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ORIGINAL ARTICLE

Morphometric study of sacral hiatus and its significance in caudal epidural anesthesia

Amol A. Shinde, Purushottam Rao Manvikar, Vaishaly K. Bharambe

Department of Anatomy, Dr. D. Y. Patil Medical College, Pimpri, Pune, Maharashtra, India

ABSTRACT

Context: Sacral hiatus is used for administration of caudal epidural block. A frequent problem in this is needle placement as it is difficult to determine the location of sacral hiatus. The knowledge of anatomy of sacral hiatus plays a major role in the success of needle placement. **Aim:** To study the anatomy of sacral hiatus from point of view of caudal epidural anesthesia. **Materials and Methods:** The sacral hiatus of 300 sacra was studied. Parameters of sacral hiatus such as shape, level of apex and base, length, anteroposterior (AP) diameter at apex, and intercornual distance along with distance between superolateral sacral crests and their distance from apex of sacral hiatus were studied. **Results:** Inverted "U" shape (46.33%) was most commonly encountered. Apex and base of the hiatus were most commonly seen at the level of S4 and S5 respectively. Length of sacral hiatus ranged between 8.8 mm and 45.7 mm. AP diameter at apex of sacra and intercornual distance were seen most commonly in the range 4–6 mm and 11–15 mm respectively. **Conclusion:** The study of these sacra indicated the type of variations in shape and size of sacral hiatus in population of state of Maharashtra in India. While absent sacral hiatus leads to poor outcome of the caudal epidural anesthesia, dorsal agenesis of the sacrum would lead to only partial anesthesia. The formation of equilateral triangle by joining superolateral sacral crests and apex of sacral hiatus forms a practical guide in locating sacral hiatus for caudal epidural anesthesia.

Keywords: Absent sacral hiatus, caudal epidural anesthesia, dorsal agenesis of sacral hiatus, sacral hiatus

INTRODUCTION

Sacrum is a triangular bone forming the caudal end of the vertebral column, formed by fusion of five sacral vertebrae. Sacral hiatus is the opening present at the caudal end of sacral canal formed by the nonfusion of the lamina of the fifth (occasionally fourth) sacral vertebra. The fifth inferior articular processes project caudally and flank the sacral hiatus as the sacral cornua.

The structures passing through sacral hiatus are a pair of 5th sacral nerves, a pair of coccygeal nerves, filum terminale externam, which passes to coccyx and fibro-fatty tissue.[1]

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On the body surface, the sacral hiatus lies about two inches above the coccyx and can be palpated as a concave depression between the sacral cornua above the sacrococcygeal joint.[2]

The sacral hiatus has been utilized for administration of caudal epidural anesthesia in obstetrics as well as orthopedic practice for treatment and diagnosis.[3,4] The most frequent problem encountered in caudal epidural block is needle placement as sometimes it is difficult to determine the anatomical location of sacral hiatus especially in adults. Clinical evaluation of needle placement can be done with ultrasonography or fluoroscopy. However, it is not always feasible to do so because of time and cost constraints.

Variations have been found in the shape and level of sacral hiatus. Anatomical landmarks and the knowledge of actual shape and size of sacral hiatus and its variations play a major role in the success of needle placement.[5]

Morphometric study of sacrum has been done by many workers in many different geographical areas

Corresponding Author: Dr. Vaishaly K. Bharambe, D-9 State Bank Nagar, Panchvati, Pashan Road, Pune, Maharashtra, India. E-mail: vaishalybharambe@yahoo.co.in

across the globe.[6,7] These studies have concluded that understanding the variations of sacral hiatus may improve the success of caudal epidural block.

Present study was taken up to conduct sacral hiatus morphometry to determine the anatomical landmarks of sacral hiatus including variations of sacral hiatus in population residing in Maharashtra state of India. Such a geographical regional study covering this region has not been done earlier. It is likely that there can be racial and anthropometrical variations in the sacral hiatus.

MATERIALS AND METHODS

The study was carried out by obtaining 300 sacra from 11 Medical and Dental Colleges from state of Maharashtra. Only those bones that were intact, with no breakages, fracture or any other pathology were considered for the study.

All the bones were numbered carefully to avoid repetition and confusion during measurement.

Each sacrum was studied for the following features. Shape of hiatus was observed. Level of the apex and base of hiatus with relation to the number of sacral vertebra was observed and recorded. Length of hiatus was measured from apex of hiatus to the midpoint of the base [Figure 1]. Transverse width of the sacral hiatus at the base was measured as the distance between the inner aspects of inferior limits of sacral cornua. Anteroposterior (AP) diameter of sacral hiatus at the apex was also measured.

As shown in Figure 2, right superolateral sacral crest was labeled as point A, left superolateral sacral crest as point B and apex of sacral hiatus as point C. Thus, a triangle ABC was constructed by joining these points. Distance between the two superolateral sacral crests, distance between the right superolateral sacral crest and apex of sacral hiatus and distance between the left superolateral sacral crest and apex of sacral hiatus were measured.

All measurements were taken by a sliding vernier caliper and a flexible measuring tape to the nearest millimeter.

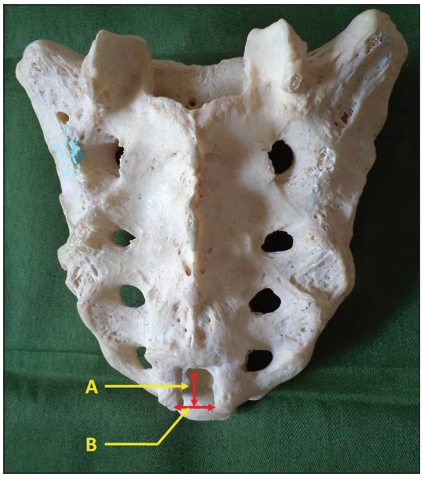

Figure 1: Photograph showing length of sacral hiatus (a) and intercornual distance (b)

RESULTS

The results regarding each of the above measurements related to sacral hiatus are given in Tables 1-5. Figures 3 and 4 are depicting sacra showing complete dorsal agenesis and closed sacral hiatus respectively.

DISCUSSION

Variations in anatomical features of sacral hiatus have clinical implications in technique of caudal epidural anesthesia. With this background, morphometric study of sacral hiatus was carried out with reference to population of Maharashtra state of India as geographical and racial factors have been seen to affect measurements. Three hundred dry sacra from various medical colleges were included in this study. Various relevant measurements of sacral hiatus were taken and analyzed.

In the present study, many variations were observed in the shape of the sacral hiatus.

"Inverted U" shape was the most common shape seen in 46.33% of sacra. This finding is similar to findings by

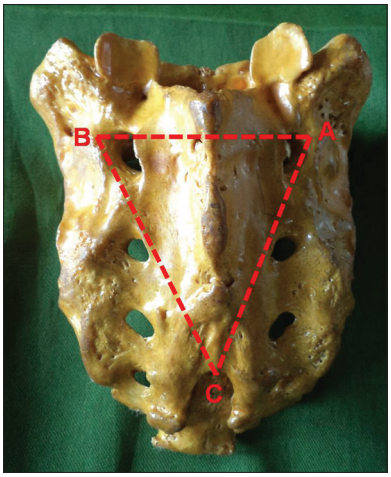

Figure 2: Photograph showing right superolateral sacral crest (point A), left superolateral sacral crest (point B) and apex of sacral hiatus (point C). The construction of triangle ABC is depicted by joining the three points. The inverted "U" shaped sacral hiatus can also be seen here

Figure 3: Photograph showing complete dorsal agenesis of sacrum

Figure 4: Photograph showing closed sacral hiatus

Table 1: Observations regarding shape of sacral hiatus

Shape	Percentage
Inverted U	46.33
Inverted V	29.67
Dumbbell	10.33
Irregular	8.67
Bifid	3
Complete dorsal agenesis	1.3
Closed	0.67

Table 2: Observations regarding level of apex and base of sacral hiatus

Level (%)	S2	S3	S4	S5	Coccyx
Apex	1.01	32.77	60.04	6.08	0
Base	0	0	11.82	77.03	11.15

Note – 4 sacra with complete dorsal agenesis are not included

Table 3: Measurements of length of sacral hiatus

Length of sacral hiatus (mm)	Percentage
0-10	2.05
11-20	38.75
21-30	33.33
31-40	23.11
41-50	2.73

Note – 4 sacra with dorsal agenesis and 2 with closed hiatus were not included

Table 4: Measurements of anteroposterior diameter at apex

AP diameter at apex (mm)	Percentage
0-3	20.95
4-6	69.22
7-9	9.50
More than 9	0.33

Note – 2 sacra with closed hiatus were not included

Nagar in Gujarati population and Suma *et al*. in South Indian population, where their incidence was 41.5% and 44% sacra respectively.[3,8] But present observations differed from that of Kumar *et al*. in Punjabi population where "inverted V" shape was most common and amounted to 70% of the sacra.[6] "Inverted V" shape was second most common in present study with incidence of 26.67%, this finding being nearer to findings of Njihia and Awori who reported incidence of 32.1% in a study of dry sacra of African population.[9]

"Dumbbell" and "irregular" shaped sacral hiatus was seen in 10.33% and 8.67% sacra respectively in present study. These figures differ from those of Aggarwal *et al*. who reported 7.01% for "dumbbell" shaped hiatus and 15.78% incidence for "irregular" shaped sacral hiatus in Punjabi population and Nagar who reported presence of 14.1% "irregular" shaped sacral hiatus.[3,10]

Bifid sacral hiatus was seen in 3% of sacra in the present study. Nevertheless, similar findings were reported by Nagar (4.38%) and Suma *et al*. (5.33%).[3,8]

Absence of sacral hiatus is a rare finding. Its incidence was reported to be 1.2% by Njihia and Awori.[9] The incidence was least that is, 0.67% in the present study and which was similar to 0.7% incidence reported by Nagar.[3] Sekiguchi found absence of sacral hiatus in 4% of sacra.[4] Absent sacral hiatus is one of the factors for poor outcome of caudal epidural anesthesia.[11]

As regards to dorsal agenesis, present study showed dorsal agenesis in 1.33% of sacra, a finding very similar to Sekiguchi *et al*., Trotter and Nagar who reported findings of 1%, 1.8% and 1.5% sacra respectively.[3,4,12] Kumar *et al*. report 2.7% and 12.5% incidence of dorsal agenesis in male and female sacra respectively.[13] Sacral hiatus is the site for administration of epidural anesthesia. Knowledge of anatomy of sacral hiatus is essential for a successful application of epidural anesthesia. Hiatal agenesis or complete dorsal agenesis

of sacrum causes failure of caudal epidural block in 7% of cases.[4] Black *et al*. state that caudal block in case of dorsal agenesis could never be more than partially successful, as the anesthetic solution would be likely to infiltrate into the surrounding tissue.[14] This kind of anatomical variation in the sacral hiatus may also lead to failure of transpedicular and lateral mass screw placement.[15]

Apex of the hiatus was found most commonly at S4 level in 60.04% sacra while the base was found at S5 level in 77.03% sacra. Nagar reported similar findings with 55.9% of apex being at S4 and 72.6% base being at S5. Apex at S2 level was seen in lesser number that is, in 1.1% sacra in the present study as compared to 3.4% sacra as reported by Nagar.[3] The apex of the sacral hiatus is an important bony landmark in the success of caudal epidural block, but it may be hard to palpate, particularly in obese patients.[5] Dural puncture is a known complication of caudal epidural anesthesia. Dural puncture can occur if there is an anatomic malformation, especially if the sacral hiatus is as high as S1 or S2. When the apex is at a higher level, the needle can inadvertently be inserted into the sacral canal at a higher segmental level.[2] In such cases, there are increased chances of advancing needle of caudal epidural anesthesia piercing the dura mater. If dural puncture occurs and goes undetected, then the entire volume of local anesthetic may get injected into the subarachnoid space, leading to total spinal anesthesia.[16]

In the present study, the base of hiatus was at the level of coccyx in 11.15% sacra. A higher incidence of 16.3% and 25.62% was reported by Nagar and Suma *et al*. respectively.[3,8]

The maximum length of sacral hiatus was found to be 45.7 mm and minimum 8.8 mm. In 38.75% of sacra, the length of sacral hiatus ranged between 11 and 20 mm. Nagar reported a similar 35% incidence of sacra with hiatal length in the range between 11 mm and 20 mm.[3] Very few sacra that is, 2.05% were found to have length of sacral hiatus in the range 0–10 mm, a point to be noted for insertion of needles during caudal anesthesia. This figure was substantially low compared to 10.3% reported by Nagar.[3] Senoglu *et al*. reported 36.7% incidence of sacra having length of sacral hiatus in the range 30–40 mm.[5] The importance of knowing the length of sacral hiatus lies in the fact that while carrying out caudal epidural anesthesia, after the needle pierces the sacrococcygeal membrane, it is advanced for 2–3 mm cranially so that the entire bevel of the needle is in the sacral canal. In case of short length of sacral canal, the advancing needle may pierce the dura.[16]

Anteroposterior diameter at the apex of sacral hiatus was seen in the range of 1.9–9.2 mm in this study. Maximum 69.22% sacra showed AP diameter between 4 and 6 mm. This is similar to the findings reported by Nagar.[3] However in a study conducted by Patel *et al*., 55.33% sacra showed AP diameter at apex of sacral hiatus to be in the range of 0–3 mm.[17] The AP diameter at the hiatus is important as it should be sufficiently large as to admit the needle or catheter of caudal epidural anesthesia.[17]

Distance at the base of sacral hiatus ranged from 8.5 mm to 25.7 mm. Highest number of sacra that is, 59.06% had a intercornual distance ranging between 11 mm and 15 mm, which is a finding similar to the 54% reported by Nagar.[3]

The distances AB, AC and BC were measured and the mean of each of the distances was found to be 64.5 mm, 64.59 mm and 63.94 mm respectively, roughly forming an equilateral triangle [Figure 2]. Table 6 shows comparison of present findings to those of other authors. Findings in the present study are similar to those of

Table 5: Measurements of distances between the superolateral sacral crests and their distances from the apex of sacral hiatus

Distance (mm)	Percentage		
	Distance between right and left superolateral sacral crests (AB)	Distance between right superolateral sacral crest and apex of sacral hiatus (AC)	Distance between left superolateral sacral crest and apex of sacral hiatus (BC)
<40	0.33	0.68	0.68
40-50	3.67	2.03	2.03
50-55	17.33	4.39	8.78
55-60	40.67	17.57	15.88
60-65	14.67	31.08	32.09
65-70	19.33	18.92	17.23
70-75	3.67	16.22	12.50
75-80	0.33	6.42	9.46
>80	0.00	2.70	1.35

Table 6: Comparison of the mean distance between superolateral sacral crests and apex of sacral hiatus in various studies

	Senoglu *et al*.[5] (mm)	Kumar *et al*.[6] (mm)	Present study (mm)
Mean (AB)	66.5	63.55	64.5
Mean (AC)	67.1	61.8	64.59
Mean (BC)	67.5	61.02	63.94

Senoglu *et al*.[5] Kumar *et al*. in a study carried out on sacra in Northern India, also described the formation of such an equilateral triangle ABC similar to present study but the lengths were found to be comparatively lesser.[6] The superolateral sacral crests impose on the posterior superior iliac spines.[5] The position of sacral hiatus to be used for caudal epidural anesthesia can be found at the apex of the equilateral triangle thus formed, by palpating the 2 posterior superior iliac spines.[2]

CONCLUSION

A study of morphometric measurements of sacral hiatus was undertaken in population residing in Maharashtra state of India. Three hundred sacra were taken for the study. The sacra were sourced from various Dental and Medical colleges from Maharashtra state and thus had diversity in sampling. Parameters taken into account were shape of sacral hiatus, level of apex and base of sacral hiatus, length of sacral hiatus, AP diameter at apex of sacral hiatus, distance at the base of sacral hiatus and distance between superolateral sacral crests and their distance from apex of sacral hiatus.

Observations were tabulated and discussed with reference to available data in the literature. Conclusion drawn after discussion was as follows:

- There was variability in the anatomical structure of the sacral hiatus. The inverted U shape of sacral hiatus was most commonly seen
- Apex and base of the hiatus were most commonly seen at the level of S4 and S5 respectively
- Length of sacral hiatus was seen in the range of 8.8 mm to 45.7 mm. Maximum sacra had a length in the range between 11 mm and 20 mm
- AP diameter at apex of sacra and intercornual distance were seen most commonly in the range 4–6 mm and 11–15 mm respectively
- These measurements will be of immense value in administration of caudal epidural anesthesia and variations in shape, and size of sacral hiatus will help in preoperative evaluation of patients
- The triangle formed by joining superolateral sacral crests and apex of sacral hiatus was found to be equilateral in nature. This is of clinical importance as the superolateral sacral crests superimpose on the posterior superior iliac spines. This forms a practical guide in locating sacral hiatus for caudal epidural anesthesia.

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