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Original Research Article

HUMAN SACRAL HIATUS IN DRY BONES OF TELANGANA REGION & ITS CLINICAL SIGNIFICANCE DURING CAUDAL EPIDURAL ANESTHESIA – A MORPHOLOGICAL; MORPHOMETRICAL STUDY

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ABSTRACT

It is a very important to know the anatomical variations of sacral hiatus, for a successful epidural caudal anesthesia. Eleven direct morphometric measurements were done on sacral vertebrae and hiatus of 150 adult dry human sacral bones of unknown age and gender. Morphological features shape, level apex and base of SH were noted. Most common shape of SH was inverted inverted 'U' in 90 (60%) sacrum. In 62 (41.3%) sacra apex was present at the level of S4. The level of base of sacral hiatus – in 122(81.3%) at S5 level. Different mean values of 150 sacral hiatus are following. Height of sacral hiatus is 20.62mm; Width of hiatus is 12.11mm; distance from SH apex to S2 level is 29.38mm; distance from base of SH base to S2 level is 51.08mm; distance between upper border of S1 & SH apex is 60.08mm; depth of SH at apex level is 5.12mm; distance between two posterior superolateral crest is 60.20mm; distance between right posterior superolateral crest and apex of SH is 56.90mm; distance between leftpostero superolateral crest and apex of SH is 59.10mm; distance between right posterior superolateral crest and apex is 85.99mm; distance between left postero superolateral crest and apex of SH is 86.90mm.

KEY WORDS: sacral hiatus (SH), sacral canal, caudal epidural block (CEB).

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INTRODUCTION

Sicard and cathelin introduced caudal anesthesia in 1901, injected anesthetic drug through sacral hiatus into epidural space. In 1921 page and 1927 by dogliotti described lumbar epidural technique. Because of variations of sacral hiatus use of caudal epidural block declined. In caudal epidural block only cephalic distribution of the anesthetic agent occurs, so the loss of dermatomal segments are blocked[1].

Sacral canal is formed by sacral vertebral foramina, triangular in section. Upper opening is seen on the basal surface. Its caudal opening is sacral hiatus. The dural and arachnoid sheaths of spinal cord terminates at the level of S2 vertebrae. The part of sacral canal below the S2 called caudal epidural space, which is filled with coccygeal nerves, venous plexus filum terminale and fats. This space is used for caudal epidural block for anesthesia and approach to it is through sacral hiatus[2].

Anatomical variations maybe shifting sacral

hiatus upwards or downwards, sometimes may absence of fusion of dorsal wall of sacrum (agenesis), and variations in shape, depth, narrowing, partial obliteration of sacral hiatus and canal, it may be traumatic or of pathological origin etc[3].

Sacral hiatus has been used for: 1) analgesia anesthesia in various clinical procedures, by injecting the drug into the epidural space through the hiatus in obstetrics & gynecology, hernia corrections, etc[4].

Sacral hiatal variations are always difficult for clinicians., 2) thecaloscopy[5], 3) trans-sacral endoscopy[6], 4) myelography[6], 5) caudal epidural injection of steroids / pain killers as a therapeutic agents[7] and 6) anterior epiduroscopic neural decompression: a minimal invasive spinal surgery[8].

So, the present study was conducted to find out the anatomical variations of sacral hiatus for caudal epidural block, with the help of morphometric measurements of the sacrum in relation to sacral hiatus in dry sacral bones.

MATERIALS AND METHODS

Fully ossified and un damaged 150 adult dry human sacral bones of unknown age and sex, obtained from the department of anatomy of Sri Venkata Sai Medical College And Hospital, Mahabubnagar, Telangana, India., were used. Measurements were taken by using a Vernier caliper of accuracy of 0.01mm, divider and steel measuring tape. The posterior closure and agenesis of dorsal wall bones were excluded. Morphological features, like shape, level of apex of sacral hiatus, level of base of sacral hiatus and following morphometric measurements were taken.

1. Height of sacral hiatus.
2. Width of sacral hiatus (distance between two sacral cornua).
3. Distance from the apex of sacral hiatus to the level of S2 foramen.
4. Distance from the base of sacral hiatus to the level of S2 foramen.
5. Distance between the upper border of S1 and sacral apex (length of sacral canal).
6. Depth of sacral hiatus at the level of its apex (anteroposterior diameter).
7. Distance between the two posterior superolateral crest.
8. Distance between right posterior superolateral crest and apex of sacral hiatus.
9. Distance between left posterior superolateral crest and apex of sacral hiatus.
10. Distance between right posterior superolateral crest to sacral apex.
11. Distance between left posterior superolateral crest to sacral apex.

Since the posterior superior iliac spine is readily palpable, impose on the superolateral sacral crest of sacrum. Line joins the both right and left superolateral crests of sacrum forms the base of triangle and the line joining the apex of sacral hiatus to both right and left superolateral crests, forms the other two arms of the triangle, which helps practically detect the triangle.

Statistical analysis: data were expressed as meancalculations and in percentages.

RESULTS

Agenesis of sacral hiatus in two sacrum, and complete agenesis of dorsal wall of sacrum found in one sacrum were excluded. Most common shape of hiatus was 'U' shaped found in 90(60%); in 42(28%) 'V' shaped; irregular shapes found in 8(5.3%); 'M' shaped found in 6(4%); dumbbell shaped in 4(2.6%) was out of total 150.

Apex was found in at the level of S4 in 62(41.3%) sacra. At the level of S3 are 32(21.3) && S2 are 6(4%).

Following different Mean values have found, height/length of sacral hiatus in 20.62mm; maximum width of hiatus found 12.11mm; distance from SH apex to S2 level 29.38mm; distance from SH base to S2 level 51.08mm; distance between upper border of S1 SH of apex 60.08mm; depth of SH at apex level 5.12mm; distance between two posterior superolateral crest 60.20mm; distance between right posterior superolateral crest and apex of SH 56.90mm; distance between left posterior superolateral crest and apex of SH 59.10mm; distance between right posterior superolateral crest and sacral apex 85.99mm; distance between left posterior superolateral crest and sacral apex 86.90mm.

Fig. 1: Completed agenesis of dorsal wall of Sacrum.

Fig. 2: Showing the "U" Shaped Sacral hiatus.

'M' shaped

Fig. 3: Showing the "M" Shaped Sacral hiatus.

Fig. 4: Showing the "V" Shaped Sacral hiatus.

Fig. 5: Showing the "dumbbell" Shaped Sacral hiatus.

Table 1: Shapes of sacral hiatus.

S.No.	Shapes	Frequency (n)	%
1	Inverted 'U'	90	60
2	Inverted 'V'	42	28
3	Irregular	8	5.3
4	'M' shaped	6	4
5	Dumbbell	4	2.6
6	Total	150	100

Table 2: location of apex and base in relation to the sacral vertebrae.

S.No.	Level of vertebrae	Location of apex		Location of base	
		Frequency (n)	%	Frequency (n)	%
1	S5	-	-	122	81.3
2	S4	62	41.3	20	13.3
3	S3	32	21.3	-	-
4	S2	6	4	-	-
5	Coccyx	-	-	8	5.3

Table 3: Showing the results of different morphometric measurements.

S.No.	Parameters	Mean value
1	Height of Sacral Hiatus	20.62
2	Width of Sacral Hiatus	12.11
3	Distance from SH Apex to S2 level	29.38
4	Distance from SH Base to S2 level	51.08
5	Distance between Upper Border S1 & SH Apex	60.08
6	Depth of SH at apex level	5.12
7	Distance between two posterior superolateral crest	60.2
8	Distance between right posterior superolateral crest and apex of SH	56.9
9	Distance between left posterior superolateral crest and apex of SH	59.1
10	Distance between right posterior superolateral crest and sacral apex	85.99
11	Distance between left posterior superolateral crest and sacral apex	86.9

Fig. 6: Showing width measurement at the base of the Sacral hiatus.

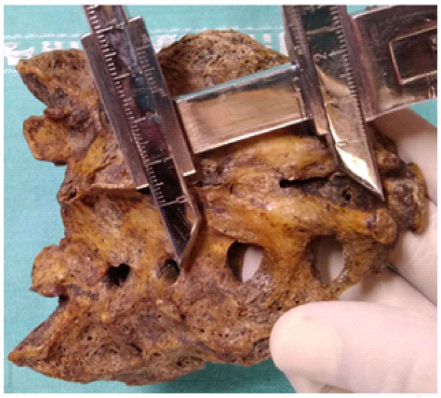

Fig. 7: Showing width measurement at the base of the 2nd Sacral bone.

Fig. 8: Left posterior superolateral crest of apex.

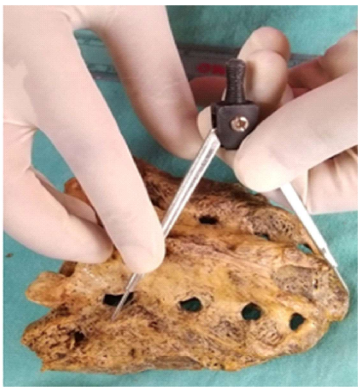

Fig. 9: Showing measurement from left crest to apex of sacrum.

Fig. 10: Showing the measurement at upper border of S1 to apex of Sacral hiatus.

Fig. 11: Showing measurement of AP diameter of the Sacral hiatus.

Fig. 12: Showing measurement from Apex to S2 Level.

Fig. 13: Showing measurement of height of sacral hiatus.

Fig. 14: Showing measurement between two superolaterl crest.

Fig. 15: Showing measurement of the Depth of Sacral hiatus at Apex.

Fig. 15: Showing measurement of the Depth of Sacral hiatus at Apex.

Table 4: Comparison of Shapes of Sacral Hiatus by different authors.

S.No.	Authors	Total number	Inverted'U' shape(%)	Inverted 'V' shape (%)	Irregular shape (%)
1	Osunwoke et al [14]	54	24.1	33.1	**13**
2	Vinod et al [15]		29.7	46.53	-
3	Nasr A Y et al [16]	150	31.33	38.66	**15.33**
4	Qudusia et al [13]	194	62.37	22.16	**8.76**
5	Deepa S et al [25]		57.5	25	**17.5**
6	Archana singh et al [33]	56	60.7	25	**7.1**
7	**Present study**	**150**	**90**	**42**	**8**

Table 5: Level of apex & base of sacral hiatus reported by different authors.

Authors	Total no. (N)	Level of Apex of Sacral Hiatus			Level of Base of Sacral Hiatus			
		S4	S3	S2	S5	S5	S4	Co
Nagar et al(2004) [17]	270	147(55.9%)	98(37.3%)	9(3.4%)	9(3.4%)	191(72.6%)	29(11.1%)	**43(16.3%)**
Dipali Rani et al(2012) [18]	160	80(50%)	72(45%)	_	8(5%)	132(82.5%)	14(8.7%)	**14(8.7%)**
Rammurti KS et al (2013) [4]	116	59(50.8%)	48(41.3%)	9(7.7%)	_	84(72.4%)	22(18.9%)	**10(8.6%)**
Nasr A Y et al (2014) [16]	150	81(54%)	22(14.66)	2(1.33%)	41(27.33%)	105(70%)	18(12%)	**27(18%)**
Archana singh et al (2015) [33]	56	28(50%)	24(42.9%)	4(7.1%)	_	46(82.1%)	8(14.3)	**2(3.6)**
Present study	**150**	**70(46.6%)**	**66(44%)**	**8(5.3%)**	**6(4.3%)**	**128(85.3%)**	**18(14.3%)**	**4(2.6%)**

Table 6: Height, Width and AP Diameters of sacral hiatus reported by different authors.

Authors	Total SH(mm)	Length of SH(mm)	Width of SH(mm)	AP diameter of SH(mm)
Senoglu et al (2005) [27]	96	32.1	17.47	**4.46**
Dipali Rani et al (2012) [18]	160	23.61 ±8.28	12.75 ± 2.92	**5.34 ± 1.39**
Lakshmi et al (2013) [31]	51	34.96 ± 12.9	14.8 ± 2.32	**4.61± 1.5**
Sanatnu B et al (2013) [32]	100	35.92 ± 3.75	9.79 ± 1.31	**7.23 ± .71**
Clarista MQ et al (2013) [19]	104	24.73 ± 9.38	16.87 ± 3.66	**5.58 ± 1.39**
Nasr A Y et al (2014) [16]	150	27.16 ± 1.29	11.50 ± 3.13	**4.78 ± 1.68**
Mishra M et al (2014) [21]	93	19.73	12.11	**4**
Archana singh et al (2015) [33]	56	21.73 ± 8.92	11.59 ± 3.25	**5.02 ± 2.09**
Present study	**150**	**24.52 ± 8.32**	**13.65 ± 1.42**	**5.28± 1.44**

Table 7: Comparison of Depth (Diameter) of Sacral hiatus at its Apex.

Authors	Total no. of sacrum	Mean diameter (mm)
Blanchis et al [29] (by USG)	-	**5.3 mm**
Chen et al [11] (by USG)	-	**6 mm**
Crigton et al [30] (by MRI)	15	**4.6 mm**
Archana singh et al [33]	56	**5.02 ± 2.09 mm**
Present study	**150**	**5.06 mm**

Table 8: Distance from apex of SH to S2 foramen (C).

Authors	Total Number	Mean distance (C) (mm) + SD
Rammurti KS et al [4]	116	**30.2 ± 10.5**
Dipali Rani et al [18]	160	**31.33 ±10.59**
Lakshmi et al [31]		**31.53 ± 9.05**
Mustafa MS et al [23]	46	**41± 11.4**
Santanu et al [32]	100	**43.41± 8.5**
Archana singh et al [33]	56	**30.30 ± 11.01**
Present study	**150**	**38.40±10.6**

Table 9: Triangle between two Post Superolateral Crestand apex of sacral hiatus (EFG) reported by different authors

Authors (N)	Base (E) (mm) +SD	Right margin (F) (mm) + SD	Left margin (G) (mm) + SD	Type of triangle
Senoglu et al [27](2005)n=96	66.51 ± 53.52	67.10 ± 9.95	67.53 ± 9.48	**equilateral triangle**
Lakshmi et al [31] (2013)n=51	61.51 ± 19.49	58.28 ± 9.36	58.54 ± 9.47	**equilateral triangle**
Sanatnu B et al [32](2013) n=100	64.77 ± 5.2 mm	58.41 ± 2.70	58.37 ± 2.76	**isosceles triangle**
Aggarwal et al [28] (2009)n= 114	50.96 ± 6.69	59.92 ± 8.84	59.99 ± 8.31	**Equilateral triangle -45% 55% cases both sides were much shorter than the base of the triangle.**
Rammurti K S et al [4] (2013)n=116	69.5± 5.8	61.4± 11.2	57.4± 9.7	**Isosceles triangle**
S Deepa et al [25](2014)n=40	62.3±4.4	69±14.5	71±17.7	**Isosceles triangle**
Archana singh et al [33] (2015)n=56	61.16 ± 5.42	57.54 ± 10.2	58.32 ± 10.59	**equilateral triangle**
Present study n=150	**64.6±8.48**	**57.24±6.8**	**62.22±8.6**	**equilateral triangle**

DISCUSSION

For successful sacral caudal epidural block, the knowledge of anatomical variations and structural modifications of sacral hiatus is necessary. Caudal epidural block is a technique of injecting medication in to epidural space via sacral hiatus. It is practiced since 1952 to anaesthetize lumber and sacral dermatomes and also for the symptomatic relief of low backache disorders in patients by injecting corticosteroids. Injecting technique used is prone position of patient,table is flexed or with pillow beneath the pelvis,followed by palpation of sacral cornu and hiatus with the help of left hand fingers. Needle is then inserted 2-3 mm at an angle of 45 degrees, 'pops 'through the sacrococcygeal ligament[3]. A failure rate has been reported by

some authors; in children 14.82% failure rate noted by Paolo Busoni et al[9] and in adults Shu-Yam Wong[10] reported a highest success rate 95.9%. Ultrasound guided needle placement success was 100% by Carl P. C. Chen[11]. The apex of the sacral hiatus is an important bony point for caudal epiduaral block but there may be difficulty in its palpation in some patients especially in obese. Hence other bony landmarks can also be used in relation with sacral hiatus. We can use a triangle which is drawn between the posterior superior iliac spines (superolateral sacral crest in dry sacral bones) and the apex of sacral hiatus. We measured the distance between these points which can guide the clinician for detection of sacral hiatus easily and increase the success rate of caudal epidural block. William R. Meeker[12] and colleagues noted that the diameter of sacral canal is 4.5mm and it is difficult to pass the needle into the sacral hiatus if it cannot be located accurately.

In present study the shape of sacral hiatus were variable and the most common being the inverted 'U' shaped in 90(60%) sacrum, followed by inverted 'V' shaped in 14(25%) sacra and this was similar to Qudusia et al[13] (2014) in which they found the most common shape of sacral hiatus was the inverted 'U' shape in121(62.37%) sacra and inverted 'V' shaped in 43(22.16%) sacra but was not similar with the Osunuokietal[14] and Vinod et al[15]. Vinod et al (1992) noted most common shape of sacral hiatus was inverted 'V' shape in 94(46.55%) sacra and inverted 'U' shape 58(38.66%) sacra and inverted 'U'shape in 47(31.33%)Egyptian sacrum.

In present study 4(2.6%) sacra was found to have its outline like dumbbell which was very low when compared with other studies as by Nagaret al[17](2004) in 36(13.3%) sacra and Dipali Rani et al[18](2012) in20(12.5%) sacra. M shaped sacral hiatus was observed in 6(4%) sacra in this study which was near to the study done by Clarista MQ et al[19] (2013) noted in 3(2.9%) sacra.

In present study apex of the SH was most commonly found at the level of S_4 sacral vertebrae, in 62(41.3%), which was almost similar with the observations by Nagar et al [17] (2004) in 147 (55.9%), by Dipali Rani et al[18](2012) in 80(50%) by Rammurti KS et al[4] (2013) in 59(50.8%) sacra and by Nasr A Y et al[16] (2014) in 81(54%) sacra. The base of sacral hiatus was seen most commonly at the level of S5 vertebrae, in 122(81.3%) sacra in present study similar with the Dipali Rani et al[18](2012) in 132(82.5%) ,Manisha B Sinha et al[20](2014) in 55(88.7%) sacra and by Mishra M et al[21] (2014) in 79(89.77%)sacra.

Cornua are palpable as a landmark on either side just below the apex of hiatus for localization of the sacral hiatus clinically. In the present study the distance between the two cornu was found to be 12.11mm. Sekiguchi et al[26] (2004) noted 10.2mm, Senoglu et al[27](2005) noted 17.47mm, Aggarwal et al[28] (2009) noted 11.95mm, Blanchais et al[29](2010) noted 14.2mm, Nasr A Y et al[16] (2014) noted 11.5mm, Mishra M et al[21] (2014) noted 12.11mm and S Deepa et al[25] (2014) noted 12.2mm.

Diameter(anterio-posterior length of SH at the apex) of sacral hiatus is important because if it is <2mm, then there may be difficulty int heuse of 22 Gneedle for Caudal epidural space. In present study 12.5% sacra had AP diameter <2mm and lowest measured value was 1.64mm and the mean value was 5.12mm (given in table4). Similar observation were noted by Kumar et al[15] (1992) 4.8mm, by Nagar et al[17](2004) 4.8mm, by Sekiguchi et al[26](2004) 6mm, by Senoglu et al[27](2005)4.46mm, by Mishra Met al[21](2014) 4mm and by Nasr A Y et al[16](2014) 4.78$\pm$1.87mm in Egyptian sacra. AP diameter by ultrasonographic study was measured by Blanchisetal[29] and Chen et al[11] and found to be mean AP diameter 5.3mm and 6mm respectively. By MRI study done by Crigtonetal [30] AP diameter found to be 4.6 mm, which was similar to the present study.

Length of sacral canal is measured as vertical distance between the apex of SH and the upper border of the sacral canal; in present study it is found to be 60.08mm which is similar to that measured by Mourgella et al[5] using MRI 59.03mm. Patil et al[3](2012) noted 64.77$\pm$17.07 mm, Lakshmi et al[31] (2013) noted 60.41$\pm$13mm and Santanu et al[32](2013) noted 66.19$\pm$4.8mm. As the dural sac ends at the level of S_2 vertebrae, the distance from the SH apex to S2 spine

and distance from the base of SH to apex of S2 spine noted, because anaethetist or endoscopist must know that how far to push the needle or instrument intothe sacral canal from the SH. In present study the distance between apex of SH to spine of S2 was found to be mean of 29.38mm. By other authors it was reported as Rammurti KS etal[4] (2013) 30.2±10.5mm, by Dipali Rani et al[18] (2012) 31.33±10.59 mm and by Lakshmi etal[31] (2013) 31.53±9.05mm which was similar with the present study. The distance between the base of SH and S2 spine was reported in present study was 51.08 mm and by other authors it was found to be as by Rammurti K S et. al[4] (2013) 59.5±8.8mm, by Dipali Rani et al[18] (2012) 54.88±7.92mm which was similar with the present study but by Santanu et al[32](2013) and Phalgunan et al[24](2013) it was noted as 79.64±8.9mm and 60.23±17.97mm respectively which was little higher than presentstudy.

A triangle formed between the two posterior superior iliac spines and the apex of SH, usedas an important landmark to locate the SH clinically. In this study thistriangle had almost equilateral features. The mean value of three sides of triangle i.e. base, right margin and left margin were 61.16±5.42mm, 57.54±10.2mm and 58.32±10.59mm respectively, these values are nearly equal and formed an equilateral triangle which is similar to other studies done by Senoglu et al[27] (2005) mean values of three sides were 66.51±53.52mm, 67.10±9.95mm and 67.53± 9.48 mm

Respectively and forming equilateral triangle. By Lakshmi et.al[31] (2013) the values were 62.6±10.48mm, 56.24±6.8mm and 64.22±8.6mm respectively, forming almost equilateral triangle. By Mustafa MS et al[23] (2012) these values were 75.5±10.3mm, 75±10.2mm and 75±10.2mm, forming equilateral triangle, but by some authors it was not found to be equilateral triangle as by Sanatnu B et al[32] (2013) it was an isosceles triangle and mean values were 64.77±5.2mm, 58.41±2.70mm and 58.37±2.76 mm and by Aggarwal et al[28] (2009) reported mean values of three sides were 50.96±6.69mm, 59.92±8.84mm and 59.99±8.31mm respectively and found equilateral triangle only in 45% cases and in rest 55% cases both sides were much shorter than the base of the triangle.

CONCLUSION

There are variabilities in the anatomical structure of SH.This may be due to genetic and racial factors.The given landmarks in this study,resulting the formation of equilateral triangle, which can provide the practical benefit to the clinician for localization of SH in CEB.Further clinical trials are required to compare the existing techniques and our anatomical description to support the result of this study.

Conflicts of Interests: None

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