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Original Research Paper

Anatomy

"A MORPHOMETRIC STUDY OF SACRAL HIATUS ON DRY HUMAN SACRUM FOR CAUDAL EPIDURAL BLOCK"

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ABSTRACT

Sacral hiatus (SH) is an inverted arched shaped opening on the dorsal wall of sacrum, which is formed by incomplete midline fusion of the laminae of the fifth or sometimes the fourth sacral vertebrae. For the successful caudal epidural block (CEB) accurate placement of needle into the epidural space through the sacral hiatus is required in different clinical conditions. Among the observed cases the most commonly encountered shape of sacral hiatus is inverted 'U' in 36% cases. In 2 sacra there was complete agenesis of the dorsal wall of sacral canal. Knowledge of these variations are clinically very important for the successful application of CEB.

The level of apex of the sacral hiatus showed considerable variations ranging from S2 to S5 but its commonest position was against S4 (58%). Base of the sacral hiatus was present most commonly at the level of S5 vertebrae (67.34%), in the plane of coccyx in (30.61%) and rarely it is present at the level of 4th Sacral vertebrae.

The mean height, width and depth of sacral hiatus at the apex were 25.19 mm, 15.62 mm and 6.21 mm respectively. The mean distance between the two points on lateral sacral crests at the level of first sacral foramina (base of triangle) was 62.52 mm. The average distances of those two points on right and left lateral sacral crests from the apex of the sacral hiatus were 63.8mm and 63.2 mm respectively. A complete equilateral triangle is demonstrated in 16 cases by union of right and left sacral crests with apex of hiatus 34.04 %. An isosceles triangle was observed in 26 cases 55.31% and a scalene triangle was present in 5 cases 10.63%.

The mean distance from the apex of sacral hiatus to the level of S2 foramina was 40.73 mm and the mean distance from the base of sacral hiatus to the level of S2 foramina (mean distance from the apex of sacral hiatus to the level of S2 foramina + height of sacral hiatus) was 65.92 mm.

KEYWORDS :

INTRODUCTION

Caudal epidural block is considered a very safe method for anaesthesia and analgesia below umbilicus in young ages as well as in urgent procedures like incarcerated hernia, perineal procedures, lower limb surgeries and in superficial operations such as skin grafting. CEB is utilized for administration of epidural anaesthesia in orthopaedics for diagnosis and treatment of various diseases, in obstetrics for painless delivery and for treating patients with low back pain, but sometimes it is difficult to determine the anatomical location of the sacral hiatus and the caudal epidural space. In the caudal epidural block (CEB) the injection of anaesthetic medicine is administered into the epidural space through the sacral hiatus for different clinical conditions.[1] For the successful caudal epidural block (CEB) accurate placement of needle into the epidural space after penetrating the sacrococcygeal ligament is required. Anatomical variations of the sacrum and abnormalities of the sacral hiatus are challenges during caudal injections making it difficult to locate the sacral hiatus may lead to the failure of caudal epidural block.[2]

The Sacrum is a large triangular bone forms the posterior superior wall of the pelvic cavity.[3] On the dorsal surface of the sacrum in the median plane, there is a raised median sacral crest with 4 or sometimes 3 tubercles which represent the fused sacral spines. Lateral to median sacral crest there are two intermediate sacral crests on its either sides formed by fusion of articular facets of sacral vertebrae.[4]

Sacral hiatus (SH) is an inverted arched shaped opening on the dorsal wall of sacrum, below the fourth or the third tubercle.[4] It is usually an inverted 'V' or inverted 'U' shaped space located at the distal part of the sacrum which is formed by incomplete midline fusion of the laminae of the fifth or sometimes the fourth sacral vertebrae and even if the laminae of the higher sacral vertebrae are not fused than hiatus will be seen at a higher level. Sometimes non fusion of all the five laminae of sacral vertebrae occurs which represents as a midline gap dorsally, such clinical condition known as spina bifida.[5]

Sacral hiatus is covered by a superficial posterior sacrococcygeal ligament and is an important landmark in CEB. The lower sacral nerve roots, coccygeal nerve roots, filum terminale and fibrofatty tissue are the contents of SH.[3]

Prevalence-- Nadeem (2014) in his study observed different shapes of sacral hiatus which includes- Inverted U (56%), Inverted V (14%), Irregular (16%), Dumb-bell (10%), Bifid (2%) and Elongated (2%).[6] Nagar (2004) observed various shapes of sacral hiatus out of which in 4 sacra (1.5%) – complete agenesis of the dorsal wall of sacral canal, inverted U (41.5%), inverted V (27%), irregular (14.1%), dumbbell (13.3%) and bifid (1.5%)[7]

Landmarks for locating sacral hiatus- Sacral hiatus is identified on the surface by a point about 2 inches above the tip of coccyx under the skin covering the natal cleft (Waldman 2004)[3].

Superficial posterior sacrococcygeal ligament- It can also marked by palpation of the sacral cornua keeping the patient in the lateral position or lying prone over a pelvic pillow.[8,9]

Sacral cornua are the remnants of inferior articular process of fifth sacral vertebra projects downward on both sides of sacral hiatus. It is very important landmark to locate the sacral hiatus during caudal epidural anaesthesia. On the body surface the hiatus can be marked two inches above the tip of coccyx beneath the skin of natal cleft.[10,11]

At the middle of the sacrum (between S1 & S3), the arachnoid and subdural spaces are closed and the lower sacral spinal roots with filum terminale pierces the arachnoid and duramater at this level.[8,9] Introduction of needle into sacral canal through sacral hiatus is safe as the dural sac terminates around the level of second sacral vertebrae.

According to the observations made by Senoglu N et.al., the posterior superior iliac spines are easily palpable on the body surface of the patients which impose on the upper part of lateral sacral crest and the line joining those points of the lateral sacral crest termed as superolateral crest. Superolateral crest joining the two posterior superior iliac spines passes through the lower point of the 1st dorsal sacral foramina in most of the cases and forms the base of a triangle whose other two sides are formed by the lines joining the apex of the sacral hiatus with the right & left posterior superior iliac spines or the superolateral sacral crests.[9] Sacral hiatus may be identified by constructing an equilateral triangle based on a line joining the posterior superior iliac spines (Standring et.al., 2008).[12]

The success rate of caudal epidural block (CEB) is based on determination of the landmark by clinician (Senoglu et al.2005).[9]Variations in anatomy of sacral hiatus (SH) can lead to failure of CEB. Tsui et.al (1999) studied that caudal epidural block has 25% failure rate. So, the purpose of this study is to explore the variations of sacral hiatus among the North Indian population to increase the success rate of CEB.[13]

AIM & OBJECTIVES

Aim

1. To assess the morphometric measurements of the sacral hiatus in North Indian population.

OBJECTIVES

1. To identify additional anatomical landmarks that may increase success rate of CEB in cases where the sacral cornua could not be identified to locate the apex of the sacral hiatus.

MATERIAL AND METHODS

The present study was conducted in the Department of Anatomy, Santosh Medical College & Hospital Ghaziabad and Saraswathi Institute of Medical Sciences, Hapur, U.P. A total of 50 dry complete and undamaged human sacral bones with undetermined sex and age were collected from Osteology lab of the Anatomy Department. Damaged, multilated & deformed sacra were excluded.

Various qualitative and quantitative parameters were observed such as shapes of the sacral hiatus, level of apex and base of sacral hiatus and the metric parameters were measured with the help of digital vernier caliper.

	Parameters
1	Length of sacral hiatus- measured from apex to midpoint of the base.
2	Transverse width (intercornual distance) - measured between the inner aspect of inferior limit of sacral cornua.
3	Antero-posterior width of sacral hiatus at the apex.
4	Distance between the two posterior superior iliac spines (superolateral sacral crests)
5	Distance between right posterior superior iliac spines and apex of sacral hiatus.
6	Distance between left posterior superior iliac spines and apex of sacral hiatus.
7	Distance from the apex of sacral hiatus to the level of S2 foramina.
8	Distance from the base of sacral hiatus (sacral apex) to the level of S2 foramina.

RESULTS

Among the observed cases the most commonly encountered shape of sacral hiatus is inverted 'U' in 36% cases. In 1 sacra sacral hiatus was absent and in 2 sacra there was complete agenesis of the dorsal wall of sacral canal. Agenesis of dorsal wall of sacral canal is more likely a groove rather than a canal. Knowledge of these variations are clinically very important for the successful application of CEB. In one case the apex of sacral hiatus found at the level of S2 vertebrae due to failure of fusion of continuously higher laminae culminating in progressively increasing length of sacral hiatus. The result is reported in table-1 and different varieties of sacral hiatus are demonstrated from (figure 1-6).

The level of apex of the sacral hiatus showed considerable variations ranging from S2 to S5 but its commonest position was against S4 (58%). In 18% it was at the level of S3, rest all the values are depicted in table-2. Base of sacral hiatus was present most commonly at the level of S5 vertebrae (67.34%) and in the plane of coccyx in 7 cases (30.61%) rarely it is present at the level of 4thSacral vertebrae.

The mean height, width and depth of sacral hiatus at the apex were 25.19 mm, 15.62 mm and 6.21mm respectively. The mean distance between the two points on lateral sacral crests at the level of first sacral foramina (base of triangle) was 62.52mm. The average distances of those two points on right and left lateral sacral crests from the apex of the sacral hiatus were 63.8mm and 63.2 mm respectively. A complete equilateral triangle is demonstrated in 16 cases by union of right and left sacral crests with apex of hiatus 34.04 %. An isosceles triangle was observed in 26 cases 55.31% and a scalene triangle was present in 5 cases 10.63%.

The mean distance from the apex of sacral hiatus to the level of S2 foramina was 40.73 mm and the mean distance from the base of sacral hiatus to the level of S2 foramina (mean distance from the apex of sacral hiatus to the level of S2 foramina + height of sacral hiatus) was 65.92 mm.

Table-1 Different Types Of Sacral Hiatus (n=50)

Inverted U	Inverted V	Irregular	M	Dumbbell	Spina bifida	Absent Scaral hiatus
18 (36%)	12 (24%)	7 (14%)	3 (6%)	7 (14%)	2 (4%)	1(2%)

Table-2 Location Of The Apex Of Sacral Hiatus (n=50)

2nd Sacral vertebrae	3rd Sacral vertebrae	4th Sacral vertebrae	5th Sacral vertebrae

Table-3 Location Of The Base Of Sacral Hiatus

4th Sacral vertebrae	5th Sacral vertebrae	Coccyx
1 (8.16%)	33 (67.34%)	15 (30.61%)

Table-4 Morphometric Measurements Of Sacrum

Parameters	Mean mm	Range mm	Standard Deviation mm
Length of Sacral hiatus	24.806	8.77-63.60	7.793
Width of Sacral hiatus	15.498	7.47-18.78	2.331
Depth of Sacral hiatus	6.139	.01-9.45	1.886
Distance between right and left lateral sacral crest at the level of first sacral foramina	62.501	48.76-76.58	6.042
Distance between right lateral sacral crest and apex of sacral hiatus	64.423	32.24-74.11	9.280
Distance between left lateral sacral crest and apex of sacral hiatus	63.822	30.66-77.32	9.450

Distance from the apex of sacral hiatus to the level of S2 foramina	39.682	21.59-60.77	11.238
Distance from the base of sacral hiatus to the level of S2 foramina	65.92	52.95-93.42	9.768

Fig-1 U shape SH

Fig-2V shape SH

Fig-3 Irregular shape SH

Fig-4 M shape SH

Fig-5 Dumbbell shape SH

Fig-6 Spina bifida SH

Fig-7 Length of SH

Fig-8 Width of SH

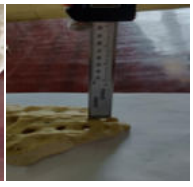
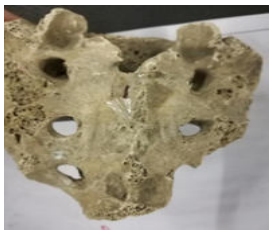


Fig-9 AP diameter of SH



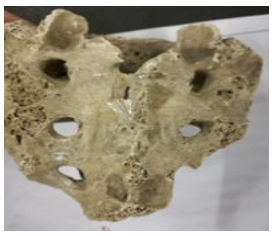


Fig-10 & 11 showing absence of sacral hiatus

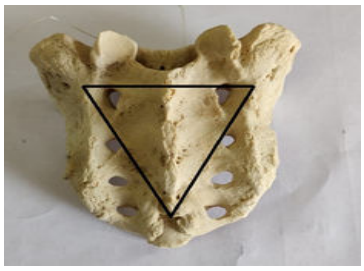


Fig-12 Equilateral triangle on the dorsum of the sacrum

DISCUSSION

In Caudal epidural block (CEB), Ultrasonography or Fluoroscopy is 100% successful but always it is not possible due to time, cost & personal availability.[14] So, the most frequently used technique for the (CEB) based on feeling the 'pop' on penetrating the sacrococcygeal membrane, after determining the sacral hiatus by palpating the sacral cornua. Jean-Anthanase Sicard, a radiologist, was the first to describe injection of dilute solutions of cocaine through the sacral hiatus (the caudal route into the epidural space in 1901, to treat patients suffering from severe, intractable sciatica pain or lumbago).[15] One week later but independently, in 1901, Cathelin, urologist, described caudal administration of local anaesthetic for surgical procedures and also injection of cocaine for relief of pain due to inoperable carcinoma of the rectum.[16] Edward et.al 1942 took the advantage of this natural gap at the lower end of sacral canal for continuous caudal analgesia during labour.[17] Epidural steroid injections have been used since 1952. The volume of sacral hiatus is 34ml (on average in dried bone specimens) and the volume of local anaesthetics (5-10 ml) is very small used in day to day pain management.

According to the previously reported cases there is a failure rate in 25-26% cases of CEB even in experienced hands as the identification of caudal epidural space is not always possible due to the anatomical variations of the sacral hiatus. So, the sacral hiatus is the most crucial anatomical landmark affecting CEB.

In the present study predominantly Inverted U shaped sacral hiatus observed in 36% and Inverted V shape found in 24% which were favourable for CEB. This findings shows incidence of Inverted U is higher & Inverted V shape is almost same among the identical population as the Singh et al in 2016 found same incidences 22.3% of U & V shape sacral hiatus. M shape sacral hiatus was seen in 3 cases 6% which is higher to that reported by Nagar (2004) in Gujarat State 1.5% [7]& by Parshuram (2015) in Karnataka in 2% cases and less than from the study of Singh et.al in 2016 in UP State.[19]

In the present study the commonest position of the apex of the sacral hiatus was against the S4 vertebrae in (58%) which is less to that reported by Ukoha et. al (2014) in 69%,[20]Singh et al in 2016 (62.30%)[3] and Sekiguchi et al (2004) found in 65% [21]of sacra while Kumar et.al 2009 in 72% [19], Mustafa et al (2012) in Egypt in 70% of sacra.[23]All previous studies including the present study noted that the level of apex can vary from upper part of 2nd sacral vertebrae to lower part of 5th sacral vertebrae.

Base of sacral hiatus was seen at the level of 5th sacral vertebrae in 67.34% of sacra in the present study which is nearly similar to Nagar studies it was 72.6% but the value of our study is lower from the study of Singh et al 2016 in 81.97%, Shewale et al 2013 found in 82% of sacra in Maharastra state [24]and Parshuram 2015 noted in 93.3% of sacra in Karnataka region and it was much higher [16] when compared to study conducted by Malarvani et al. (2014) in 54% of sacra of Nepalese.[25]

Mean of length of the sacral hiatus was 24.806 mm and SD 7.793 mm in the present study that is almost similar to that reported by Lanier et al (1945) [26]who found the mean length of sacral hiatus is to be 25.3 mm while in previous studies Patel et. al 2011[27]Aggarwal et al. 2012[28] Shewale et al.2013 showed the average length of the hiatus 20.21mm vary from 18.81mm to 22.87mm which is lower from the present study but the study by Patil et al. 2012[29]& Bhattacharya et al. 2013 describes higher average values (34.13mm and 35.92mm) [4] than the current study.

In the present study, the transverse width of sacral hiatus varied between 7.47mm to 18.95mm with arithematic mean of 15.498 mm and SD 2.331 mm which was similar to the study conducted by Singh and Mahajan 2013 who reported 0.3 to 18mm in North Indian population. Trotter et al. 1944 in his study noted that it varies from 7mm to 26mm with arithematic mean of 17mm higher value from present study. Sekiguchi et.al 2004 reported a lower valve approx. 10.2 mm.

Antero-posterior depth of sacral hiatus is important as it should be sufficiently large to admit a needle for subcutaneous deposition of anesthetic drug. Antero-posterior depth ranged from 0.1-11.44 mm with the arithematic mean of 6.139 mm and SD 1.886 mm whereas the mean diameter observed by Kumar et al. 1992 - 4.8 mm, Nagar 2004 - 4.8 mm, Trotter et al. 1944 - 5.3 mm.

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, equilateral triangle is very helpful to locate the apex of sacral hiatus easily. Aggarwal et al. 2012 and Patil et al. 2012 reported an equilateral in 45% and 23% cases respectively. On the contrary, Bhattacharya et.al 2013 observed an isosceles triangle in general but a complete equilateral triangle was found only in 16% cases. The present study described a scalene triangle 10.63% in addition to isosceles triangle (55.31%) and complete equilateral triangle in (34.41% which is the unique finding of the study).

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 avoid the dural puncture. In the study of Bhattacharya et. al the distance between the S2 foramen and the apex of the sacral hiatus was 4.341 cm or 43.41 mm which is higher from the mean of present study i.e 39.682 mm and SD is 11.238 mm. Distance from the base of sacral hiatus to the level of S2 foramen 7.964cm or 79.64mm it is higher from the mean 65.92 mm of present study. Knowledge of the anatomical variations of sacral hiatus will facilitate the procedure.

CONCLUSION

Sacral hiatus is very important part of sacrum which has anatomical variations. Less than 3mm depth of sacral hiatus causes difficulty in the insertion of the needle. Variations in its shapes, surrounding bony irregularities and defects in dorsal canal should be studied in order to avoid failure of epidural block. Exact location of sacral hiatus in caudal epidural block determines its success rate. Hence, detailed knowledge of sacral hiatus is essential. Knowledge of the distance between the sacral hiatus and dural sac anatomically also plays a crucial role in minimising risk for the dural sac. The variabilities provided in this study should be kept in mind before giving CEB.

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