Original article:

A morphometric study of sacral hiatus for caudal epidural block among the population of West Bengal.

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Abstract:
Introduction: Single bony landmark may not help to detect the hiatus properly for caudal epidural block (CEB). The aim of the study was to measure the different aspects of the sacral hiatus and to identify significant anatomical landmarks to locate it.
Methods: Different morphometric measurements were taken of one hundred sacra with a Vernier caliper. These measurements may provide a guideline to locate the sacral hiatus.
Results: The average height and depth of the sacral hiatus were 3.592(mean)±0.3769(SD)cm and 0.723(mean)±0.0709(SD)cm respectively. The distance between right and left posterior superior iliac spines (superolateral sacral crests) was 6.48(mean)±0.5232(SD)cm and the distances from the apex of the sacral hiatus & sacral apex to those points were 5.841(mean)±0.2705(SD)cm,5.837(mean)±0.2769(SD)cm,8.137(mean)±0.2806(SD)cm,8.141(mean)±0.2793(SD)cm respectively.
Conclusion: Two isosceles triangles were obtained by joining the right and left superolateral sacral crests with apex of the hiatus and sacral apex. These triangles can be a bony landmark to detect the sacral hiatus easily. As the minimum distance between S2 and apex of the sacral hiatus is 1cm, introduction of needle beyond that is not safe during CEB.
Key words: caudal epidural block, sacrum, sacral hiatus, sacral cornua.
Key notes: Anatomical features of the sacral hiatus have clinical importance during caudal epidural block.

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]. It is useful when anesthesia of the lumbar and sacral dermatomes is needed[1]. Bony landmarks of the CEB are sacral hiatus and sacral cornua [2, 3]. The sacrum articulates with the fifth lumbar vertebra above and the coccyx below. On the dorsal surface of the sacrum there is a raised median sacral crest, with four, sometimes, three tubercles which represent the

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fused sacral spines. Below the fourth (or the third) tubercle there is an arched sacral hiatus (on the posterior wall of the sacral canal), produced by the failure of the fusion of the two laminae of the fifth sacral vertebrae or sometimes the fourth in the median plane. 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 [4]. The fifth sacral spinal nerve emerges through the sacral hiatus with the coccygeal nerve to provide partial innervations to the pelvic organs including the uterus, fallopian tubes, urinary bladder and prostate in addition to the sensory and motor innervations to the respective dermatomes and myotomes [2, 4]. The sacral canal also contains filum terminale externa, terminal parts of the dura mater and arachnoid mater, fibro fatty tissue and epidural venous plexus that generally ends at the level of S4, but may continue inferiorly[2, 4]. 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[2, 4]. So, introduction of needle into sacral canal through the sacral hiatus should be safe.

The hiatus is covered by superficial posterior sacrococcygeal ligament, attached to the margins of the hiatus and the deep posterior sacrococcygeal ligament, attached to the floor of sacral hiatus[2, 4].Flanking the median sacral crest there are intermediate sacral crests and lateral to that there are four pairs of dorsal sacral foramina[4]. Lateral to those foramina there are lateral sacral crests [4]. Even though CEB has a wide range of clinical applications, it is sometimes difficult to determine the anatomical location of the sacral hiatus and the caudal epidural space, especially in adults [5, 6]. The cause of failure of CEB may depend on anatomic basis [3]. So, understanding the anatomic variations of sacral hiatus using bony landmarks may improve the reliability of CEB [3, 5].

Aims & Objectives: The main goal of this study was the morphometric measurements of the sacra and sacral hiatus in different aspects and to identify anatomical landmarks (in addition to the sacral cornua) to detect the sacral hiatus among the people of West Bengal. These observations can provide a guideline for CEB.

Materials and methods

One hundred adult dry sacral bones, collected from the different Medical Colleges of Kolkata, were used. The desired study population was selected from the departmental records. Total posterior closure and agenesis of dorsal wall cases were excluded from the study. Only undamaged sacral bones with intact sacral hiatus were included in study. The bones were of undetermined gender and age. Several morphometric measurements like height and depth of the sacral hiatus, intercornual width etc. were performed on these specimens by using a Vernier caliper.

The posterior superior iliac spine imposes on the upper part of lateral sacral crest and that point of overlapping on the lateral sacral crest was named by Senoglu N and colleagues as superolateral sacral crest and 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 [5]. 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

of the triangle [5, 6]. The three arms of this triangle were measured in each sacrum. This triangle can be a practical guide to detect the sacral hiatus. As the dural sac terminates around the level of S2 [5], the distances from the apex and base of the sacral hiatus to the level of the S2 foramina were also measured separately in this study.Thus nine direct morphometric measurements, related to the sacral vertebra and hiatus, were obtained from different literatures [2, 3, 5, 6] (Fig-1 & 2). In addition to these parameters, the distances from sacral apex to right and left posterior superior iliac spines or the superolateral sacral crests were also measured in this study. Those formed two arms of another triangle having the same base of previous triangle. To the best of our knowledge this triangle has never been used as a guideline for CEB before. Collected data was tabulated in Microsoft excel spread sheet and was analyzed by Epi-info 3.5.1. Software.

Observations & Results

Among the observed cases the most commonly encountered shape of sacral hiatus is inverted 'U' shaped (65%). Inverted 'V' shaped sacrum was found in 23% cases and in rest of the cases (12%) the shape of sacral hiatus was irregular (Fig-3). The apex of the sacral hiatus showed considerable variations ranging from S3 to S5 but most commonly it was at the level of S4 (72%). In 23% cases it was at the level of S5 and in rest of the cases (5%), it was at the level of S3. The mean height and width of the sacral hiatus were 3.592 cm with standard deviation 0.3752 cm (range 3-4.3 cm) and 0.979 cm with standard deviation 0.1313 cm (range 0.7-1.2 cm) respectively. In majority of the cases (18%), 3.5cm long sacral hiatus was found and 4.2 cm long sacral hiatus had lowest frequency (1%) (Table-I).

Table-I: Showing distribution of sacra according to the length of sacral hiatus.

Length of sacral hiatus (cm)	Number of sacra	Percentage
3	10	10.0%
3.1	5	5.0%
3.2	6	6.0%
3.3	5	5.0%
3.4	8	8.0%
3.5	18	18.0%
3.6	13	13.0%
3.8	7	7.0%
4	13	13.0%
4.1	10	10.0%

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4.2	1	1.0%
4.3	4	4.0%
Total	100	100.0%

Table-II: Showing the result of different morphometric measurements.

Measurement parameter	Mean	Standard deviation(SD)	Minimum	Maximum	Median	Mode
A (cm)	3.592	0.3752	3.0	4.3	3.55	3.5
B (cm)	0.979	0.1313	0.7	1.2	1.0	1.0
C (cm)	4.341	0.8548	1	5.2	4.4	4.4
D (cm)	7.964	0.8919	4	9.3	8.05	8.0
E (cm)	6.619	0.4826	5.4	7.2	6.8	6.0
F (cm)	0.723	0.0709	0.6	0.8	0.7	0.7
G (cm)	6.477	0.5232	5	7.2	6.6	6.5
H (cm)	5.841	0.2705	5.4	6.4	5.8	6
I (cm)	5.837	0.2769	5.4	6.4	5.8	5.8
J(cm)	8.137	0.2806	7.5	8.6	8.2	8.4
K(cm)	8.141	0.2793	7.5	8.6	8.2	7.8

A= Height of sacral hiatus.
B=Width of sacral hiatus at the level of sacral cornua.
C= Distance from the apex of sacral hiatus to the level of S2 foramina.
D= Distance from the base of sacral hiatus (sacral apex) to the level of S2 foramina (A+C).
E= Distance between the upper border of S1 and sacral apex.
F= Depth of sacral hiatus at the level of its apex.
G= Distance between the two posterior superior iliac spines (superolateral sacral crests).
H= Distance between right posterior superior iliac spine (superolateral sacral crest) and apex of sacral hiatus.
I= Distance between left posterior superior iliac spine (superolateral sacral crest) and sacral apex.
K= Distance between left posterior superior iliac spine (superolateral sacral crest) and sacral apex.

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Distinct bilateral sacral cornua were found in 86% cases and unilateral prominences of sacral cornua were found in rest of the cases. The average distance between the two posterior superior iliac spines or the superolateral sacral crests (base of the triangle) was 6.48 cm with standard deviation 0.5232 cm (range 5-7.2cm). The mean distance between the right posterior superior iliac spine or the right superolateral sacral crest and the apex of the sacral hiatus was 5.841 cm with standard deviation 0.2705 cm (range 5.4-6.4cm). The mean distance between the left posterior superior iliac spine or the left superolateral sacral crest and the apex of the sacral hiatus was 5.837 cm with standard deviation 0.2769 cm (range 5.4 - 6.4cm). So, the mean distances from the right and left posterior superior iliac spines (superolateral sacral crest) to the apex of the hiatus were same in each sacrum which indicated the isosceles nature of the triangle. Moreover, according to our recorded measurements a complete equilateral triangle was found only in 16% cases.

Similarly, the mean distances between the right and left posterior superior iliac spine (superolateral sacral crest) and the sacral apex were 8.137 cm with standard deviation 0.2806 cm (range 7.5-8.6cm) and 8.141 cm with standard deviation 0.2793 cm (range 7.5-8.6cm) respectively. So, another isosceles triangle similar to the previous triangle was obtained by joining the above points. Different morphometric measurements of the present study are depicted in Table-II.

Discussion

Sacral approach to epidural space produces reliable and effective block of sacral nerves [6]. Epidural injection of cortico-steroids and local anaesthetic agents were widely used to provide symptomatic relief in patients with low back disorder [1]. 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 sciatic pain or lumbago[7]. 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 [8].Epidural steroid injections have been used since 1952 [1]. The volume of sacral hiatus is 34 ml (on average in dried bone specimens) but much smaller volume of local anaesthetics (5-10 ml) is used in day to day pain management [2].

In most of the cases the sacral hiatus was inverted 'U' shaped [2, 5] with apex (in about 64% of the cases) at the level of S4 [3, 5, 9]. The most frequently used technique to identify the caudal epidural space is based on feeling the 'pop' on penetrating the sacrococcygeal ligament, after determining the sacral hiatus by palpating the sacral cornua [1, 3]. According to the previously reported cases there is a failure rate in 25-26% cases of CEB even in experienced hands [1, 5, 9, 10, 11] as the identification of the caudal epidural space is not always possible due to anatomical variation of the sacral hiatus [6, 9]. 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 [6].

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 [5]. According to Senoglu et al (2005), this was one equilateral triangle and was helpful to detect the apex of sacral hiatus easily [5]. Aggarwal et al (2009) also found this equilateral triangle in 45%

cases [6]. But in the present study it was an isosceles triangle in general, although a complete equilateral triangle was found only in16% of the cases.

Sekiguchi and colleagues stated that the diameter of sacral canal was less than 2 mm in 1% of sacral bones; hence impeding use of 22 G needles for CEB [3]. But in the present study no such case was found. The smallest diameter recorded was 6mm which reflected a possibility of high success rate of CEB among the West Bengal population. Previous studies showed that the mean distance between the two sacral cornua was 10.2-17.47 mm and the depth of sacral hiatus at its apex was 4.46-6.0mm [3, 5]. So, according to the present study the intercornual width (mean=9.79mm, Standard deviation=1.31mm) was smaller but the depth (mean=7.23mm, Standard deviation=0.71 mm) was greater among the West Bengal population than the other populations.

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 [5]. In our study the distance between the S2 foramen and the apex of the sacral hiatus was 4.341 cm with standard deviation 0.8548 cm (range 1-5.2 cm) and distance from the base of sacral hiatus to the level of S2 foramen was 7.964 cm with standard deviation 0.8919 cm (range 4-9.3 cm). In the study of Aggarwal et al 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 [6]. But, according to present study that minimum distance was 1cm. So, introduction of needle beyond 1cm after piercing the sacrococcygeal membrane is not safe for CEB among the West Bengal population.

Chen and colleagues stated (in 2004) that the use of ultrasonography to guide needle placement into the caudal epidural space during CEB, would increase the success rate of it by 100% [1]. Caudal needle placement should be confirmed by fluoroscopy or epidurography [1]. Fluoroscopy is most commonly used in interventional spine procedure and is used in confirming the location of caudal epidural needle to decrease the risks of subarachnoid puncture and intrathecal or intravascular injections [2, 5, 12]. However, using ultrasonography or fluoroscopy is not always possible due to time, cost-effectiveness and personnel availability [5]. Radiation exposure is the major concern when obtaining fluoroscopic images [1]. So, when ultrasonography or fluoroscopy cannot be applied, other anatomical landmarks (like the triangles mentioned above) will facilitate the procedure [2, 5, 6].

Conclusion

Due to considerable variations in the anatomy of the sacrum and its hiatus the isosceles 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 clinicians in determining the location of the apex of the sacral hiatus. Moreover, another isosceles triangle between posterior superior iliac spine and sacral apex will throw a new light to locate the sacral apex. As the average distance from the apex of the sacral hiatus to sacral apex was 3.592 cm with standard deviation 0.3769cm (height of the sacral hiatus), the present study provided a proper guideline to locate the sacral hiatus with its extent.

Although these two triangles will be helpful to locate the position of sacral hiatus with accuracy, further clinical trials are required involving males and females of different age groups separately to compare

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the existing techniques and our findings to support the results of this study.

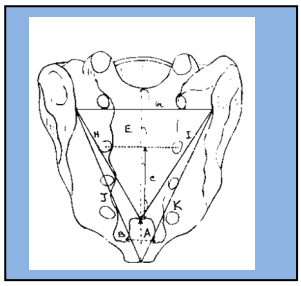

Figure 1: Posterior view of a hand drawn sacrum with the indices of different morphometric measurements.

INDEX:

A= Height of sacral hiatus.

B=Width of sacral hiatus at the level of sacral cornua.

C= Distance from the apex of sacral hiatus to the level of S2 foramina.

D= Distance from the base of sacral hiatus (sacral apex) to the level of S2 foramina (A+C).

E= Distance between the upper border of S1 and sacral apex.

G= Distance between the two posterior superior iliac spines (superolateral sacral crests).

H= Distance between right posterior superior iliac spine (superolateral sacral crest) and apex of sacral hiatus.

I= Distance between left posterior superior iliac spine (superolateral sacral crest) and apex of sacral hiatus.

J= Distance between right posterior superior iliac spine (superolateral sacral crest) and sacral apex.

K= Distance between left posterior superior iliac spine (superolateral sacral crest) and sacral apex.

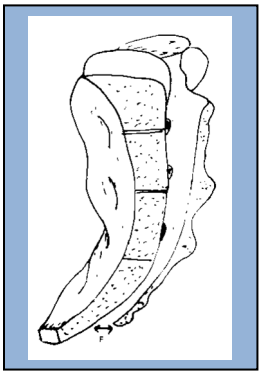

Figure 2 – Medial view of the sagittal section of a hand drawn sacrum indicating the depth of sacral hiatus .

Index F=Depth of sacral hiatus at the level of its apex.

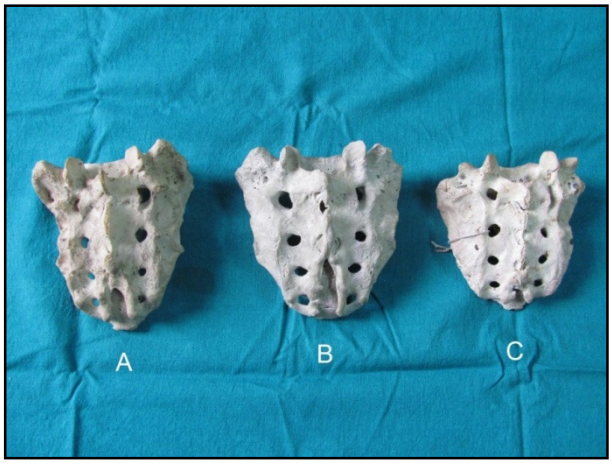

Figure 3 – Three sacra with different types of sacral hiatus.

INDEX:

A= inverted 'U' shaped

B=inverted 'V' shaped

C= irregular

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