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Pooja Singh, Ritu Singh, Archana Rani, R.K. Diwan, R.K. Verma, Deepshikha Kori and Stuti Tandon

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Morphological and Morphometrical Study of Sacral Hiatus in North Indian Population

Pooja Singh, Ritu Singh, Archana Rani, R.K. Diwan, R.K. Verma,

Deepshikha Kori and Stuti Tandon

Department of Anatomy, King George's Medical University, Uttar Pradesh, Lucknow, India

ABSTRACT

Sacrum is a large triangular bone formed by fusion of five sacral vertebrae and it forms caudal region of the vertebral column. The present study was done to identify variation in sacral hiatus (SH) in North Indian population to improve the access of SH for caudal epidural anaesthesia and analgesia.

67 dry human sacra with undetermined sex and age were collected from osteology lab of the Department of Anatomy, King George's Medical University, Uttar Pradesh, Lucknow. Damaged, mutilated, and deformed sacra were excluded. The study was done under parameters of shape, length, transverse width, antero-posterior depth, level of apex and base of SH. The parameters were measured with the help of vernier calipers (accurate to 0.01 mm) recorded, tabulated and analysed.

Inverted U shaped and inverted V shaped sacral hiatus was observed in maximum number of specimens i.e. 22.39% of each. The apex of SH was most commonly located at 4th sacral vertebra in 62.30% cases while base was located at 5th sacral vertebra in 81.97% cases. In 47.54% bones, length of SH was found to be 10 to 20 mm. In present study, absence of SH was seen in 7.46% cases while narrowing of sacral canal in 24.59% cases (i.e. depth of SH was < 3 mm).

Absence of sacral hiatus and its narrowing at the apex observed in some specimens is very important for anaesthetists, orthopaedic surgeons and neurosurgeons while applying caudal epidural anaesthesia. Knowledge of variations of different parameters studied in the present study may help to improve the success of caudal epidural block.

Keywords: Sacral hiatus, Anaesthesia, Analgesia, Caudal Epidural block and Sacral Canal.

INTRODUCTION

The sacrum is a large triangular bone formed by the fusion of five sacral vertebrae and it also forms the caudal region of the vertebral column. It forms the postero superior wall of the pelvic cavity, wedged between the two in nominate bones. Due to its great size, the sacrum is usually the last bone of a buried body to rot. The sacral hiatus (SH) is an inverted V-shaped space located at the distal part of the sacrum. This space is formed by incomplete midline fusion of the posterior elements of the distal portion of the fifth or sometimes, the fourth sacral vertebra, which is covered by superficial posterior sacrococcygeal ligament, attached to the margin of the hiatus and deep posterior sacrococcygeal ligament, attached to floor of SH. This hiatus is surface marked about 2 inches above the tip of coccyx under the skin covering the natal cleft (Waldman 2004). The lower sacral nerve roots, coccygeal nerve roots, filum terminale and fibro-fatty tissue forms the content of the SH. This area is utilized for administration of epidural anesthesia in orthopedics for diagnosis and treatment of various diseases, in obstetrics for painless delivery and for treating patients with low back pain. The success rate of caudal epidural block (CEB) is based on determination of the landmarks by clinician (Senoglu et al. 2005). Variations in anatomy of sacral hiatus (SH) can lead to failure of CEB. Tsui et al. (1999) studied that Caudal epidural block (CEB) has 25% failure rate. However, to the best of our knowledge, very few publications are available in the literature for North Indian population that discusses the issue of anatomical variation of sacrum (Sinha et al. 2013, Sharma et al. 2011). However most of the previous studies did not mentioned the absence of sacral hiatus and narrowing of sacral canal. Therefore this study is an effort to fill this lacuna by doing morphological and morphometrical evaluation of sacral hiatus.

MATERIAL AND METHODS

The present study was conducted in the Department of Anatomy, King George's Medical University, Uttar Pradesh, Lucknow. 67 dry human sacra with undetermined sex and age were collected from Osteology lab of the department. Damaged, mutilated & deformed sacra were excluded. The six sacra having absent or incomplete dorsal wall were excluded from the measurements as features of typical sacral hiatus was not present in them. The measurements were taken with the help of digital vernier caliper (accurate to 0.01mm), divider and steel measuring tape. Observations were substantiated with photographs. The different nonmetric parameters including shape of the sacral hiatus, level of apex and base of sacral hiatus were observed. The metric parameters such as length, transverse width (intercornual distance) and antero-posterior width of sacral hiatus was also noted and analysed. All the measurements were done by two observers separately to avoid differences in the data.

OBSERVATIONS AND RESULTS

Shape of the sacral hiatus: Many variations were seen in the shape of sacral hiatus. Both inverted U and inverted V shape hiatus was noted in 22.39% of bones. 17.91% of specimen exhibited dumb-bell shape hiatus with a nodular bony growth projecting medially from both margins. M-shaped (bifid) variety was observed in 8.96%, irregular in 19.40%, incomplete dorsal wall in 1.49% and its absence was seen in 7.46% (Fig. 1, Table1).

Level of the apex of sacral hiatus: The level of the apex was quite variable and extended between middle of second to fifth sacral segments.

In 62.30% of cases, the apex was found at the fourth sacral segment followed by 21.31% at third sacral segment. In 14.75% of cases it extended upto fifth sacral segment and in 1.64% of cases upto second sacral segment (Fig. 2, Table 2).

Level of the base of sacral hiatus: The level of base varied between the middle of fourth sacral segment upto the middle of first piece of coccyx. In 18.03% bones, the base was found at the first coccygeal level and in 81.97% of cases it was present at the fifth sacral segment while none of the bone showed the base level at fourth sacral segment (Fig. 3, Table 3).

Length of the sacral hiatus: Length was measured from the middle of apex to the middle of base of sacral hiatus. The length varied from 5 to 45 mm and in maximum (47.54%) cases it was between 10 to 20 mm (Fig. 4, Table 4).

Transverse width of sacral hiatus: The maximum width was measured between two sacral cornu (intercornual distance). In present study it was between 3 to 18 mm (Fig. 5, Table 5).

Antero-posterior width (depth) of sacral hiatus: It was measured at the level of apex of sacral hiatus which ranged between 1.5 to 12.5 mm (Fig. 6, Table 6).

DISCUSSION

One of the causes of CEB failure is anatomical variation. Clinically the study on the variations of sacral hiatus can help to identify the caudal epidural space in giving caudal epidural block by palpating the sacral cornu (Chen et al. 2004). Ultrasonography or fluoroscopy is 100% successful in caudal epidural block but it is not always possible due to time, cost and personal availability. So knowing the anatomical relations of the sacral hiatus will facilitate the procedure (Stitz and Sommer 1999).

Because the apex of the sacral hiatus is associated with the entrance to the sacral canal, the sacral hiatus is the most critical anatomical landmark affecting CEB. The anatomical variations of absent hiatus and complete agenesis of the sacral hiatus will lead to CEB failure (Aggarwal et al. 2009). However, at times, clinicians experience difficulty in performing CEB even though the sacral hiatus is palpated well. A narrow sacral canal makes it difficult to locate the sacral canal opening (Sekiguchi et al. 2004).

Shape of sacral hiatus: The common arrangement for the hiatus to be formed is by the non fusion of fifth and sometimes fourth sacral vertebra. In current study, 5 cases (7.46%) were devoid of sacral hiatus which was higher than those documented in previous studies done by Nagar (2004) in Gujarat state (0.7%), Sekiguchi et al. (2004) in Japanese population (4%) and Senoglu et al. (2005) in Turkey (6.25%).

In the present study, most common shape of sacral hiatus observed was inverted U as well as inverted V in 22.39% of sacra with equal incidence of each. Both the above types were considered as normal; still these values were lesser than the previous studies. Kumar et al. (1992) noted U-shaped in 29.70% and V-shaped in 46.53% bones while Nagar (2004) reported these values in 41.50% and in 27% respectively. In a study by Vijisha and Baskaran (2013), the inverted U and inverted V had equal frequencies of 35% each. Bifid sacral hiatus was seen in 6 (8.96%) sacra which was higher to that reported by Nagar (2004) in Gujarat state in 4 (1.5%) sacra and by Parashuram (2015) in Karnataka in 4 (2%) sacra. There was incomplete agenesis of dorsal bony wall of sacral canal in 1.49% sacra in the present study. Complete agenesis was not reported in our study while it was observed by Trotter and Letterman (1944) in 1.8% and Kumar et al. (1992) in 1.49% of specimen.

S. NO.	SHAPE	NUMBER OF BONES (n=67)	INCIDENCE (%)			
1.	Inverted U	15	22.39			
2.	Inverted V	15	22.39			
3.	Dumb Bell	12	17.91			
4.	M Shaped (Bifid)	6	8.96			
5.	Irregular	13	19.40			
6.	Incomplete Dorsal Wall	1	1.49			
7.	Absent	5	7.46			

Table 1. Different Shapes of Sacral Hiatus.

Table 2. Location of Apex of the Sacral Hiatus at Different Levels.

S.N0.	LEVEL OF APEX	NUMBER OF BONES (n= 61)	INCIDENCE (%)
1.	5 th Sacral Vertebra	9	14.75
2.	4 th Sacral Vertebra	38	62.30
3.	3 rd Sacral Vertebra	13	21.31
4.	2 nd Sacral Vertebra	1	1.64

Table 3. Location of Base of the Sacral Hiatus at Different Levels.

S.No.	LEVEL OF BASE	NUMBER OF BONES	INCIDENCE (%)
		(n=61)	
1.	Соссух	11	18.03
2.	5 th Sacral Vertebra	50	81.97
3.	4 th Sacral Vertebra	-	-

Table 4. Length of Sacral Hiatus from Apex to Mid Point of Base.

S.No.	LENGTH OF SACRAL	NUMBER OF BONES	INCIDENCE (%)
	HIATUS (mm)	(n=61)	
1.	0-10	7	11.48
2.	10-20	29	47.54
3.	20-30	16	26.23
4.	30-40	6	9.84
5.	40-50	3	4.92

Table 5. Transverse Width of Sacral Hiatus (At Base of Sacral Cornu).

S.No.	TRANSVERSE WIDTH (mm)	NUMBER OF BONES (n=61)	INCIDENCE (%)
1.	0-5	4	6.56
2.	5-10	20	32.79
3.	10-15	34	55.74
4.	>15	3	4.92

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S.No.	ANTERO-POSTERIOR DEPTH (mm)	NUMBER OF BONES (n=61)	INCIDENCE (%)
1.	0-3	15	24.59
2.	3-6	17	27.87
3.	6-9	25	40.98
4.	>9	4	6.56

Table 6. Depth of Sacral Hiatus at the Level of Apex.

Table 7. Comparison of Studies between Different Races of World.

FEATURES	PRESENT	MALARVANI	NADEEM G.	UKOHA et al.	MUSTAFA
OF	STUDY (2016)	et al. (2014)	(2014) IN	(2014) IN	et al. (2012)
SACRAL	IN ARYANS IN	IN NEPALESE	CAUCASIANS	NEGROS IN	IN
HIATUS	INDIA		IN	NIGERIA	EGYPTIANS
			GERMANY		
SHAPE:					
-Inverted	22.39%	35%	56%	48.2%	26%
U	22.39%	32%	14%	34.9%	24%
-Inverted	17.91%	3%	10%	4.8%	22%
v	8.96%	2%	2%	4.8%	0%
-Dumb-	19.40%	14%	16%	4.8%	22%
bell	-	3%	-	1.2%	-
- Bifid					
-Irregular	7.46%	11%	-	1.2%	6%
-Complete					
agenesis					
-Absent					
hiatus					
LOCATION					
OF APEX:					
-4th sacral	62.3%	39%	34%	69.9%	70%
vertebrae	21.31%	42%	62%	20.5%	13%
-3rd					
sacral	14.75%	2%	2%	4.8%	17%
vertebrae	1.64%	3%	2%	2.4%	0%
-5th sacral					
vertebrae					
-2nd					
sacral					
vertebrae					
LOCATION					
OF BASE					
<u>OF</u>	81.97%	54%	62%	88%	91%
HIATUS:					
- 5th	0%	31%	24%	2.4%	9%
sacral	18.03%	1%	14%	7.2%	0%
vertebrae					
-4th sacral					

27.71 mm	12-37 mm	25.2 mm	20.05 mm	-
5.08 mm	2-9 mm	5.53 mm	5.52 mm	-
10.30 mm	7-27 mm	19.5 mm	12.35 mm	-
	27.71 mm 5.08 mm 10.30 mm	27.71 mm 12-37 mm 5.08 mm 2-9 mm 10.30 mm 7-27 mm	27.71 mm 12-37 mm 25.2 mm 5.08 mm 2-9 mm 5.53 mm 10.30 mm 7-27 mm 19.5 mm	27.71 mm 12-37 mm 25.2 mm 20.05 mm 5.08 mm 2-9 mm 5.53 mm 5.52 mm 10.30 mm 7-27 mm 19.5 mm 12.35 mm

Apex of sacral hiatus: The apex of sacral hiatus is usually present at the level of fourth sacral vertebra (Standring 2005). In the present study, the apex of sacral hiatus was seen at the level of fourth sacral vertebra in 62.30% of sacra which is nearly similar to that reported by Sekiguchi et al. (2004) in 65% of sacra and Ukoha et al (2014) in 69.9%, while Kumar et al. (1992) reported in 76.23% of sacra, Kumar et al. (2009) in 72%, Mustafa et al (2012) in Egypt in 70% of sacra and of sacra. All previous studies including the present study noted that the location of apex can vary from upper part of second sacral vertebra to lower part of fifth sacral vertebra.

Base of sacral hiatus: Base of sacral hiatus was seen at the level of fifth sacral vertebra in 50 (81.97%) sacra in the present study, which is similar to that reported by Shewale et al (2013) in Maharashtra in 82% of sacra but it was much higher when compared to study conducted by Malarvani et al. (2014) in 54% of sacra of Nepalese. Nagar (2004) noted in 191 (72.6%) sacra at the level of fifth sacral vertebra out of 270 bones studied in Gujarat state. The value of our study is lower when compared to Parashuram (2015) who noted it in 181 (93.3%) sacra in Karnataka region. In the present study, base at the level of 4th sacral vertebra was not reported, while Nagar (2004) noted it in 11.1% bones and Nadeem (2014) in 24% cases. Base extended to coccyx in 11(18.03%) cases while Nagar (2004) found it in 16.3%. These sacra are prone for coccygeal ankylosis.

FEATURES	PRESENT		SHEWALE et al	BHATTACHARYA	NAGAR
OF	STUDY	PARASHURAM	(2013) IN	et al (2013) IN	SK
SACRAL	(2016) IN	R. (2015) IN	LATUR,	KOLKATA, WEST	(2004) IN
HIATUS	LUCKNOW,	MYSORE,	MAHARASHTRA	BENGAL	GUJARAT
	UP	KARNATAKA			
SHAPE:					
-Inverted	22.39%	50%	40.69%	65%	41.5%

Table 8. Comparison of Studies between Different States of India.

U 22.39% 27.5%	32.35%	23%	27%
-Inverted 17.91% 2%	5.89%	-	13.3%
V 8.96% 2%	-	-	1.5%
- Dumb- 19.40% 15.5%	9.31%	12%	14.1%
bell - 2%	0.98%	-	1.5%
- Bifid			
-Irregular 7.46% 1%	0.98%	-	0.7%
-Complete			
agenesis			
-Absent			
hiatus			
LOCATION			
<u>OF APEX:</u> 72.2%			
4th sacral 62.3% 20.6%	60%	72%	55.9%
vertebrae 21.31%	15%	5%	37.3%
-3rd 6.7%			
sacral 14.75% 0.5%	14.5%	23%	3.4%
vertebrae 1.64%	4%	-	3.4%
-5th sacral			
vertebrae			
-2nd			
sacral			
vertebrae			
LOCATION			
<u>OF BASE</u>			
<u>OF</u> 81.97% 93.3%	82%	-	72.6%
HIATUS:			
-5th sacral 0% 6.7%	2%	-	11.1%
vertebrae 18.03% 0%	16%	-	16.3%
-4th sacral			
vertebrae			
	22.07	25.02	
Mean 27.71 mm 19.63 mm	22.87 mm	35.92 mm	5-6.9
length of			mm
Maan E.08 mm 4.25 mm	Г 19 то то	7.22 mm	2.14 mm
diameter	5.18 mm	7.23 mm	2-14 mm
of corrol			
on sacrai			
(donth)			
Mean 10.30 mm 11.42 mm	13.68 mm	9.79 mm	0.3-19
width at			mm
base of			
sacral			
hiatus			

Legends for Figures

<image>

Figure 1. Different shapes of sacral hiatus- (a) Inverted U shaped; (b) Inverted V shaped; (c) Dumb bell shaped; (d) M shaped; (e) Irregular shaped; (f) Absent

FIGURE-2





FIGURE- 3



Figure 3. Level of base of sacral hiatus (black line).



FIGURE-4

Figure 4. Measurement of length of sacral hiatus (from apex to base).



FIGURE- 5

Figure 5. Measurement of width (transverse diameter) of sacral hiatus.



FIGURE- 6

Figure 6. Measurement of depth (antero-posterior diameter) of sacral hiatus, at the level of apex.

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Length of sacral hiatus: Length of the sacral hiatus varied from 1.91mm to 43.83mm and the arithmetic mean was 27.71mm in the present study. This is similar to that reported by Lanier et al (1945) who found the mean length of sacral hiatus to be 25.3 mm while Bhattacharya et al (2013) reported 35.92 mm, which was much higher than present study. Trotter et al. (1944) and Parashuram (2015) reported that the length of sacral hiatus varied from 0mm to 60mm and 4mm to 51mm respectively which was high compared to the values of present study. The length of hiatus in about half of sacra 29 (48%) was >10-20 mm in the present study while Singh and Mahajan (2013) reported the length of hiatus in about 2/3rd of sacra (65%) to be 11-30 mm.

Transverse width of sacral hiatus: In the present study, the transverse width of sacral hiatus varied between 2.24 mm to 15.78 mm with arithmetic mean of 10.30 mm, which was similar to the study conducted by Singh and Mahajan (2013) who reported 0.3 to 18 mm in North Indian population. Trotter et al. (1944) in his study noted that it varies from 7 mm to 26 mm with arithmetic mean of 17mm. Sekiguchi et al. (2004) also reported a lower figure of 10.2 \pm 0.35 mm.

Antero-posterior depth of sacral hiatus: Antero-posterior width of sacral hiatus is important as it should be sufficiently large to admit a needle for subcutaneous deposition of anesthetic drug. In the present study, the antero-posterior depth ranged from 0.31 mm to 10.63 mm with arithmetic mean of 5.08 mm whereas maximum values were found in the range of 6mm to 9mm (40.98%). Mean diameter as observed by various workers are Kumar et al. (1992) –4.8 mm, Nagar (2004) –4.8mm (range from 2-14mm), Trotter et al. (1944) – 5.3mm (range from 0-11mm) and Sekiguchi et al. (2004) –6.0 \pm 1.9mm.

In the present study, sacra having antero-posterior depth of sacral canal at apex of sacral hiatus less than 3 mm was observed in 15 (24.59%) bones which is much more higher than the earlier studies as Trotter et al. (1944) observed only 4% sacra with 0-2 mm depth and Nagar (2004) noted in 4 (15.6%) sacra with 0-3 mm depth while Lanier et al. (1945) not reported any case with less than 3 mm depth.

The different parameters discussed have been compared with different population and race within different states of India and world respectively (Tables 7 & 8).

CONCLUSION

The surgical treatment requiring caudal epidural anesthesia can be much helped by knowing the variations in sacral hiatus which could improve the success rate of this procedure.

In present study, percentage of irregular shaped SH (19.4%) was significantly higher and antero- posterior depth at the level of apex <3mm (narrow sacral canal) was about 25%, which may be a major cause of failure of CEB in North Indian population. However, with advances in surgical methods and instrumentation in the field of spinal surgery, there is a continued need to better understand the anatomy of this region, as caudal epidural anesthesia is widely used for diagnosis and treatment of lumbar spinal disorders in orthopedics. Further studies are required to compare and provide more accurate data to support the results of this study.

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Corresponding author: Dr. Pooja Singh, Department of Anatomy, King George's Medical University, Uttar Pradesh, Lucknow, India.

Name of the Institute/college: King George's Medical University Email id: <u>poojaanilsingh@gmail.com</u> Contact no. +917587216959