Original Research Article

Anatomical Study of Variations of Sacral Hiatus and its Clinical Relevance in Caudal Epidural Block

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Abstract

Introduction: The human sacrum is a large, triangular shield-shaped bone formed by the fusion of five separate vertebrae along with the inter-vertebral discs. Gross morphology of sacrum shows a concave ventral surface, a convex dorsal surface and a triangular sacral canal. The sacral canal consists of an anterior wall formed by the fusion of the posterior aspect of the bodies of sacral vertebrae and the dorsal wall is formed by the fused laminae, spines and ossified ligamentum flava. Sacral hiatus is the opening present at the caudal end of sacral canal. Non fusion of laminae of 4th or 5th sacral vertebrae results in its formation. Clinically sacral hiatus is used for epidural injections.**Aim of the study:** Present study is aimed at determining the anatomy of sacral hiatus with the help of morphometric measurements and to identify significant anatomical variations to locate it for caudal epidural block.**Material and Method:** Total 96 dry human sacra from Department of Anatomy & Forensic medicine, SRMS-IMS, Bareilly, were studied.A Vernier caliper was used for anatomical measurements. Study period was from July 2016 to December 2016.**Result:** The average height of sacral hiatus was 34.13±11.82 mm. Different shapes of sacral hiatus were observed, inverted U shaped hiatus were most common. The apex of the sacral hiatus was most commonly found at the level of 4th sacral vertebrae.Right and left superolateral crests of the sacrum were taken as two points on dorsal surface of sacrum (forming the base of a triangle) because posterior superior iliac spines,impose on superolateral sacral crests. The distance between the two superolateral crests, the distance between the right and left superolateral sacral crest and the sacral apex were on average 60.61±6.71, 61.95±11.71 and 61.40±11.98 mm respectively. **Conclusion:** An equilateral triangle formed between the apex of sacral hiatus and right and left superolateral sacral crests. This equilateral triangle will help in determining the location of the sacral hiatus during caudal epidural block. Also the length of sacral hiatus should be kept in mind.

Keywords: Caudal Epidural Block(CEB), Sacral Hiatus (SH), Sacral Cornua (SC).

Introduction

Caudal epidural block (CEB) involves the injection of anaesthetic medications into the epidural space through the sacral hiatus to provide analgesia and anaesthesia for different clinical conditions [1].The human sacrum is a large, triangular shield-shaped bone formed by the fusion of five separate vertebrae along with the inter-vertebral discs. Gross morphology of sacrum shows a concave ventral surface, a convex dorsal surface and a triangular sacral canal [2]. On the dorsal surface of the sacrum there is a raised median sacral crest, with four tubercles which represent the fused sacral spines. Below the fourth tubercle there is an arched sacral hiatus, produced by the failure of the fusion of the two laminae of the fifth sacral vertebrae in the median plane covered by the posterior aspect of the sacrococcygeal membrane.Flanking the median sacral crest there are intermediate sacral crests and lateral to that there are four pairs of dorsal sacral foramina. Lateral to those foramina there are lateral sacral crests [3].

The remnants of the inferior articular processes of the fifth lumbar vertebra elongates downwards on both sides of the sacral hiatus to form the sacral cornua. It is an important clinical landmarkto locate the sacral hiatus during caudal epidural block (CEB) [1].Opposite the middle of the sacrum (between S1 & S3), the subarachnoid and subdural spaces are closed and the lower sacral spinal roots with filum terminale pierce the arachnoid and dura mater at this level [3]. So,introduction of needle into sacral canal through the sacral hiatus should be safe.Epidural anaesthesia in obstetrics and transpedicular and lateral mass screw placement in orthopaedic practice is done through sacral hiatus [4,5].As the variations in location, shape and

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size of the sacral hiatus are also caused by sacral spina bifida, so knowledge of these anatomical variants also improve the above clinical procedures. The variant morphology and morphometry of sacral hiatus is important for successful colposcopy also [6]. The large sacral hiatus due to development, sacral bifida or otherwise will reduce the area for the attachment of extensor muscle at back causing painful conditions [7]. Sacral hiatus with guide wire assistance is an accessible conduit for uncomplicated entry into the subarachnoid and basal cisternal space without damaging the surrounding structures [8]. Thus more precise the knowledge of anatomical variations of sacral hiatus, the more successful and reliable caudal epidural anaesthesia will be.

Present study is aimed at determining the anatomy of sacral hiatus with the help of morphometric measurements and to identify significant anatomical variations to locate it for caudal epidural block, commonly used in procedures like perineal surgery and for caudal analgesia for a painless delivery.

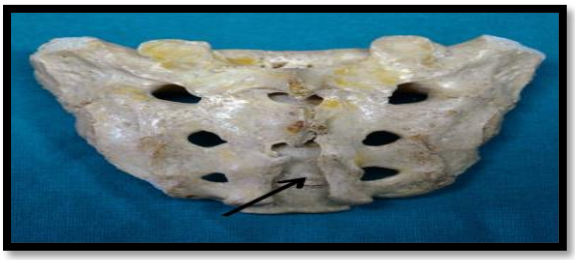

Fig 1: Sacrum showing sacral hiatus (arrowhead)

Material and Methods

Total 96 dry human sacra from Department of Anatomy & Forensic medicine, SRMS-IMS, Bareilly were studied. Study period was from July 2016 to December 2016. Undamaged sacral bones with intact sacral hiatus of all ages, irrespective of their sex.were included in this study. Sacra showing some loss of osseous material, with any sign of fracture or showing features of sacralisation or lumbarisation was excluded from the study. A Vernier caliper was used for anatomical measurements, each sacrum was studied for different features of sacral hiatus with regards to:

1. Shape of hiatus
2. Level of apex of hiatus.
3. Height of sacral hiatus.
4. Width of sacral hiatus at the level of sacral cornua.
5. Distance from the apex of sacral hiatus to the level of S2 foramina.
6. Distance between the two superolateral sacral crest.
7. Distance between right superolateral sacral crest and apex of sacral hiatus.
8. Distance between left superolateral sacral crest and apex of sacral hiatus.

Superolateral sacral crests of the sacrum were used as landmarks in the measurements as the posterior superior iliac spines (palpable on the body surface of a patient) impose on the superolateral sacral crests of the sacrum.The line joining the two posterior superior iliac spines passes through the lower point of the 1st dorsal sacral foramina in most of the cases [9]. So, in non-articulated pelvis this line was used to locate the position of posterior superior iliac spine on lateral sacral crest.This line formed the base of a triangle and the lines joining the apex of the sacral hiatus with the right & left posterior superior iliac spines or the superolateral sacral crests formed the other two arms.The three arms of this triangle were measured in each sacrum[5].

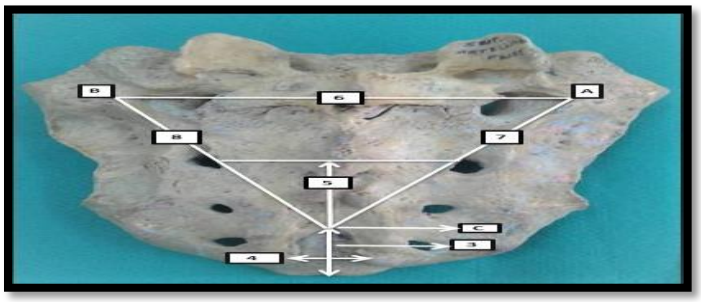

Fig 2: Morphometric Parameters measured in Sacrum showing right superolateral crest (A), left superolateral crest (B) & apex of sacral hiatus (C)

Observation & Results

The shape and size of the hiatus depends on the number of laminae that fails to fuse in the midline posteriorly.These features of sacral hiatus are important for administering caudal epidural anesthesia. The shapes of sacral hiatus as shown in table 1 were variable. Most common was inverted U (56.25%). In 10.42%, the sacral hiatus was dumb-bell, while in 16.67% it had irregular outline. Bifid hiatus was seen in 2.08%. Elongated hiatus was observed in 2.08% of sacrum.

Table 1: Distribution of Sacrum according to shape of hiatus

S. NO.	Shape	Number	Percentage
1	Inverted U	54	56.25
2	Inverted V	12	12.5
3	Irregular	16	16.67

4	Dumb-bell	10	10.42
5	Bifid	2	2.08
6	Elongated	2	2.08

Fig 1: Inverted U

Fig 2: Inverted V

Fig 3: Irregular

Fig 4: Dumb-bell

Fig 5: Bifid & Elongated

Table 2: Position of Apex of Sacral Hiatus

S.No.	Location of apex	number	percentage
1	3rd Sacral vertebrae	30	31.25
2	4th Sacral vertebrae	62	64.58
3	2nd Sacral vertebrae	2	2.08
4	5th Sacral vertebrae	2	2.08

The position of apex of sacral hiatus can vary from S2 to S5 vertebrae. The most common level of apex of sacral hiatus is S4 vertebra followed by S3 and least common in S2 as illustrated in table 2.

Table 3: Morphometric measurements in Sacrum

In mm	Mean ± SD	Min.	Max.
Height of sacral hiatus	34.13 ± 11.82	7	76
Width of sacral hiatus at the level of sacral cornua	13.71 ± 2.24	9	20
Distance from hiatus apex to S2	32.88 ±13.34	0	65
Distance between the two superolateral sacral crests	60.61 ± 6.71	43	78
Distance between right superolateral sacral crest and apex of sacral hiatus	61.95 ± 11.71	29	95
Distance between left superolateral sacral crest and apex of sacral hiatus	61.4 ± 11.98	28	91

The average length of the sacral hiatus was 34.13 (±11.82) mm (range 7–76 mm). Width of Sacral Hiatus at level of sacral cornua was 13.71(±2.24) mm. The average distance between the two superolateral sacral crests was 60.61(±6.71) mm. The distance between the right superolateral sacral crest and the sacral apex was 61.95(±11.71) mm. The distance between the left superolateral sacral crest and the sacral apex was 61.4(±11.98) mm.

Discussion

According to the previously reported cases there is a failure rate in 25-26% cases of CEB as the identification of the caudal epidural space is not always possible due to anatomical variation of the sacral hiatus [9,11].Anatomical abnormalities of the sacrum include upward and downward displacement of the 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 in shape of the sacral hiatus [10].So, bony irregularities, different shapes of hiatus and defects in the dorsal wall of the sacral canal should be taken into consideration before undertaking CEB [12]. Kumar V et al. (1992) and Nagar et al. (2004)noted various shapes of sacral hiatus, most common being Inverted V and Inverted U in 76.23% sacra and 68.5%, sacra respectively [13,14]. Kumar V et al. (1992) found 7.63% and Nagar et al. (2004) found 13.3% sacra were dumb-bell shaped [13,14]. In the present study also the shapes of sacral hiatus were variable. Most common was inverted U (56.25%). In 10.42%, the sacral hiatus was dumb-bell, while in 16.67% it had irregular outline.Bifid hiatus was seen in 2.08% which was reported earlier by Nagar et al. (2004) having 1.5% bifid sacra [14]. In addition to this 2.08% sacra had elongated hiatus.Inverted U and V shapes provide enough space for needle access during caudal epidural anesthesia making anesthetists more comfortable in giving

anesthesia, whereas dumbbell and irregular shapes provide challenge for this process [15,16]. The average length of the sacral hiatus was 34.13 (11.82) mm (range 7–76 mm).Width of sacral hiatus at level of sacral cornua was 13.71 (2.24) mm.The apex of the sacral hiatus showed considerable variations ranging from S2 to S5 but most commonly it was at the level of S4 (64.58%).Singh R (2013) classified these variations of dorsal wall of sacrum i.e. as sacral spina bifida occulta into five types: as Type I with completely open sacral canal,apex at S1 level corresponds to Type-II sacral spina bifida oculta (SSBO) and that at S2, S3 to Type III and Type IV SSBO respectively& as Type V with apex at S4 [18]. Shifting apex of sacral hiatus at higher level is due to failure of fusion of continuously higher laminae culminating in progressively increasing length of sacral hiatus [17, 18]. Increase in length of the sacral hiatus is also caused by the defect of unfused 2nd and 3rd and 4th pair of sacral laminae and also by coccygeal ankylosis [17,19].As the apex of the sacral hiatus is difficult to palpate, especially in obese patients, other landmarks may be of use, such as the triangle formed between the posterior superior iliac spines and the apex of sacral hiatus.

According to Senoglu et al. (2005), this was equilateral triangle and was helpful to detect the apex of sacral hiatus easily [9].Aggarwal A et al. (2009)also found this equilateral triangle in 45% cases, in the present study this equilateral triangle was found in 40% of the cases[20].The average distance between the two superolateral sacral crests was 60.61 (± 6.71) mm. The distance between the right superolateral sacral crest and the sacral apex was 61.95 (±11.71) mm. The distance between the left superolateral sacral crest and the sacral apex was 61.4 (±11.98) mm. From these mean values, we can note that the distances from the right and left sacral crests to the hiatus were nearly similar forming nearly an equilateral triangle.

Aggarwal A et al. (2009) used posterior superior illiac spine (instead of superolateral sacral crest) and got following values 70.1 (±7.8), 66 (±9.6), 65.3 (±9.8) mm respectively and observed equilateral triangle in 51% specimens [20].This equilateral triangle can act as guide to the location of the apex of sacral hiatus during caudal epidural block and one can avoid problem of failure in needle placement. An important point in CEB is the knowledge of the distance between the sacral hiatus and dural sac which ends around the level of S2, to prevent the iatrogenic injury of dural sac [5,9].The distance between the S2 foramen and the apex of the sacral hiatus was 35.4 (± 10.4) mm (range 11–62 mm) in the study by Senoglu et al.(2005) while in present study it was 32.88 (± 13.34) mm (range 0–65 mm) which are nearer to observations by N. Senoglu et al [9] .In the study of Aggarwal et al. (2009) the minimum distance between S2 and apex of sacral hiatus was 7.25 mm which suggested that it would not be safe to push the needle beyond 7 mm into sacral canal so as to avoid dural puncture [20]. To reduce the frequency of dural puncture and other possible complications the needle should be cautiously advanced after penetrating the sacrococcygeal membrane. According to Dalens BJ (2006), the known shape and size of sacral hiatus provides easy accessto the sacral epidural space at a level below the termination of the duralsac where most of the roots of the caudaequina are no longer inside the sacralcanal [21].

Conclusion

There is variability in the anatomical structure of the sacrum, especially the sacral hiatus. However, we believe that the equilateral nature of the triangle formed between the two posterior superior iliac spines and the apex of the sacral hiatus will be of practical benefit to the clinician in determining the location of the sacral hiatus during CEB. Further clinical trials are required to compare the existing techniques and our anatomical description to provide more data to support the results of this study.

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