International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Original Research Article

An Anatomical Study of Size and Position of Sacral Hiatus; Its Importance in Caudal Epidural Block

Neeta Chhabra

Assistant Professor, Dept. of Anatomy, Army College of Medical Sciences, Delhi Cantt-10, India.

Received: 31/10/2014 *Revised: 24/11/2014* *Accepted: 24/11/2014*

ABSTRACT

This study was carried out on 32 dry human sacra to know the variations in morphology of the sacral hiatus. Various shapes of sacral hiatus were observed which included inverted V (43.75%), inverted U (28.12%), irregular (12.5%) and dumbbell (9.38%). The apex of sacral hiatus was commonly found at the level of 4th sacral vertebra in 60% of the bones studied. Base of the hiatus was commonly found at the level of S5 (63.33%). Morphology of sacral hiatus and its variations are significant while administering caudal epidural anaesthesia.

Key Words: sacral hiatus, subdural space, spinal nerves, caudal analgesia, low backache

INTRODUCTION

Caudal epidural block (CEB) is widely used to provide anaesthesia for various clinical procedures; treatment of lumbar spinal disorders and for the management of chronic back pain. It involves the injection of anaesthetic medications into the epidural space through the sacral hiatus and is useful when anaesthesia of the lumbar and sacral dermatomes is needed. [1] Sacral hiatal route was used in obstetrics for first time in 1941 for administration of epidural anaesthesia for painless delivery and in orthopaedic practice it is used for transpedicular and lateral mass screw placement. It is also used in surgery below the umbilicus such as hernia repair, surgery on lower limb, skin grafting and procedures on the anal canal and rectum. [2] Even though caudal anaesthesia has a wide range of clinical applications, it is sometimes hard to determine the anatomical location of the sacral hiatus and the caudal epidural space, especially in adults. The determination of landmarks by the clinician enables the sacral hiatus to be ascertained and may increase the success rate of CEB. [3]

Sacrum is a triangular bone formed by fusion of five vertebrae and forms the posterosuperior wall of the pelvic cavity, wedged between the two hip bones. Its caudal apex articulates with the coccyx and its superior, wide base with the fifth lumbar vertebra at the lumbosacral angle. [4] Sacral hiatus is an opening present at the caudal end of sacral canal which is formed due to incomplete midline fusion of the posterior elements of the fifth (occasionally 4th) sacral vertebra. It is located inferior to the 4th (or 3rd) fused sacral spines or lower end of median sacral crest and can be marked on

the body surface two inches above the tip of coccyx beneath the skin of natal cleft. [5] This inverted U shaped hiatus is covered posteriorly by skin, a subcutaneous fatty layer and the sacrococcygeal membrane. [3] The dura and the arachnoid sheath of spinal cord ends at the level of the second piece of sacrum within the vertebral canal but varies between the lower border of the S1 foramen in adults to S3 in children. The sacral canal below this level is called epidural space or caudal space which contains extradural fat, vertebral venous plexus, lower sacral nerve roots and the filum terminale. [6] The remnants of inferior articular processes of the 5th sacral vertebra elongate downwards on both sides of sacral hiatus to form sacral cornua. The fifth sacral spinal nerve emerges through the sacral hiatus with the coccygeal nerve to provide partial innervations to the pelvic organs, in addition to the sensory and motor innervations to the respective dermatomes and myotomes. Sacral hiatus and sacral cornua are important clinical landmarks during CEB. [7]

The reliability and success of caudal epidural block depends upon accurate localization of sacral hiatus. Anatomical variations in the sacral hiatus may relate to the failure of caudal epidural anaesthesia. For optimal access into sacral epidural space and to prevent the hazard of dural sac puncture it is necessary to have a detailed knowledge of the anatomical variations in sacral hiatus which results in discrepancies in its shape and size. The present study was undertaken to find out the anatomical variations of the sacral hiatus in the form of shape, length and breadth and antero posterior diameter.

MATERIALS AND METHOD

The present study was conducted on 32 dry human sacra collected from the Department of Anatomy, Army College of Medical Sciences, Delhi Cantt. The sex and age of bones was unknown. Bones showing wear and tear, fracture or pathology were excluded. All the measurements were taken using Vernier Callipers. Linear recording was taken to the nearest millimetre and statistical analyses were carried out. Each sacrum was studied with regards to its composition and different features of sacral hiatus. The parameters noted were:

1) Composition of Sacrum
2) Shape of hiatus
3) Level of apex of hiatus
4) Level of base of hiatus
5) Length of hiatus: Measured from apex to midpoint of base
6) Anteroposterior diameter of the hiatus at the apex
7) Transverse width of hiatus at the base: Measured between inner aspects of inferior limit of sacral cornua.
8) Distance from the apex of sacral hiatus to S2 spinous process
9) Distance from the base of sacral hiatus to S2 spinous process.

Total nine morphometric measurements relating to the sacral vertebra and hiatus,were obtained having importance for CEB.

OBSERVATIONS AND RESULTS

Table1: Composition of Sacrum (n=32)

Sr.No.	Composition of sacrum	No. of Specimens	Percentage (%)
1.	4 Segments	02	6.25
2.	5 Segments	24	75.0
3.	6 Segments	02	6.25
4.	Coccygeal ankylosis	04	12.5
	Total	32	100

Table 2: Shape of Sacral Hiatus (n=32)

Sr.No.	Shapes	No. of Specimens	Percentage (%)
1.	Inverted -U	09	28.12
2.	Inverted-V	14	43.75
3.	Irregular	04	12.5
4.	Dumbbell	03	9.38
5.	Agenesis	01	3.12
6.	Fused	01	3.12

Total 32 bones were observed for the different parameters of sacral hiatus and the following measurements were noted.

Table 3: Location of Apex of Sacral Hiatus (n=30)

Sr.No.	Location of Apex	No. of Specimens	Percentage (%)
1.	S2 level	02	6.67
2.	S3 Level	10	33.33
3.	S4 Level	18	60.0

Table 4: Location of Base of Sacral Hiatus (n=30)

Sr.No.	Location of Base	No. of Specimens	Percentage (%)
1.	4th Sacral vertebra	06	20.0
2.	5th Sacral vertebra	19	63.33
3.	Coccyx	05	16.67

Table 5: Length of Sacral Hiatus from apex to midpoint of base (n=30)

Sr.No	Length(mm)	No. of specimens	Percentage (%)
1.	0-10	01	3.33
2.	11-20	09	30.0
3.	21-30	10	33.33
4.	31-40	09	30.0
5.	>40	01	3.33

Table 6: Transverse width of Sacral Hiatus at the base (n=30)

Sr.No.	Transverse width (mm)	No. of specimens	Percentage (%)
1.	0-5	nil	-
2.	6-10	03	10.0
3.	11-15	19	63.33
4.	>16	08	26.67

Table 7: Anteroposterior diameter of Sacral Hiatus at apex (n=30)

Sr. No.	Diameter (mm)	No. of specimens	Percentage (%)
1.	0-3	nil	-
2.	4-6	15	50
3.	7-9	12	40
4.	> 9	03	10

Table 8: Morphometry of Sacrum

Sr. No	Parameters (mm)	Mean (mm)	Median (mm)	SD (mm)	Min (mm)	Max (mm)
1.	Length of Sacral Hiatus	25.05	23.37	10.96	9.98	61.98
2.	Width of Sacral Hiatus	12.84	12.75	2.41	6.53	16.9
3.	AP diameter at apex	6.30	6.01	1.39	4.11	9.67
4.	Distance from apex to S2	27.64	28.00	13.45	2.05	54.02
5.	Distance from base to S2	53.36	53.65	10.22	31.66	68.55

Most commonly sacrum is made up of five vertebrae. Present study also documented similar composition in 24(75%) sacra whereas 2(6.25%) cases were made up of 4 segments (Table 1).The most common shape of sacral hiatus encountered in present study was Inverted V(43.75%) followed by Inverted U(28.12%) cases (Table 2). Apex of sacral hiatus was mostly seen at 4th sacral vertebra in 60% of cases (Table 3) while base was commonly located at the level of 5th sacral vertebra in 63.33% sacra (Table 4). The mean length of sacral hiatus was 25.05±10.96 mm (Table 8). The mean width and mean anteroposterior diameter of sacral hiatus at apex was 12.84±2.41& 6.30±1.39 mm respectively (Table 8).The mean distance from apex to S2 vertebra and from base of sacral hiatus to S2 was 27.64±13.45 mm & 53.36±10.22 mm respectively (Table 8).

Various Parameters of Sacrum

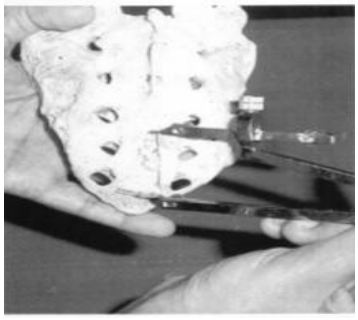

Fig. 1: Measuring the length of sacral hiatus.

Fig 2: Measuring the depth of sacral hiatus.

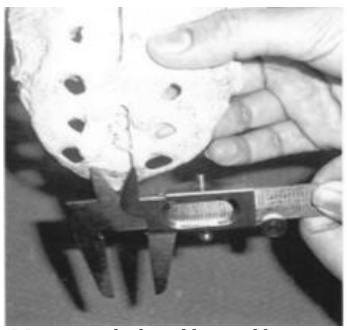

Fig 3: Measuring the breadth sacral hiatus.

Various Shapes of Sacrum

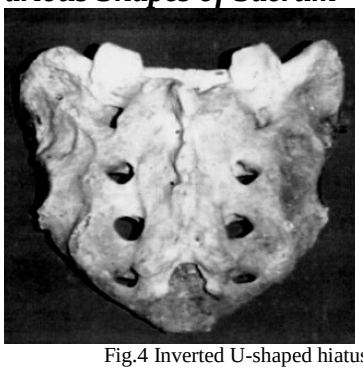
Fig.4 Inverted U-shaped hiatus

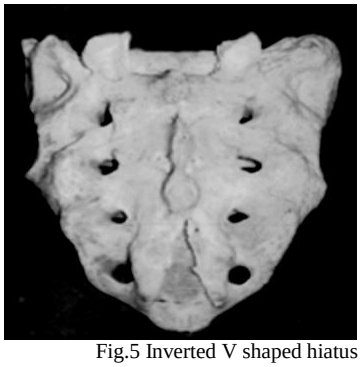
Fig.5 Inverted V shaped hiatus

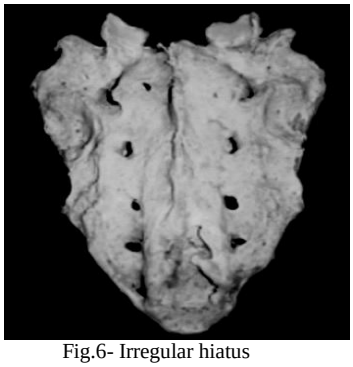
Fig.6- Irregular hiatus


Fig 7- Dumb bell shaped hiatus

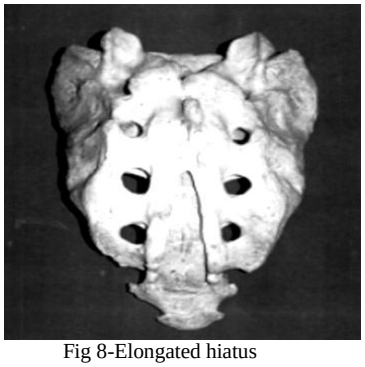
Fig 8-Elongated hiatus

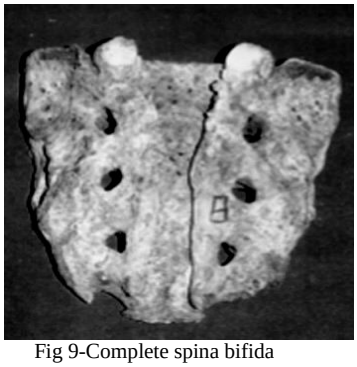
Fig 9-Complete spina bifida


Fig 10-Absent sacral hiatus

DISCUSSION

Study on the variation in anatomical features of sacral hiatus and the dorsal wall of sacral canal is related with regards to its clinical application in caudal epidural block, perineal surgery and for painless delivery. Sacral approach to epidural space produces reliable and effective block of sacral nerves. Epidural injection of cortico-steroids and local anaesthetic agents were widely used to provide symptomatic relief in patients with low back disorder. Caudal epidural block has 25% failure rate. It is mostly due to the anatomical variations at the level of apex of sacral hiatus, difficulty in palpating in some patients and also includes dorsal wall deficient cases. Identification of the caudal epidural space is not always possible even for experienced clinicians, and anatomical variation may be an influence. The apex of the sacral hiatus is an important bony landmark in the success of CEB but it may be hard to palpate, particularly in obese patients. Hence other prominent anatomical bony landmarks should be used.

Composition of Sacrum: In the present study 24 (75%) sacrum were made up of 5 segments whereas 2 (6.25%) cases showed 4 segments. Vinod Kumar et al [8] and Shewale et al [9] noted 5 segmented sacra in 141(69.80%) and 69.6% cases and 4 segmented sacra in 1.48% and 2.45% cases respectively. However, Trotter and Lanier (1945) [10] observed 4 segments in sacrum in 8(0.7%) cases only. The findings of the present study are in agreement with those of Vinod Kumar et al and Shewale et al.

Partial or complete sacralisation of 5th lumbar vertebra and coccygeal ankylosis was observed in 2 (6.25%) cases and 4 (12.5%) cases respectively in the present study. Shewale et al [9] observed sacralisation of 5th lumbar vertebra in 9.8% and coccygeal ankylosis in 18.13% cases respectively. Willis (1923) [11] studied 850 thoracolumbar columns and reported that partial or complete sacralisation and coccygeal ankylosis was present in 4.4% and 1.1% cases respectively. Trotter and Lanier [10] (1945) observed sacralisation of 5th lumbar vertebra and coccygeal ankylosis in 12.6% and 39.3% respectively.

Shape of sacral hiatus: Among the observed cases in the present study the most commonly encountered shape of sacral hiatus was Inverted 'V' in 43.75% cases while Inverted 'U' shaped sacrum was found in 28.12% cases. These two shapes provide enough room for introducing needle into sacral canal without any obstacle and thus may be the most favourable shapes for CEB. The other shapes found in the present study were irregular and dumbbell in 12.5% & 9.38% cases respectively. These shapes due to their irregularity may obstruct needle insertion and even lead to needle breakage. Comparative analysis of the shapes of the sacral hiatus in the present study was done with those of previous workers. The findings of the present study are similar to that of Vinod Kumar et al [8] who found Inverted 'V' and Inverted 'U' shapes in 46.53% and 29.70% cases respectively.

Complete agenesis of the dorsal bony wall of the sacral canal or 'spina bifida' occurs due to failure in complete fusion of sacral vertebrae. It may lead to weakness of muscles and low backache as there is no bony area available for attachment of muscles. In spina bifida caudal epidural block is still possible as it is closed by sacrococcygeal ligaments and may also be partially successful as the infiltrated anaesthetic agent penetrates the surrounding tissues and does not block the nerves. Extensive review of literature has revealed only a few studies reporting the absence of sacral hiatus. Sekiguchiet al [12] and Senogulu et al [3] found the absence of sacral hiatus in 4% cases. Failure of CEB was observed in such cases. In the present study spina bifida and complete absence of the sacral hiatus was found in one sacra (3.12%) each. These two sacra were excluded from the measurements as typical sacral hiatus was not present in them. The findings of the present study are in consonance with those carried out by Seema et al [2] who observed absence of sacral hiatus and complete spina bifida in 2.5% & 3.14% cases respectively.

Apex of sacral hiatus: Apex of sacral hiatus is an important landmark for carrying out successful caudal epidural block. It shows considerable variation ranging from S2 to S4. Knowledge of level of apex of sacral hiatus is very important when the apex is located at 2nd or 3rd sacral vertebra. There are more chances for the puncture of dural sac during caudal epidural block as the apex of the hiatus is very close to the lower end of the dural sac. If the apex is higher, more precaution should be taken while deciding length of the needle to be introduced into the canal. On the other hand, low apex requires long needle.

In the present study in 60% of the sacra the apex was located at the level of S4 vertebra, in 33.3% cases at the level of S3 and in rest 6.67% at the level of S2. The findings of present study are in agreement with the studies done by Clarista [13] where apex was found at S4 in 67.7%, at S3 in 27.1% and at S2 in 5.2% cases. Sekiguchi et al 2004 [12] noted the apex at S4 level in 64% & at S2 in 4% sacra which was almost close to the present study but they found a lower incidence of 15% at S3. Patel et al [14] found the apex at S4 in 59.33% cases. Nagar (2004) [15] reported the level of the apex to be at S3 in 37.3% sacra which was similar to the present study. The position at this level

has been reported by various other authors also.

Base of sacral hiatus: The base of sacral hiatus was located at the lower end of 4th sacral vertebra to the coccyx. In 63.33% sacra in the present study it was seen at 5th sacral vertebra. The findings of the present study are more or less in agreement with those of various authors namely Suma et al [16] and Aggarwal et al [17] where they found the base at 5th sacral vertebra in 64.84% & 61.40% cases respectively. In 20.0% cases the base was at the level of S4 vertebra while in five sacra (3.33%) it was located at the level of coccygeal vertebra. However when base of the sacral hiatus is present at the coccygeal level it is a little narrower as compared to that of the sacral level.

Length of sacral hiatus: In the present study the length of the sacral hiatus varied from 9.98 mm to 61.98 mm with a mean of 25.05±10.96 mm. In 33.33% cases 21 to 30 mm long sacral hiatus was found. Less than 10 mm and more than 40 mm long sacral hiatus had lowest frequency (3.33%) each. These findings are similar to the studies done by Trotter& Lanier [10] (1945) who reported a mean hiatal length of 24.8 mm in American males and19.8 mm in females. Similar results were observed by earlier studies of Trotter & Letterman [18] (1944) in which the length of the hiatus varied from 0-66 mm with a mean of 22.5 mm and Lanier et al [19] (1944) where he noted a mean hiatal length of 25.3±9 mm. The present and past studies clearly show that the increase in length of hiatus is influenced by the defect and non-union of 2nd or 3rd pair of sacral lamina and also by coccygeal ankylosis.

Transverse width of sacral hiatus at the base: In the present study the width at the base of sacral hiatus varied from 6.53 to 16.9 mm with a mean of 12.84 mm. In 63.33% cases it was between 11 to 15 mm. The findings of the present study coincided with the studies done by Vinod Kumar et al [8] who found mean transverse width of 13 mm with a range of 5-20 mm. It is also similar to studies done by Aggarwal et al [17] who observed a mean transverse width of 11.95±2.78 mm. Sekeiguchi et al [12] (2004) reported a lower figure of 10.2±0.35 mm. However this may be because they noted the average distance between sacral cornua.

Diameter of sacral canal at apex: The anteroposterior diameter of sacral canal at the apex of hiatus is important to decide on the accurate needle usage for the epidural block. It should be sufficiently large to admit a needle. Varying diameters lead to subcutaneous deposition of anaesthetic drug. The mean anteroposterior diameter of sacral canal at the apex in present study was 6.30±1.39 mm with a range of 4.11 to 9.67 mm. The findings of the present study concur with the studies done by Sekiguchi et al [12] (2004) and Lanier et al [19] where they noted a mean anteroposterior diameter of 6.1±0.2 mm and 6.0±1.9 mm respectively. In the present study 50% of sacra showed anteroposterior diameter of sacral hiatus between 4-6 mm while there was no case with diameter less than 3 mm. Lanier,Mc Knight & Trotter [19] (1944) also did not find any case with diameter of less than 3 mm.

Distance from apex of sacral hiatus to S2: An important part in CEB is awareness of the distance between the sacral hiatus and dural sac anatomically in relation to the risk of dural puncture. The level of S2 foramina is important because in adults duramater and arachnoid end at the level of second sacral vertebra. Hence this distance decides the length of the needle that can be safely introduced into the canal. The mean distance from apex to S2 in present study was 27.64±13.45 mm with a range of 2.05 to 54.02 mm. These findings are more or less similar to the studies done by Ramamurthi & Anil [20] who found a mean distance of 30.2±10.5 mm with a range of 12-53 mm. It is also similar to the studies done by

Aggarwal et al [17] & Clarista et al [12] who reported a mean distance of 30.16±14.07 & 32.16±12.96 respectively in their studies. However the findings of the present study are much smaller than those measured by Senogulu [3] at 35.4±10.4 mm. Hence from this data it would be safer to advance the needle only few millimetres after penetrating the sacrococcygeal membrane.

Distance from base of sacral hiatus to S2: The mean distance from base of sacral hiatus to S2 vertebra in the present study was 53.36±10.22 with a range of 31.66 to 68.55 mm. The findings of the present study coincide with those of Pal et al [21] who found a mean distance of 54.88 mm with a range of 37 mm to 79 mm in their studies.

The sacral hiatus has anatomical variations and understanding of these variations may improve the success of caudal epidural anaesthesia. Ultrasound or fluoroscopy guided needle placement is definitely more successful. 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. Chen &colleagues [1] (2004) stated 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%. However, using ultrasonography or fluoroscopy is not always possible due to time, cost-effectiveness and personnel availability. Radiation exposure is the major concern when obtaining fluoroscopic images. In the present study dumbbell shaped hiatus and narrowing of the sacral canal at apex of sacral hiatus was found in a significant percentage than reported by different authors, which should be kept in mind while giving caudal anaesthesia in Indian population.

CONCLUSION

Present study concludes in support of other studies regarding variability in the anatomical structure of sacral hiatus. Variations in the shape and level of the hiatus may lead to failure of CEB. The incidence of variations may be due to genetic and racial factors. Exact location of sacral hiatus in caudal epidural block determines its success rate. The variabilities provided in this study should be kept in mind before giving Caudal Epidural Block. Further clinical trials are required to compare the existing techniques and our anatomical description to provide more data to support the results of this study.

REFERENCES

1. Chen PC, Tang SFT, Hsu TC et al. Ultrasound guidance in caudal epidural needle placement. Anaesthesiology 2004;101(1):181–4.
2. Seema, Singh M, Mahajan A. An anatomical study of variations of sacral hiatus in sacra of North Indian origin and its clinical significance. Int J Morphol.2013;31(1):110-4.
3. Senoglu N, Senoglu M, Oksuz H et al. Landmarks of the sacral hiatus for caudal epidural block: an anatomical study. Br. J Anaesth 2005;95(5):692-5.
4. Patil D, Jadav H, Kumar B et al. Anatomical study of sacral hiatus for caudal epidural block. Nat J Med Res 2012;2(3):272-5.
5. Standring S. Grays Anatomy. the anatomical basis of clinical practice. London:Elsevier Churchill Livingstone. 2005;40th Edn 724-728.
6. Adil Asghar & Shagufta Naaz. Volume of caudal space in human sacrum. J Clin Diagn Res 2013;l7(12):2659-60.
7. Bhattacharya S, Majumdar S, Chakraborty P et al. Morphometric study of sacral hiatus for caudal epidural block among the population of West Bengal. Ind J Basic and App Res. June 2013;7(2):660-7.

8. Vinod K, Pandey SN, Bajpai RN et al. Morphometric study of sacral hiatus. J Anat Soc India 1992;41(1):7-13.
9. Shewale SN, Laeeque M, Kulkarni PR et al. Morphological and morphometrical study of sacral hiatus. Int J Recent Trends in Sci & Tech 2013; 6(1):48-52.
10. Trotter M and Lanier PF. Hiatus canalis sacralis in American whites and Negroes. Hum Biol. 1945;17:368 -81.
11. Willis TA. The thoracolumbar column in White and Negro stocks. Anat rec.1923;23:31-42.
12. Sekiguchi M, Yabuki S, Satoh K et al. An anatomical study of the sacral hiatus: a basis for successful caudal epidural block. Clin J Pain 2004;20(1): 51–4.
13. Clarista MQ & Gautham K. Morphometrical study of sacral hiatus in dry human sacra in West Indian population.CIB Tech Journal of Surgery. 2013;2(2):56-63.
14. Patel ZK, Thummar B, Rathod SP et al. A multi-centric morphometric study of dry human sacrum of Indian population in Gujarat region. NJIRM 2011;2(2):31-5.
15. Nagar SK. A study of sacral hiatus in dry human sacra. J Anat Soc India 2004;53(2):18-21.
16. Suma HY, Kulkarni R, Kulkarni RN. A study of sacral hiatus among sacra in South Indian population. Anatomica Karnataka 2011;5:40-4.
17. Aggarwal A, Aggarwal A, Harjeet et al. Morphometry of sacral hiatus and its clinical relevance in caudal epidural block. Surg Radiol Anat 2009;31:793-800.
18. Trotter M & Letterman GS. Variations of the female sacrum: their significance in continuous caudal anaesthesia. Surg Gynaecol Obstet 1944;78(4):419-24.
19. Lanier VS, Mc knight HE &Trotter M. Caudal analgesia: an experimental and anatomical study. Am J Obstet Gynaecol 1944;47(5):633-41.
20. Ramamurthi KS & Anil KR. Anatomical study of sacral hiatus for successful caudal epidural block. Int J Med Res Health Sci 2013;2(3):496-500.
21. Pal DR, Rahman MA & Fatema K. Morphometric study of sacral hiatus. a basis for successful caudal epidural block. Bangladesh J Anat. 2012;10(1):5-10.

How to cite this article: Chhabra N. An anatomical study of size and position of sacral hiatus; its importance in caudal epidural block. Int J Health Sci Res. 2014;4(12):189-196.

****