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Study of Various Shapes of Sacral Hiatus in North Indian Population

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Abstract: ***Variations around sacral hiatus directly affect the outcome of caudal epidural block. The study is done to know the extent and anatomical variations of sacral hiatus in North Indian Population. The present study was carried on 89 dry human sacra of unknown sex. Each sacrum was studied for composition, shape of hiatus, and level of the apex of hiatus, level of the base of hiatus, length of hiatus, Anterio-posterior diameter and Transverse diameter at base of hiatus. All the measurements were taken with the Vernier caliper. Composition of sacra were observed with most common being 5 segments (70.11%), 4 segments (2.29%), 6 segments (partial/complete sacralisation) (11.49%), coccygeal ankylosis (16.09%). Diverse shapes of sacral hiatus were noted with most common being Inverted V (29.21%), Inverted U (22.47%), Irregular (20.22%), Elongated (16.85%), Dumb-bell (6.74%), Bifid and complete agenesis of dorsal wall (2.24%). Apex was found to be commonly located at 4th sacral vertebra (55.05%). Base of hiatus was commonly located at 5th sacral vertebra (81.6%). The mean length of sacral hiatus was 23.29±9.27mm. Mean Anterio-posterior diameter of sacral hiatus was 4.97 ±1.37mm. Narrowing of sacral hiatus at apex with diameter less than 3mm was observed in 14.94% cases. Mean transverse diameter of sacral hiatus was 15.90±2.38mm. Sacral hiatus forms the basis of caudal epidural block. Hence, it becomes imperative to study different populations to know their pattern of variations.***

Keywords: Sacral hiatus, caudal epidural block, epidural space, sacrococcygeal ligament, coccygeal ankylosis, caudal analgesia

1. Introduction

Caudal anesthesia is a special type of epidural anesthesia, in which needle enters the epidural space through sacral hiatus lying in natal cleft for anesthesia of lower limb and sacral roots (Abrahams et al., 1998). The technique of caudal anesthesia/ epidural block entirely depends upon exact localization of sacral hiatus through which clinicians can access the epidural space. The precise knowledge about different anatomical variations related to sacral hiatus will affect its success rate. Sacral hiatus can be palpated in the living subjects as it lies 2 inches above the tip of coccyx, beneath the skin of natal cleft. It gives passage to 5th sacral nerves, a pair of coccygeal nerves, filum terminale externa and fibrofatty tissue (Abrahams et al., 1998; Newell, 2008). Sacral hiatus is covered externally by skin, subcutaneous tissue, sacrococcygeal ligament and needle pierces all these structures to open into epidural space.

Nowadays it is recommended/ mandatory to use ultrasound guided needle placement during caudal epidural block thereby increasing the overall success rate by 100% (Chen et al., 2004). Sacral hiatus finds its use during administration of corticosteroids in the treatment of sciatica (Czarski, 1965).However, caudal anesthesia has also been recommended for various surgical procedures performed below the level of umbilicus including inguinal hernia repair, urinary and digestive tract surgery, orthopaedic procedures on pelvic girdle and lower limbs (Dalens, 2002) Sacral hiatus was first used in 1942 by Edward and Hingson for continous caudal analgesia during labor (Edward and Hingson, 1942).

Sacrum is considered to be the most variable portion of spine (Esses and Botsford, 1997). These variations may occur due to different genetic and racial factors. Congenital malformation range from variations in sacral hiatus and caudal agenesis (Estin and Cohen, 1995). Sacral hiatus is a caudal opening in the dorsal wall of sacrum resulting due to failure of fusion of laminae of fifth sacral vertebra making it arch shaped gap (Johnson, 2005). The dural sac ends at the level of second sacral vertebra. The distance between tip of dural sac and apex of sacral hiatus is 4.5cms. So, the needle should not be advanced more than 1-2 cms as it can injure dural sac resulting in spinal headache (Miller et al., 2015). Malformations like hiatal agenesis/complete agenesis of dorsal wall of sacrum can result in failure of epidural block in 7% cases (Sekiguchi et al., 2004).

Recently, fluoroscopy is being considered gold standard for correct needle placement in hiatus which prevents subarachnoid puncture, intrathecal/intravascular injection (Stitz and Sommer, 1999; Spaccarelli, 1996; Weinstein et al., 1995). In order to perform these various sophisticated procedures, the clinicians must have a sound knowledge of the anatomical variations of the dorsal surface of sacrum including sacral hiatus. Thus, an attempt has been made to study the various dimensions of sacral hiatus and reporting the variations present in the North Indian Population.

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2. Materials and Methods

The study was conducted on 89 dry human sacra procured from Department of Anatomy, Pt.B.D. Sharma Post-Graduate Institute of Medical Sciences, Rohtak. Bones with wear and tear, fractures were excluded from study, only bones complete in all aspects and with clear sacral hiatus were studied. All the measurements were taken with the help of vernier caliper. All measurements were taken in millimeters. Following parameters were studied:-

- **Sacral Composition**

It is noted whether sacrum is composed of 4 segments, 5 segments, 6 segments (partial/ complete sacralisation) and coccygeal ankylosis.

- **Shapes of Sacral Hiatus**

Diverse shapes like Inverted V, Inverted U, and Irregular, Elongated, Dumb-bell, Bifid and complete agenesis of dorsal wall of sacrum were noted.

- **Level of Apex of Hiatus**

The highest point on arch shaped gap on dorsal surface corresponds with which sacral vertebra on ventral surface of sacrum.

- **Level of Base of Hiatus**

It was observed whether base corresponds with 5th sacral vertebra, 4th sacral vertebra or coccygeal vertebrae.

- **Length of Sacral Hiatus**

Distance from the apex to the midpoint of base of sacral hiatus, measured using vernier caliper (Fig.1).

- **Anterio-Posterior Diameter of Sacral Hiatus**

Maximum diameter is measured at apex by using divider and then taken in millimeters by placing divider on standard graph paper (Fig. 2).

- **Transverse Diameter at Base of Sacral Hiatus**

Distance between the inner aspects of sacral cornua, measured using vernier caliper (Fig.3).

Figure 1: Length of hiatus.

Figure 2: AP Diameter of hiatus

Figure 3: Transverse diameter of hiatus

3. Results

During study two sacra (2.24%) with complete agenesis of dorsal wall were excluded from measurements. The most common composition was 5 segments (70.11%), 4 segments (2.29%), 6 segments (11.49%) and coccygeal ankylosis (16.09%). The most common shapes were Inverted V (29.12%) and Inverted U (22.47%), least common shapes were bifid and complete agenesis both with (2.24%) (Table 1) [Fig.4 (A), (B), (C), (D), (E), (F) and (G)]. Most common location of apex of sacral hiatus was at 4th sacral vertebra (55.05%) followed by 3rd sacral vertebra (35.95%) and least common was at coccyx (12.64%). Base of sacral hiatus was commonly located at 5th sacral vertebra (81.6%) and least common at coccyx (12.64%) (Table 2). The mean length of sacral hiatus was 23±2.4mm with range 9.5-59.60mm. Mean Anterio-posterior diameter of hiatus was 4.96±0.95mm with range 3-10mm. Mean transverse diameter of sacral hiatus was 15.90±6.5mmwith range 9.4-20.1mm (Table 3).

Table 1: Sacral Composition and Shapes of Hiatus

S. No	*Sacral composition*	*No. of sacra*	*Percentage*	*Sacral shapes*	*No. of sacra*	*Percentage*
1	4 segments	2	2.29%	Inverted V	26	29.12%
2	5 segments	61	70.11%	Inverted U	20	22.47%
3	6 segments(partial / complete sacralisation)	10	11.49%	Irregular	18	20.22%
4	Coccygeal ankylosis	14	16.09%	Elongated	15	16.85%
5				Dumbbell	6	6.74%
6				Bifid	2	2.24%
7				Complete agenesis	2	2.24%

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Table 2: Apex and Base in Relation to Sacral/Coccygeal Vertebra

S no.	*Level of apex*	*No. of sacra*	*Percentage*	*Level of base*	*No. of sacra*	*Percentage*
1	4th sacral vertebra	49	55.05%	5th sacral vertebra	71	81.60%
2	3rd sacral vertebra	32	35.95%	4th sacral vertebra	5	5.74%
3	5th sacral vertebra	5	5.61%	coccyx	11	12.64%
4	2nd sacral vertebra	1	1.12%	——-	—-	——-

Table 3: Length, AP Diameter & Transverse Diameter of Sacral Hiatus

S no.	*Length of hiatus*	*No. of sacra*	*Percentage*	*AP diameter*	*No. of sacra*	*Percentage*	*Transverse diameter*	*No. of sacra*	*Percentage*
1	0- 10 mm	2	2.29%	0-3 mm	13	14.94%	0-5mm	—-	
2	11-20mm	37	42.50%	4-6 mm	62	71.26%	6-10mm	2	2.29%
3	21-30mm	30	34.48%	7-9 mm	11	12.64%	11-15 mm	30	34.48%
4	31-40mm	13	14.94%	10-12mm	1	1.14%	16-20mm	51	58.62%
5	41-50mm	4	4.59%				21-26mm	4	4.59%
6	51-60mm	1	1.14%						

Figure 4(A)

Figure 4(B)

Figure 4(C)

Figure 4(D)

Figure 4(E)

Figure 4(F)

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Figure 4(G)

Figure 4: (A), Inverted V (29.12%). (B), Inverted U (22.47%). (C), Irregular (20.22%). (D), Elongated (16.85%). (E), Dumb-bell (6.74%) (F), Bifid (2.24%) (G), Complete agencies of Dorsal wall of sacrum (2.24%)

4. Discussion

With growth of individual, axis of sacrum changes and it becomes difficult to locate sacral hiatus in adults. In children older than 6-7years of age epidural fat becomes dense, allowing less spread of local anesthesia making it difficult to perform caudal epidural anesthesia (Crighton et al., 1997). Shewale et al. (2012) studied the sacral composition and reported the most common was 5 segments (69.6%), 4 segments (2.45%), 6 segments (9.82%) and coccygeal ankylosis (18.13%). In present study, the results were in agreement with above study as most common composition was 5 segments (70.11%), 4 segments (2.29%), 6 segments (11.49%) and coccygeal ankylosis (16.09%). Nagar (2004) observed various shapes of sacral hiatus in Indian sacra, with maximum number of cases were found with Inverted U (41.5%) and Inverted V (27.0%), in (13.3%) cases, it was dumb-bell and in (1.14%) cases it was irregular. In present study, results obtained were in agreement with above study, most common shapes were Inverted V (29.22%) and Inverted U (22.47%), in (6.74%) cases it was dumb-bell, irregular in (20.22%) cases and elongated in (16.85%) cases. Kumar et al. (1992) reported most common shape as Inverted V and Inverted U in (76.23%) cases, in (7.43%) cases it was dumb-bell. Patel et al. (2011) also worked on shapes and found most common type being Inverted U in (49.33%) cases and Inverted V in (20%) cases, in (4%) cases the shape was dumb-bell and (2%) cases with elongated sacral hiatus. While Shewale et al. (2012) reported Inverted U in (40.69%) cases, Inverted V in (32.35%) cases, elongated and irregular in (9.31%) cases. In present study, complete agenesis of dorsal wall of sacrum is seen in two sacra (2.24%), similar to previous studies of Nagar (2004) observed (1.5%) cases and Sekiguchi (2004) with 3% cases.

In early studies by Lanier (1944) and Trotter (1947), the apex of sacral hiatus was found at the level of lower third of sacral fourth sacral vertebra. Nagar (2004) also found apex lying against fourth sacral vertebra in (55.9%) cases which is similar to present study, apex was found at the level of fourth sacral vertebra in (55.05%) cases, also were in agreement with previous studies like Sekiguchi (2004) in (64%) cases. Nagar (2004) observed the base at the level of fifth sacral vertebra in (72.6%) cases, at fourth sacral vertebra in (11.10%) cases, at coccyx in (16.3%) cases. While Patel et al. (2011) reported base lying at the level of fifth sacral vertebra in (79.33%) cases. In present study, results were similar with base lying at the level of fifth sacral vertebra in (81.6%) cases, at fourth sacral vertebra in (5.74%) cases and at coccyx in (12.64%) cases. Seema et al. (2013) found base at the level of fifth sacral vertebra in (70.46%) cases, at fourth sacral vertebra in (13.42%) cases and coccyx in (16.10%) cases. Chhabra (2014) reported base at the level of fifth sacral vertebra in (63.33%) cases, at fourth sacral vertebra in (20%) cases, at coccyx in (16.67%) cases. Sinha (2014) also found base at the level of fifth sacral vertebra in (88.71%) cases, at fourth sacral vertebra in (6.45%) cases and coccyx in (4.83%) cases.

Nagar (2004) reported length of sacral hiatus was 11mm to 30mm in (65.8%) cases. While Kumar et al. (1992) observed mean length as 20mm in males and 18.9mm in females. Akhtar et al. (2016) reported range of length from 7.12mm to 59.93mm, with mean of 26.92±12.19mm. Chhabra (2014) observed mean length as 25.05±10.96mm and range from 9.98mm to 61.98mm, very similar to results obtained in present study with range from 9.5mm to 59.60mm, mean of 23.29±9.27mm.While Sinha et al. (2014) found length of sacral hiatus between 10.01 to 20mm in (44%) cases. Trotter and Lanier (1945) also observed mean length in American males as 24.8mm and in American females as 19.8mm. Trotter and Letterman (1944) reported range of anterio-posterior diameter of sacral hiatus at its apex from 0-11mm, with mean of 5.3mm, narrower sacral hiatus apex was found in (4%) cases. Trotter et al. (1947) reported diameter as 5mm in Whites and 6mm in Negro groups, narrower sacral hiatus apex was found in (5%) cases. While Nagar (2004) observed range of anterio- posterior diameter of sacral hiatus at apex from 2mm to 14mm with mean of 4.8mm. Seema et al. (2013) reported range from 2mm to 14mm with mean of 4.70mm, narrower sacral hiatus apex was found in (5.36%) cases. Akhtar et al. (2016) found range from 2.1mm to 10.87mm with mean of 5.39±1.96mm very much in agreement with results of present study, range from 3mm to 10mm with mean of 4.97±1.37mm and narrower sacral hiatus at apex observed in (14.94%) cases.

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Chhabra (2014) observed transverse diameter of sacral hiatus at base ranges from 6.53mm to 16.9mm with mean of 12.84mm. While Akhtar et al. (2016) found the range of transverse diameter from 2.1mm to 10.87mm with mean of 5.39±1.96mm. The result of above studies resembles the present study with range from 9.4mm to 20.1mm and mean of 15.90±2.38mm. Nagar (2004) observed diameter between 10-15mm in (54%) cases. Seema et al. (2013) found range varied from 0.3mm to 18mm with 52% cases between 11-15mm.

5. Conclusion

In present study, narrowing of apex of sacral hiatus was found in 14.94% cases, this will not allow the 22G needle to enter into epidural space. Hence, these parameters form the basis for improving the overall success rate of caudal epidural block.

6. Conflict of Interest

Nil

7. Acknowledgement

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Legends
Figure 1- Length of sacral hiatus.
Figure 2- Anterio-posterior (AP) diameter of sacral hiatus.
Figure 3- Transverse diameter of sacral hiatus.
Figure 4- Different shapes of hiatus.

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