Indian Journal of Basic and Applied Medical Research; December 2019: Vol.-9, Issue- 1, P. 51 - 63

Original article

A Morphometric Study on Sacral Hiatus in the Specimens of Articulated Pelvis Preserved in a Tertiary Care Hospital for Caudal Epidural Block

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Abstract

The present study has been conducted on morphometric measurements of the sacral hiatus. It is a one of a kind among similar studies, since, as far as my knowledge is concerned this is the first morphometric study of sacral hiatus done in the specimens of adult, dry, articulated pelvis whose gender and age have also been taken into account. 41 such specimens were collected and with the help of a digital caliper various measurements were taken. The study population included articulated pelvis bones and not patients as the probability of finding appropriate patients undergoing CEB at a Tertiary Health Care hospital was very less. In this study two isosceles triangles were found between the two posterior superior iliac spines as base and the distances between the right and left posterior superior iliac spines and the respective apex of sacral hiatus and sacral apex as arms. Since the distance between the apex of sacral hiatus and the sacral apex is found to be 33.74mm in males and 36.94mm in females, these landmarks can serve as a good guide for the anesthetists performing CEB. Moreover, diameter of the sacral canal was found to be less than 2mm in 19% of the study population (62% in female bones and 38% in male bones), impeding use of 22G needle for the procedure. Conclusive results have been found regarding the depth of needle insertion after piercing the sacrococcygeal membrane- 19mm in case of males and 34mm in case of females. None of the parameters chosen in this study showed considerable correlation with age. Since much subcutaneous fat is not present above the sacral apex and sacral canal, this study can be taken as a more or less accurate guide for the process of CEB. Still, further studies can be done on patients undergoing CEB to tally the obtained values.

Key words: Caudal epidural block, sacral hiatus, pelvis

Introduction

Caudal epidural block (CEB) involves the injection of medications into the epidural space through the sacral hiatus to provide analgesia and anesthesia. It is especially useful when anesthesia of the lumbar and sacral dermatomes is needed[1]. Pelvis is formed by the sacrum, which is a triangular bone formed by fusion of five vertebrae and forms the poster superior wall of the pelvic cavity, wedged between the two hip bones[2]. Caudal apex of sacrum articulates with the coccyx and its superior wide base with the fifth lumbar vertebra at the lumbosacral angle[2]. It is set obliquely and curved longitudinally, its dorsal surface being convex, the pelvic concave[2].The fifth inferior articular processes of sacrum project caudally and flank the sacral hiatus as sacral cornua, connected to coccygeal cornua by intercornual ligaments[2]. Due to incomplete midline fusion of the posterior elements of the distal portion of the fifth or sometimes the fourth sacral vertebra sacral hiatus is inverted U-shaped space, covered by the posterior aspect of the sacrococcygeal membrane[2]. Superficial posterior sacrococcygeal ligament is attached to the margins of the hiatus and the deep posterior sacrococcygeal ligament, attached to the floor of sacral hiatus[3,4]. The hiatus is covered only by skin, a subcutaneous fatty layer and the sacrococcygeal membrane. Sacral hiatus and sacral cornua are commonly used landmarks for CEB[3,5]. 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

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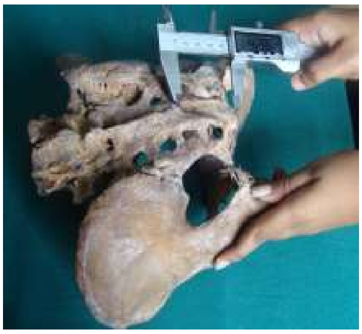
respective dermatomes and myotomes[3,4]. The sacral canal also contains filum terminale externa, terminal parts of the dura mater and arachnoid mater, fibro fatty tissue and epidural venous plexus[3,4]. Between S_1 & S_3, the subarachnoid and subdural spaces are closed and the lower sacral spinal roots with filum terminale pierce the arachnoid and dura mater at this level[3,4]. So, paralysis of the supplying dermatomes and organs may occur during introduction of needle into sacral canal through the sacral hiatus. CEB is also reportedly associated with adverse events (AEs) such as infection, hematoma, intravascular or subarachnoid penetration, direct nerve injury, and urinary retention[6]. These AEs are thought to be due to the depth of the needle that enters the epidural space and due to a lack of accuracy in needle placement[7]. In adults it is sometimes difficult to determine the anatomical location of the sacral hiatus and the caudal epidural space.[2] Thus a morphometric study of sacral hiatus was performed on 41 dry, articulated, adult specimens of pelvis after verifying their gender and age and their measurements have been compared with previous studies and other resources so that a conclusion can be reached.

Material and Methods:

Descriptive, observational, anthropometrical study with cross sectional design of data collection was conducted in the Department of Anatomy & Forensic Medicine of Calcutta National Medical College for the period of two months [May 2014- June 2014]. 41(21 were male and 20 were female specimens) pelvis were examined during the study period. Adult, undamaged, dry articulated pelvis were collected for morphometric measurement. Only undamaged sacral bones with intact sacral hiatus above the age of 16 years and below the age of 60 years were included in the study. Any congenital (Total posterior closure and agenesis of dorsal wall cases) or acquired deformity (kyphosis, scoliosis, post fracture etc.) was excluded from the study. Measurements of pelvis being done with the help of a Digital caliper.

Fig-1: Measurements of pelvis with digital caliper



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Adult dry articulated pelvis comprising of both hip bones & sacrum will be collected from Department of Anatomy & Forensic Medicine of Calcutta National Medical College by following inclusion and exclusion criteria.

⬇

Gender and age of the collected specimens were determined from the records and verified according to anatomical landmarks before taking the measurements.

⬇

Several morphometric measurements like height and depth of the sacral hiatus, intercornual width etc. were performed on these specimens by using a Digital caliper.

⬇

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[23]. 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 formed the other two arms of the triangle [23,24].
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[23], 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[3,5,23,24] . In addition to these parameters, the distances from sacral apex to right and left posterior superior iliac spines were also measured in this study. Those formed two arms of another triangle having the same base of previous triangle. Collected data was tabulated in Microsoft excel spread sheet and was analyzed by Epi-info 3.5.1. Software.

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Fig-2: The following morphometric measurements have been taken

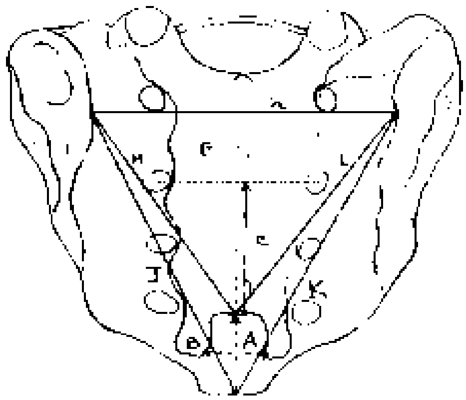

Figure 1: Posterior view of a hand drawn sacrum with the indices of different morphometric measurements

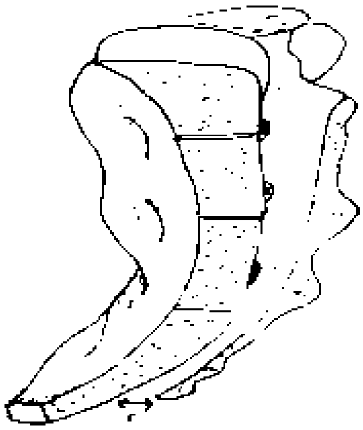

Figure 2 – Medial view of the sagittal section of a hand drawn sacrum indicating the depth of sacral hiatus (F) .

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 the 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

H = Distance between right posterior superior iliac spine and apex of sacral hiatus I = Distance between left posterior superior iliac spine and apex of sacral hiatus

J = Distance between right posterior superior iliac spine and sacral apex K = Distance between left posterior superior iliac spine and sacral apex

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Results and Observation:

Among the observed cases average age was 49.41 yrs with the standard deviation of 10.42 yrs (range 16 – 60 yrs). The most commonly encountered shape of sacral hiatus is inverted 'U' shaped (61%). Inverted 'V' shaped sacrum was found in 22% cases and in rest of the cases (17%) the shape of sacral hiatus was irregular.

Table I: Distribution of mean height of sacral hiatus (A) according to gender. (n = 41)

Gender	Mean	Standard deviation	Range	Median	Mode	Test of significance
Male	33.74	8.28	19.72-58.28	32.89	19.72	T Statistic = 1.4801 P- value = 0.1469
Female	36.94	5.08	26.7– 45.66	36.89	26.78	

Table II: Distribution of mean width of sacral hiatus at the level of sacral cornua (B) according to gender. (n = 41)

Gender	Mean	Standard deviation	Range	Median	Mode	Test of significance
Male	13.15	3.91	3.45 – 22.04	13.41	3.45	T statistic=1.1267 P value=0.2668
Female	14.29	2.32	10.23– 18.00	15	10.23	

Comment: No significant difference of average width of sacral hiatus was obtained between male and female sacral hiatus at the level of sacral cornua. (p> 0.05)

Table III: Distribution of mean distance from the apex of sacral hiatus to the level of S2 foramina (C) according to gender. (n = 41)

Gender	Mean	Standard deviation	Range	Median	Mode	Test of significance
Male	39.78	9.83	19.29– 51.93	41.79	19.29	T statistic=1.3386
Female	43.06	4.95	34.65 – 52.90	43.02	34.65	P value=0.1885

Table IV: Distribution of mean distance from the base of the sacral hiatus (sacral apex) to the level of S2 foramina (A+C = D) according to gender. (n = 41)

Gender	Mean	Standard deviation	Range	Median	Mode	Test of significance
Male	73.53	9.13	58.4 – 86.92	71.84	58.4	T statistic=2.8297
Female	80.01	4.74	70.07– 87.69	79.39	70.07	P value=0.0073

Comment: Significant difference of average distance from the base of the sacral hiatus (sacral apex) to the level of S2 foramina was obtained between male and female sacrum. **(p < 0.05)**

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Table V: Distribution of mean distance between the upper border of S1 and sacral apex(E) according to gender. (n = 41)

Gender	Mean	Standard deviation	Range	Median	Mode	Test of significance
Male	95.15	9.30	80.51–110.62	95.67	80.51	T statistic=1.3314 P value=0.1908
Female	98.37	5.66	84.09–109.69	98.83	84.09	

Table VI: Distribution of mean depth of sacral hiatus at the level of its apex (F) according to gender. (n = 41)

Gender	Mean	Standard deviation	Range	Median	Mode	Test of significance
Male	4.07	2.14	0.79–9.82	3.75	0.79	T statistic=0.8680 P value=0.3907
Female	3.50	1.98	0.63–6.85	3.6	0.63	

Comment: No significant difference of average depth at the level of its apex was obtained between male and female sacral hiatus. (p > 0.05)

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Table VII: Distribution of mean distance between the two posterior superior iliac spines (G) according to gender. (n = 41)

Gender	Mean	Standard deviation	Range	Median	Mode	Test of significance
Male	70.07	8.27	53.44 – 86.31	70.36	53.44	T statistic=0.0583
Female	69.94	5.76	60.08 – 86.03	70.55	60.08	P value=0.9538

Table VIII: Distribution of mean distance between right posterior superior iliac spine and apex of sacral hiatus(H) according to gender. (n = 41)

Gender	Mean	Standard deviation	Range	Median	Mode	Test of significance
Male	55.74	7.83	39.45–68.15	57.24	39.45	T statistic=2.3605
Female	60.19	3.18	54.1 – 64.87	60.45	54.1	P value=0.0233

Table IX: Distribution of mean distance between left posterior superior iliac spine and apex of sacral hiatus(I) according to gender. (n = 41)

Gender	Mean	Standard deviation	Range	Median	Mode	Test of significance
Male	54.64	7.27	38.6 – 65.64	56.16	38.6	T statistic=3.0737
Female	60.03	2.95	54– 64.45	60.51	54	P value=0.0038

Comment: Significant difference of average distance between left posterior superior iliac spine and apex of sacral hiatus was obtained between male and female pelvis.($p < 0.05$)

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Table X: Distribution of mean distance between right posterior superior iliac spine and sacral apex (J) according to gender. (n = 41)

Gender	Mean	Standard deviation	Range	Median	Mode	Test of significance
Male	82.31	7.2	68.68– 94.57	83.21	68.68	T statistic=2.2765
Female	87.14	6.3	71.09– 98.71	88.18	87.47	P value=0.0284

Table XI: Distribution of mean distance between left posterior superior iliac spine and sacral apex (K) according to gender. (n = 41)

Gender	Mean	Standard deviation	Range	Median	Mode	Test of significance
Male	81.89	7.91	68.18 – 94.07	81.79	68.18	T statistic=2.0743
Female	86.60	6.5	70.15–98.75	87.66	70.15	P value=0.0447

Comment: Significant difference of average distance between left posterior superior iliac spine and sacral apex was obtained between male and female pelvis. **(p < 0.05)**

In case of male sacra, the distances between the right and left posterior superior iliac spines and the apex of sacral hiatus were found to be same (refer to tables VIII and IX). The distance between the two posterior superior iliac spines was found to be greater than these two (refer to table VII) and hence an isosceles triangle was formed by joining these three lines. A similar triangle was found in female sacra as well (refer to tables VII, VIII, IX). In fact, in case of both males and females, a similar isosceles triangle was found by joining the base of the previous triangle with the distances between the right and the left posterior superior iliac spines with the sacral apex on either sides (refer to tables VII, X and XI).

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Discussion:

J. H[16] (2006), concluded that the needle should be inserted at about 20^0 to the skin to avoid puncture of the bone and potential intra-osseous injection[16]. A study by Patel K Z [17](june 2011) showed that (55.33%) bones showed narrowed sacral canal at the apex (0-3mm), whereas a study by Nagar S.K.[18] (2004) showed narrowing of sacral canal at the apex of sacral hiatus, diameter less than 3mm, to be, 15.6%[17,18]. In this study,elongated hiatus and narrowing of the sacral canal at apex of sacral hiatus was found in a significant percentage, which should be kept in mind while giving caudal anaesthesia in Indian population [18]. A study by Shewale N S[19](2013), was carried on 204 dry human sacra to know the anatomical variations of sacral hiatus. It showed various mean morphometric measurements of sacral hiatus and also observed narrowing of sacral canal at the apex of sacral hiatus (diameter less than 3mm) in 7.5% cases[19]. Both Ukoha U[20] (dec 2013) as well as Mrudula C[21] (2013) in their studies concluded that the knowledge of anatomical variations of sacral hiatus is important in the administration of caudal epidural anaesthesia in the studied population and may help to reduce its failure rate[20,21]. A study by Bhattacharya S et al[22] obtained two isosceles triangles by joining the right and left superolateral sacral crests with apex of the hiatus and sacral apex and concluded that these triangles can be a bony landmark to detect the sacral hiatus easily. They also concluded that as the minimum distance between S2 and apex of the sacral hiatus is 1cm, introduction of needle beyond that is not safe during CEB [22]. A study by Senoglu N[23] (2005) found a triangle formed between the apex of the sacral hiatus and the superolateral sacral crests having the features of an equilateral triangle. According to this study this triangle will certainly be of use in determining the location of the sacral hiatus during CEB[23].

Previous researches (as shown above) were conducted on dry sacra taking a point on the superior part of lateral sacral crest[10,23]. Moreover the bones were of undetermined gender and age(in majority of the studies) and those which established the association with age found out results that helped in pediatric CEB, whereas CEB is also used in adults for various procedures like delivery[2,7,16,17,18]. Since the success rate of CEB is based on determination of the landmarks by the clinician the main goal of this study was to find practical solution of this problem[23,24].

Previous researches have been done on morphometric measurements of sacral hiatus. Their results have been shown in the following tables.The values are very close to those of the study performed by Bhattacharya S[22] as both have been performed on samples collected from West Bengal which in this case provides information about the shape of sacral hiatus among the population of this state.

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Authors (year of study)	Parameters			
	A(mm)	B(mm)	C(mm)	F(mm)
Senoglu N (2005)[23]	32.1	17.47	35.4	4.46
Aggarwal A(2009)[24]	43	11.9	72.5	3
Patil D(2012)[2]	34.13	13.71	32.88	4.26
Shewale S(2013)[19]	21.65	13.56	-	5.18
Bhattacharya S(2013)[22]	35.9	9.7	43.4	7.21
Anantharaman TL(2013)[28]	27.5	14.8	61	-
Mrudula C (2013)[21]	24.6	10.2	41.9	6
Ukoha U(2014)[20]	20.05	12.35	49.55	5.52
Present study (2014)	35.3	13.71	41.38	3.79

1) The value of average distance from the apex of sacral hiatus to the S2 foramina tallies with that of Bhattacharya S[22], Mrudula C[21].
2) The value of average depth of sacral hiatus at the level of its apex tallies with that of Senoglu N[23], Aggarwal A[24]

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 [23]. In the study of Aggarwal et al[24] 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 [24]. According to the study of Bhattacharya S et al[22] that minimum distance was 10mm. So, introduction of needle beyond 10mm after piercing the sacrococcygeal membrane is not safe for CEB among the West Bengal population[24]. In the present study we find that the minimum distance is 19.29mm in male sacrum and 34.65mm in female sacrum. So, introduction of needle beyond 19 mm in males and 34mm in females after piercing the sacrococcygeal membrane is not safe. Chen and colleagues[1] 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[3,23,32] . However, using ultrasonography or fluoroscopy is not always possible due to time, cost-effectiveness and personnel availability[23]. 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 [3,23].

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. Thus values of the different measurements as obtained in this study can be verified later on to find out whether there is any variation between the values on dry articulated pelvis bones and those taken on patients during anesthesia.

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