverted U shaped was (48.84%), followed by irregular shaped (25.58%),

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inverted V shaped (23.26%), bifid shaped (2.33%) and dumbbell shaped (0%) whereas in female inverted U shaped was (44.83%), followed by inverted V shaped was (25.86%), irregular shaped (24.14%), dumbbell shaped (3.45%) and bifid shaped (1.72%). No significance test was done regarding this variable.

Location of apex of sacral hiatus in male and female sacra

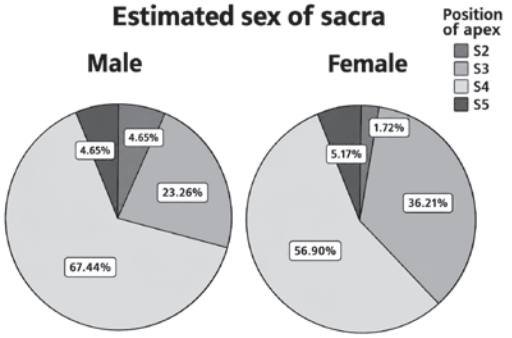


Figure: 1 Pie chart showing the percentage of location of the apex of sacral hiatus in male and female.

Figure 1 shows the location of the apex of sacral hiatus. It was found that in the highest number of sacra, the apex was at the level of 4th sacral vertebra in male (67.44%) and in females (56.90%). The second commonest position of the apex of sacral hiatus at the level of 3rd sacral vertebra was found in male (23.26%) and in female (36.21%) cases. Position of the apex of sacral hiatus at the level of 5th sacral vertebra was found in male (4.65%) and in female (5.17%) cases and lowest in number at the level of 2ndsacral vertebrain male (4.65%) and in female (1.72%).

Location of apex of sacral hiatus in male and female sacra

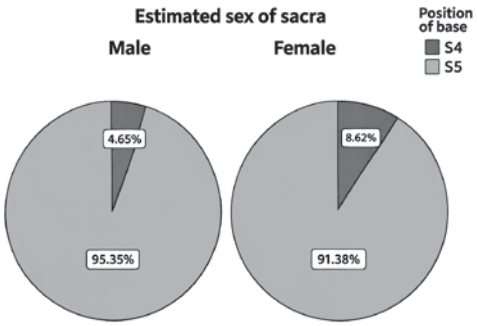


Figure: 2 Pie chart showing the percentage of location of the base of sacral hiatus in male and female

Figure 2 shows the location of the base of sacral hiatus. It was found that in the highest number of sacra, the base was at the level of 5th sacral vertebra in male (95.35%) and in females (91.38%). The rest of the case shows a base of sacral hiatus at the level of 4th sacral vertebra in male (4.65%) and in female (8.62%) cases.

Table III: Length, antero-posterior diameter at the apex and transverse diameter at the base of sacral hiatus in male and female

Variables (mm)	Sex	Measurement		P value
		Range	Mean ±SD	
Length (mm)	Male	53.80-5.65	20.13±10.43	0.180 (NS)
	Female	42.22-5.58	22.00±8.62	
Antero-posterior diameter at the apex (mm)	Male	13.07-3.66	7.52±2.07	0.074 (NS)
	Female	20.73-1.92	6.79±2.76	
Transverse diameter at the base (mm)	Male	21.40-7.72	14.48±3.62	0.220 (NS)
	Female	23.31-5.65	15.01±3.23	

P values reached from unpaired |'t' tests for male and female values

Results are shown as mean ±SD

NS=non-significant

Table III shows the mean of length, antero-posterior diameter at the apex and transverse diameter at base of sacral hiatus in male and female. Length of sacral hiatus was found 20.13±10.43 mm and 22.00 ±8.62 mm in male and female respectively. The greater length of sacral hiatus in females was not statistically significant than male (P=0.180). On the other hand, the mean of antero-posterior diameter of sacral hiatus at the apex was found 7.52±2.07 mm in male and 6.79±2.76mm in female and the transverse diameter of the sacral hiatus at the base found 14.48±3.62 mm in male and 15.01±3.23 mm in female. Both the measurements, antero-posterior diameter of sacral hiatus at the apex and transverse diameter of the sacral hiatus at the base were not significantly different in male and female (P=0.074 and 0.220 respectively).

Discussion

Skeletal measurements vary widely among populations due to genetic and environmental factors, food habits and other factors. Considering this regional variability, each population should have specific standards to optimize the accuracy of its implication. The present work was undertaken to study various morphometric variables of sacral hiatus.The sacral hiatus is an important anatomical landmark for access to the caudal epidural space, and its morphology and morphometric characteristics show considerable variation among different populations.[7,8] Previous studies have demonstrated regional and population-related differences in sacral measurements, suggesting that population-specific anatomical data may be useful for improving the accuracy and safety of procedures involving the sacral hiatus.[9,10] The present study was therefore undertaken to evaluate the morphological and morphometric characteristics of the sacral hiatus and to assess their variation between male and female sacra in a population from northern Bangladesh.In this study sacra of both sex, inverted U shaped was more common in males than females (48.84% and 44.83%) likewise irregular shaped was (25.58% and 24.14%), but inverted V shaped was more common in female than males (25.86% and 23.26%) and Other less common shapes were bifid shaped was 2.33% and 1.72% in male and female respectively. It could also be stated that dumbbell shaped was only found in females 3.45%.[11]stated among the samples inverted U shaped was 38.86% and 37.05%, inverted V shaped was 32.25% and 38.27%, irregular shaped was 16.68% and 13.57%, elongated shaped was 6.66% and 4.94%, dumbbell shaped was 5.55% and 4.94% and bifid shaped was 0.0% and 0.60% in male and female respectively.

Another study stated that inverted U shaped was more common in females than males (44.1% and 37.0%) but inverted V shaped was more common in male than females (30.6% and 24.6%). Other less common shapes were irregular shaped was 9.3% and 10.2%, elongated shaped was 6.5% and 7.6%, M shaped was 7.4% and 5.1%, dumbbell shaped was 2.8% and 5.9% and bifid shaped was 1.9% and 0.80% in male and female respectively.[12]

Similar morphological variations have been reported by several investigators. Desai et al. found inverted U to be the most common shape (42.12%), followed by inverted V (35.43%) and irregular shape (12.99%) in Indian dry sacra.[4] Another study also reported inverted U as the most frequent configuration, accounting for 40.35% of sacral hiatuses.[11]Another study reported that inverted U and inverted V were among the most common forms, with variation between male and female sacra.[13] A study also similarly found the inverted U shape to be common in both sexes.[14] These findings support the observation of the present study that the inverted U configuration is the predominant morphology of the sacral hiatus, although the frequency of individual shapes varies among populations.

Regarding the level of the apex of the sacral hiatus, the present study found that the fourth sacral vertebra was the most common level in both males (67.44%) and females (56.90%). The third sacral vertebra was the second most common level, occurring in 23.26% of males and 36.21% of females. The apex was located at the fifth sacral vertebra in 4.65% of males and 5.17% of females, while the second sacral vertebra was the least common level, occurring in 4.65% of males and 1.72% of females. The predominance of the fourth sacral vertebral level is consistent with previous anatomical studies. A study reported that the apex and base of the sacral hiatus were most commonly located opposite the fourth and fifth sacral vertebrae, respectively.[9] Another study similarly reported S4 as the most common level of the apex and S5 as the common level of the base.[13] Another study also found S4 to be the most frequent level of the apex.[4] These findings indicate that although the fourth sacral vertebra is the most frequent location of the apex, considerable variation may occur between individuals and populations.

In the present study, the base of the sacral hiatus was most commonly located at the level of the fifth sacral vertebra, occurring in 95.35% of males and 91.38% of females. The remaining sacra showed the base at the fourth sacral vertebra in 4.65% of males and 8.62% of females. This finding is comparable with previous

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studies in which the fifth sacral vertebra was reported as the commonest level of the base.[14,15] The consistent predominance of S5 as the level of the base is clinically relevant because the base and sacral cornua serve as important anatomical landmarks during identification of the sacral hiatus for caudal epidural procedures.[9,10]

Regarding the length of the sacral hiatus, the present study found mean values of 20.13±10.43 mm in males and 22.00±8.62 mm in females. The difference was not statistically significant (P=0.180). Kamal reported mean lengths of 20.71±8.39 mm in males and 17.85±8.41 mm in females, with a significantly greater length in males (P=0.011).[11] A study reported mean lengths of 26.38±12.02 mm in males and 25.63±10.46 mm in females.[12] Thus, the direction and magnitude of sex-related differences in sacral hiatus length have not been consistent across populations. Another study reported a mean sacral hiatus length of 21.70 mm, which is close to the overall magnitude observed in the present study.[4] Another study reported a considerably higher mean length of 27.16 mm in Egyptian sacra, further demonstrating population-related variation in this parameter.[10]

The anteroposterior diameter of the sacral hiatus at the apex was 7.52±2.07 mm in males and 6.79±2.76 mm in females in the present study. The difference was not statistically significant (P=0.074). The transverse diameter at the base was 14.48±3.62 mm in males and 15.01±3.23 mm in females, and this difference was also not statistically significant (P=0.220). These findings indicate that, in the present sample, the measured morphometric parameters of the sacral hiatus did not show significant sexual dimorphism. Similar variability in these measurements has been reported in different populations. A study reported a mean anteroposterior diameter of 5.50 mm at the apex, while Another study reported anteroposterior depth values ranging from 1.90 to 10.40 mm and a mean intercornual distance of 11.95±2.78 mm.[4,9] A study also demonstrated variation in the length, AP diameter and transverse width of the sacral hiatus and reported sex-related differences in some parameters.[13]

Another study reported anteroposterior diameters at the apex of 5.01±1.34 mm in males and 5.67±1.71 mm in females, with the female value being significantly greater (P=0.001).[11]Other studies have also demonstrated variation in the anteroposterior diameter of the sacral hiatus among populations.[14,15]The difference between these findings and those of the present study may be related to population characteristics, sample size, methods of measurement and the morphological variability of the sacral hiatus. Therefore, the absence of statistically significant sex differences in the present study does not exclude the possibility of clinically important individual variation.

The morphometric characteristics of the sacral hiatus have direct clinical relevance for caudal epidural procedures. Anatomical variations in the shape, level, depth and dimensions of the hiatus may influence identification of the epidural entry point and may contribute to difficulty or failure during blind caudal epidural block.[13,14,15] Another study demonstrated that different shapes, bony irregularities and defects of the dorsal wall may affect successful needle placement during caudal epidural block.[9]A study also emphasized the relationship between sacral hiatus dimensions and the success of caudal epidural anesthesia.[10]

Other study suggested that knowledge of the anatomical variations of the hiatus is important for safe and uncomplicated caudal epidural access.[13]Thus, the morphometric data obtained in the present study may provide useful baseline information for clinical procedures involving the sacral hiatus in the studied population.

The present findings should also be interpreted in the context of broader sacral morphology. Studies of sacral sexual dimorphism and population-specific sacral measurements have demonstrated differences in sacral dimensions among populations and between sexes.[16,17,18,19] However, the present study specifically focused on the sacral hiatus, and none of the measured hiatus parameters showed statistically significant sex differences. Therefore, the findings suggest that sexual dimorphism of the whole sacrum does not necessarily translate into statistically significant sexual differences in every parameter of the sacral hiatus.

Overall, the present study demonstrates considerable

morphological variation in the sacral hiatus, with the inverted U shape, apex at S4 and base at S5 being the predominant findings. Although the measured parameters did not demonstrate statistically significant differences between male and female sacra, comparison with previous studies shows substantial inter-population variation. Knowledge of these variations is important for improving the identification of the sacral hiatus and may contribute to safer and more reliable caudal epidural procedures.

Conclusion

Sacral approach to epidural space produces reliable and effective block of sacral nerves. Appropriate knowledge about the variations of sacral hiatus is necessary to improve both the reliability and safety of caudal epidural anesthesia. The findings of this study may also help to prevent failure or injury of the dural sac. Again, knowledge about the different shapes of hiatus and defects in the dorsal wall of sacral canal, various morphometric measurements and variations of structures around sacral hiatus were also studied to evaluate the possible anatomical reasons of failure.

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Limitation:

The study was carried out on sacra collected from different medical colleges of Bogura, within limited time and no sophisticated technology was used.

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