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Anatomical Study of Sacrum and its Clinical Significance.

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ABSTRACT

Background: Sacrum is formed by the fusion of five sacral vertebrae and forms the lower part of Vertebral column. The opening present at the lower end of sacral canal is known as sacral hiatus. **Methods:** This study was carried out on 75 dry human sacra of unknown sex to study the variations of sacral hiatus. Various shapes of sacral hiatus were observed which included inverted u, inverted v, irregular, dumbbell and bifid. The apex of sacral hiatus was commonly found at the level of 4th sacral vertebra. The mean length of sacral hiatus, the mean anteroposterior diameter of sacral canal was measured. The narrowing of sacral canal at the apex of sacral hiatus was measured. **Results:** We observed length of Sacral hiatus from apex to midpoint of base – maximum length was found to be 11 – 20 mm in 32 dry sacra. Anteroposterior diameter at the sacral hiatus was found to be 0 – 3 mm. in 35 dry sacra. Base (Transverse diameter) was found to be 11 – 15 mm in 36 dry sacra. Median distance between the level of lower margin of S2 and apex of sacral hiatus was 21 – 30 mm in 25(33%) Sacra. Distance between midpoint of Base to S2 foramen was found to be >40 mm in 52 Sacra and that accounts for 69 %. **Conclusion:** The knowledge of anatomical variations of sacral hiatus is clinically important for caudal epidural block in Pediatric, Obstetric, Orthopedic, Urologic and Surgical practice. The reliability and success of caudal epidural block depends upon Knowledge of Variations of Sacral hiatus.

Keywords: Sacrum, lamina, sacral hiatus, caudal epidural block

INTRODUCTION

Sacrum is a large, triangular bone formed by fusion of five vertebrae present between the two hip (innominate) bones. It presents a concave anterior or pelvic surface and a convex posterior surface. The broad base is directed above and the apex is at the lower end. The base is divided into central part consisting of body of first sacral vertebra and lateral mass or ala on either side. By its base the sacrum articulates with the fifth lumbar vertebra and by its apex it articulates with the coccyx. The base presents the upper opening of sacral canal. The superolateral margin of the body of first sacral vertebra projects forwards as the sacral promontory, which is useful in measuring the diameters of the pelvis.

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The triangular sacral canal is formed by sacral vertebral foramina [1]. The opening present at the caudal end of sacral canal is known as sacral hiatus. The laminae and spinous process of the fifth and /or fourth sacral vertebrae fail to meet in the midline creating a deficiency known as the hiatus in the posterior wall of the sacral canal.[1] It is located inferior to the fourth or third fused sacral spines or lower end of median sacral crest. The remnants elongate downwards on both sides of sacral hiatus. These two bony processes are called the sacral cornua and define important landmarks during caudal epidural block (CEB). Sacral hiatus is identified by palpation of sacral cornua. Sacral cornua are felt at the upper end of natal cleft 5cm above the tip of coccyx [2]. Structures emerge from sacral hiatus are the filum terminale, fifth sacral nerves and coccygeal nerves. The hiatus provides access to the extradural space in the sacral canal.

Sacral hiatus is covered posteriorly by skin, a subcutaneous fatty tissue and the sacrococcygeal membrane, when the needle has passed through the sacrococcygeal ligament, the hiatus communicates with the epidural space. The dural sac ends at the level of second piece of sacrum. Sacral canal below this level contains extradural fat, vertebral venous plexus, lower sacral nerve roots and the filum terminale. Sacral hiatus has been utilized for administration of epidural anaesthesia in obstetrics as well as in orthopedic practice for transpedicular and lateral mass screw placement.

The anterior surface of Sacrum bears four anterior sacral foramina which give passage to ventral rami of upper four sacral spinal nerves and lateral sacral arteries. The dorsal surface of sacrum bears four posterior sacral foramina which give passage to posterior rami of the upper four sacral spinal nerves.

Sacral canal contains the cauda equina, duramater and arachnoid mater. At the lower margin of second sacral vertebrae, the subarachnoid and subdural spaces terminate. The fifth sacral roots, coccygeal roots and filum terminale pierce the blind end of the dural tube. Beyond the dural tube, there is roomy extradural space in the sacral canal (capacity is 25 – 30 ml) [3]. Sacral canal ends at the level of the fourth of fifth sacral vertebra in about 80% of cases [4].

Reliability and success of caudal epidural block depends on anatomical variations of sacral hiatus as observed by many authors. Caudal epidural block has been widely used for treatment of chronic back pain. Sacral hiatus functions as a landmark when caudal anaesthesia is administered in Urology, Proctology, General surgery and Obstetrics and Gynaecology practice. The present study was undertaken to find out the variations of sacral hiatus which will be useful for caudal anaesthesia.

MATERIALS AND METHODS

The materials for the present study consists of Seventy five dry adult Sacra of unknown sex obtained from Anatomy department, PSG IMS & R, Coimbatore. The measurements were taken with the help of Vernier caliper on the intact parts of normal bone. Each sacrum was studied for different features with regards to:

Observations:

1. Shape of Sacral hiatus
2. Level of apex of hiatus
3. Level of base of hiatus
4. Level of maximum curvature of sacrum at S3, S4 &S5 vertebrae

Measurements:

1. Length of sacral hiatus from apex to midpoint of base
2. Anteroposterior diameter of the sacral hiatus
3. Base of sacral hiatus / intercornual distance (transverse width of sacral hiatus at the base – Measured from inner aspect of inferior limit of sacral cornua)
4. Median distance between the level of lower margin of S2 foramen and apex of sacral hiatus
5. Distance between midpoints of base of sacral hiatus to 2nd sacral foramen

RESULTS

Study on the variation in anatomical features of sacral hiatus and the dorsal wall of the sacral canal is related with regards to its clinical application in caudal epidural block in perineal surgery and painless delivery.

Sacral approach to epidural space produces reliable and effective block of sacral nerves. Epidural injection of Corticosteroids and local anaesthetic agents were widely used for symptomatic relief in low back disorders. Bony irregularities, different shapes of hiatus and defects in the dorsal wall of sacral canal have to be considered before undertaking caudal epidural block.

1. Shape of Sacral hiatus – Inverted U shape was seen about 27 Sacra, inverted V shape was seen about 15 Sacra, Dumb bell shape was seen about 16 Sacra, Irregular shape was seen about 13 sacra and Bifid shape was seen about 3 Sacra and absence of hiatus with deficient dorsal wall was found in one Sacrum [Table 1, Figure 1-6].
2. Level of Apex of Sacral hiatus was seen in S3, S4 and S5 foramina and was found to be 4th sacral vertebra in 36 dry human Sacra which constitutes higher percentage. High apex is associated with high chances of dural puncture and the lower apex needs longer needle [Table 2].

Figure 1: Complete dorsal wall agenesis.

Figure 2: Bifid sacral hiatus.

Figure 3: :Irregular shaped sacral hiatus.

Figure 4: Dumb bell shaped sacral hiatus.

Figure 5: Inverted 'U'shaped sacral hiatus.

Figure 6: Inverted 'V'shaped sacral hiatus.

3. Location of Base was observed at S4, S5 and Coccyx. It was found to be higher in S5 in 48 dry Sacra. The location of base at Coccyx was found in 15 Sacra in the present study. However base when present at Coccyx was little narrower than at the sacral level [Table 3].
4. Maximum curvature of Sacrum was observed at S3, S4 and S5 levels and was found to be at S3 in 47 dry Sacra [Table 4].

Measurements:

1. Length of Sacral hiatus from apex to midpoint of base – maximum length was found to be 11 – 20 mm in 32 dry sacra. Increase in length of the hiatus is influenced by the defect of non- union of 2nd and 3rd pair of sacral laminae and also by coccygeal fusion [Table 5].
2. Anteroposterior diameter at the sacral hiatus was found to be 0 – 3 mm. in 35 dry sacra. Anteroposterior diameter of <3mm indicates that there would be difficulty in inserting the needle [Table 6].
3. Base (Transverse diameter) was found to be 11 – 15 mm in 36 dry sacra. <10 mm Base is sufficient to insert a needle [Table 7].
4. Median distance between the level of lower margin of S2 and apex of sacral hiatus was 21 – 30 mm in 25(33%) Sacra. Dural sac terminates at S2 level. Hence distance between apex of hiatus and S2 level decides the length of the needle that can be safely introduced into the canal [Table 8].
5. Distance between midpoint of Base to S2 foramen was found to be >40 mm in 52 Sacra and that accounts for 69 % [Table 9].

DISCUSSION

In 1942, Edward introduced Continuous caudal analgesia in the field of Obstetrics to minimize the risk of labour pains of mother during delivery. Since 1952, caudal analgesia is practiced by anaesthetizing lumbar and sacral dermatomes in Obstetric analgesia and in low back disorders.[5]

Shape of Sacral hiatus was inverted 'U' shaped 121(62%) in Qudusia Sultana [5] et al study and was about 112 (41.5%) Sacra in Nagar S.K.study [6] and was about 64(43%) Sacra in Seema[7] et al study and was about 50(42%) Sacra in Jadhav Mayuri[9] et al study and was about 44% in Suma H.Y [10] study. Followed by Inverted 'V' shaped, irregular, Dumbbell and Bifid shapes of sacral hiatus were found in above studies. This was similar to our study. Inverted 'U' shaped sacral hiatus was found to be 27 (36%) Sacra and followed by other shapes of sacral hiatus in our study. Deficient dorsal wall (Non canalized) Sacrum was found in one Sacrum in our study.

Table 1: Shape of Sacral hiatus (n=75)

S. No.	Shape of sacral hiatus	Number	Percentage
1.	Inverted 'U'shaped	27	36
2.	Inverted 'V' shaped	15	20
3.	Irregular	13	17
4.	Dumbbell	16	23
5.	Bifid	3	3
6.	Deficient dorsal wall	1	1
	Total	75	100

Table 2: Location of Apex of Sacral hiatus (no=75)

S. No.	Location of Apex	Number	Percentage
1.	4th Sacral vertebrae	36	48
2.	3rd Sacral vertebrae	32	43
3.	5th Sacral vertebrae	4	5
4.	2nd Sacral vertebrae	2	3
5.	Deficient dorsal wall without apex	1	1
	Total	75	100

Table 3: Location of Base (n=75)

S. No.	Location of Base	Number	Percentage
1.	Coccyx	15	20
2.	5th Sacral vertebrae	48	64
3.	4th Sacral vertebrae	12	16
	Total	75	100

Table 4: Maximum curvature of Sacrum (n=75)

S. No.	Maximum Curvature of Sacrum	Number	Percentage
1.	S3	47	62
2.	S4	22	29
3.	S5	6	8
	Total	75	100

Table 5: Length of Sacral hiatus from apex to base

S. No.	Length In Millimetre	Number	Percentage
1.	0 – 10	6	8
2.	11 – 20	32	42
3.	21 – 30	25	33
4.	31 – 40	5	6
5.	41 – 50	5	6
6.	>51	3	4
7.	Deficient dorsal wall	1	1
	Total	75	100

Location of apex of Sacral hiatus was at fourth Sacral vertebrae in 141 (74%) in Qudusia Sultana[5] et al study and was at S4 in 147(56%) Sacra in Nagar S.K[6] study and was at S4 in 84(56%) Sacra in Seema [7] et al study and was at S4 in 67(57%) Sacra in Jadhav Mayuri[9] et al study and was at S4 in 77.5% in Suma H.Y[10] et al study.

Table 6: Anteroposterior diameter of Sacral canal at the level of apex (n=75).

S. No.	Anteroposterior Diameter In Millimetre	Number	Percentage
1.	0 – 3	35	47
2.	4 -6	31	42
3.	7 – 9	7	9
4.	>9	1	1
5.	Deficient dorsal wall	1	1
	Total	75	100

Table 7: Transverse diameter (Width) at the level of cornua (n=75).

S. No.	Transverse diameter in millimetre	Number	Percentage
1.	0 – 5	0	0
2.	6 -10	7	9
3.	11 -15	36	48
4.	>15	32	43
	Total	75	100

Table 8: Median distance between the level of lower margin of S2 and apex of sacral hiatus.

S. No.	Median Distance In Millimetre	Number	Percentage
1.	10	6	8
2.	11 -20	17	23
3.	21 -30	25	33
4.	31 – 40	20	27
5.	>40	6	8
6.	Deficient dorsal wall	1	1
	Total	75	100

Table 9: Distance between midpoints of base to S2 foramen.

S. No.	Median Distance In Millimetre	Number	Percentage
1.	<10	0	0
2.	11 – 20	2	2
3.	21 – 30	3	4
4.	31 – 40	17	23
5.	>40	52	69
6.	Deficient dorsal wall	1	1
	Total	75	100

Apex of sacral hiatus was S4 in 36(48%) dry sacral vertebrae in our study. This was similar to Nagar S.K, Seema, Jadhav Mayuri studies.

Location of Base was at fifth Sacral vertebrae in 184 (96%) in Qudusia Sultana[5] et al study and was at S5 in 191(72%) Sacra in Nagar S.K.[6] Study and was at S5 in 105(70%) Sacra in Seema[7] et al study and was at S5 in 132 (83%) Sacra in Dipali Rani Pal[8] et al study and was at S5 in 64% in Suma H.Y[10] study. Location of Base was at fifth Sacral vertebrae in 48(64%) dry Sacra in our study which was similar to previous studies.

Maximum curvature of Sacrum was observed to be at S3 vertebrae level in 82% in Suma H.Y[10] et al study and was at S3 vertebrae level in 40 Sacra in A. Anupriya[11] et al study. This was similar to our study which also showed maximum curvature of Sacrum was at S3 in 47(62%) Sacra.

Length of Sacral hiatus was found as 11 – 20 mm in 92(35%) Sacra in Nagar S.K.[6] study, 11 – 20 mm in 2/3 of sacra (65%) in Seema[7] et al study, 21 – 30 mm in 74(46%) Sacra in Dipali Rani Pal[8] et al study, 11–20 mm in 41(31%) in Mayuri[9] et al study. In our study, length of sacral hiatus was found to be 11–20 mm in 32(42%) Sacra which was found to be higher.

Anteroposterior diameter at the sacral hiatus was about 4–6mm in 169(64%) Sacra in Nagar S.K.[6] study, 107(71%) Sacra in Seema[7] et al study, 120(75%) Sacra in Dipali Rani Pal[8] et al study and 84(71%) Sacra in Jadhav Mayuri[9] et al study. But in

our study, 0–3 mm was found as maximum Anteroposterior diameter in 35(47%) dry Sacra and anteroposterior diameter of 4– 6 mm was found in 31(42%) Sacra.

Transverse diameter was found to be 11 – 15 mm in 142(54%) Sacra in Nagar S.K. [6] study, 77(52%) Sacra in Seema[7] et al study, 90(56%) Sacra in Dipali Rani Pal[8] study. This was similar to our study. Transverse diameter of 11–15 mm was observed in 36(48%) Sacra in our study.

Study by Dipali Rani Pal[8] et al observed that the distance between S2 and apex of sacral hiatus was 31.33 mm on an average (range 5 – 60 mm) and the distance to the base of sacral hiatus was 54.88 mm (range 37 – 39 mm). Study done by Senoglu N[12] et al stated that the distance between S2 foramen and apex of sacral hiatus was 35.37 mm on an average (range 11–62 mm) and the distance to the base of the sacral hiatus was 65.25 mm (range 39–85 mm). The distance between S2 foramen and apex of Sacral hiatus was 34.6 mm on an average (range 6 – 52 mm) and the distance to the base of the Sacral hiatus was 51.2 mm (range 15 – 58 mm) was observed in our study which was similar to the previous studies.

Bony irregularities, different shapes of sacral hiatus and defects in the dorsal wall of sacral canal should be considered before undertaking caudal epidural anesthesia.[13,14]

CONCLUSION

Clinicians need to be aware of the Variations of Sacral hiatus and their frequencies because the success of caudal epidural anaesthesia and analgesia depends on the measurements of sacral hiatus. Neurological symptoms may be caused due to such abnormalities. Knowledge about the variations of sacral hiatus is needed for the Anaesthetists, Radiologists, Surgeons, Orthopaedicians and Gynecologists since sacral hiatus is the site where caudal analgesia and epidural anaesthesia is given.

Exact localization of sacral hiatus would help in easy passage of needle into the sacral canal. Variations in the shape and level of the hiatus may lead to failure of caudal epidural anaesthesia. This study will be helpful to the Anaesthetists in locating the sacral hiatus during caudal epidural anesthesia.

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