ORIGINAL ARTICLE

Morphometric study of sacral hiatus in adult human Egyptian sacra: Their significance in caudal epidural anesthesia

Mohamed S. Mustafa,
Omayma M. Mahmoud[1],
Hoda H. H. A. El Raouf[1],
Hosam M. Atef[2]

Departments of Orthopedic & [1]Anatomy and [2]Anesthesia, Faculty of Medicine, Suez Canal University, Ismailia, Egypt

ABSTRACT

Background: The reliability and success of caudal epidural anesthesia depends on anatomic variations of sacral hiatus (SH) as observed by various authors. SH is an important landmark during caudal epidural block (CEB).The purpose of the present study was to clarify the morphometric characteristics of the SH in human Egyptian dry sacra and pelvic radiographs and identification of nearest ony landmarks to permit correct and uncomplicated caudal epidural accesses. **Methods:** The present study was done on 46 human adult Egyptian dry sacra. The maximum height, midventral curved length, and maximum breadth of each sacrum were measured and sacral and curvature indices were calculated. According to sacral indices, sacra were divided into 2 groups (22 male and 24 female sacra). SH was evaluated in each sacrum according to its shape, level of its apex, and base according to sacral and coccygeal vertebrae, length, anteroposterior (AP) diameter at its apex, and transverse width at its base. Linear distances were measured between the apex of SH and second sacral foramina, right and left superolateral sacral crests. The distance between the 2 superolateral sacral crests also was measured. **Results:** The most common types of SH were the inverted U and inverted V (in male) and inverted V and dumbbell shaped (in female). Absent SH was observed in male group only. The most common location of SH apex was at the level of S4 in all groups of dry sacra and S3 in all groups of lumbosacral spine radiographs, whereas S5 was the common level of its base. The mean SH length, transverse width of its base, and AP diameter of its apex were 2.1 ± 0.80, 1.7 ± 0.26, and 0.48 ± 0.19 cm. Female sacra showed narrower SH apex than male. The distance between the S2 foramen and the apex of the SH was 4.1 ± 1.14, 3.67 ± 1.21, and 4.48 ± 1.01 cm in total, female and male sacra, respectively. **Conclusion:** Sacrum and SH showed morphometric variations in adult Egyptians. The equilateral triangle is an important guide to detect SH easily and increases the success rate of CEB. Insertion of a needle into the SH for caudal block is suggested to be done at its base to avoid the anatomic variations of its apex.

Key words: *Caudal anesthesia, Egyptian sacra, morphometric, sacral hiatus*

Address for correspondence:
Dr. Hosam M. Atef,
Department of Anaesthesiology, Faculty of Medicine, Suez Canal University, Ismailia, Egypt.
E-mail: hosamatef375@yahoo.com

INTRODUCTION

Sacrum is a large triangular bone, formed by fusion of 5 sacral vertebrae. It forms the caudal end of the vertebral column and posterosuperior wall of the pelvic cavity wedged between the 2 innominate bones. The sacral canal is formed by sacral vertebral foramina. Its upper opening is located on the base of the sacrum and appears to be set obliquely. Its caudal opening is known as the sacral hiatus (SH) and presented in the sacral apex. Each lateral wall presents 4 intervertebral foramina, through which the canal is continuous with pelvic and dorsal sacral foramina.[1]

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Sacrum is an important bone for identification of gender in human skeletal system. Because it is a component of axial skeleton and pelvic girdle, it has an applied importance in determining gender with the help of measurements carried upon it. The well-known method for determination of male and female sacra has been the Sacral index (SI).[2] SI is an accurate parameter in sexing sacrum with 100%

accuracy.[3-5] The male and female values of SI are 105% and 115%, respectively.[1]

SH is formed due to the failure of fusion of laminae of the fifth (occasionally 4th) sacral vertebra (SV). The surface landmark for SH lies about 2 inches above the tip of the coccyx, beneath the skin of natal cleft. The hiatus contains lower sacral and coccygeal nerve roots, filum terminale, and fibrofatty tissue.[6] The SH is covered by skin, subcutaneous fatty layer, and superficial dorsal sacrococcygeal ligament (also called sacrococcygeal membrane), which has to be pierced to reach the sacral canal.[7] The lateral margins of the hiatus are formed by 2 sacral cornua. These are the remnants of the inferior articular processes downward extensions. They are important clinical landmarks during CEB.[8]

Sacral approach to epidural space produces reliable and effective way to block the sacral nerves. The SH has been used for administration of epidural anesthesia in obstetrics[9] as well as in orthopedic practice for treatment and diagnosis.[7] It is also used for three-dimensional color visualization of lumbosacral epidural space.[10] The distal-most portion of the dural sac terminates at the level of S2—keeping in mind the importance of determining the anatomic location of the SH during CEB. The equilateral triangle between apex of SH and superolateral sacral crests or posterior superior iliac spines is certainly of use in determining the location of SH during CEB.[11]

It is necessary to have a detailed knowledge of SH for optimal access into sacral epidural space. The purpose of the present study was to clarify the morphometric characteristics of the SH in human Egyptian dry sacra and pelvic radiographs and identification of nearest bony landmarks to permit correct and uncomplicated epidural accesses.

METHODS

The present study was done on I—46 human adult Egyptian dry sacra obtained from the Department of Anatomy, Faculty of Medicine, Suez Canal University; and II—60 AP lumbosacral spine radiographs of adult Egyptians obtained from the Orthopedic Department, Faculty of Medicine, Suez Canal University Hospital.

Dry sacra

Intact sacra with intact, undamaged and clear SH were collected and included in the present study, whereas bones showing wear and tear or fracture were excluded. The maximum height, midventral curved length, and breadth of each sacrum were measured as follows:

(1) The maximum height of sacrum (anterior straight length): The straight distance from sacral promontory in the midsagittal plane to the corresponding lowest point on the anterior margin of the sacrum by using the Dial caliper
(2) The maximum breadth (width) of sacrum: The straight distance between two points at the lateral-most part of alae of sacrum by using the Dial caliper
(3) Midventral curved length: Measured along the midline of the pelvic surface of the sacrum from middle of anterosuperior margin of promontory to middle of anteroinferior margin of the last SV by using flexible measuring tape.

Then sacral and curvature indices were calculated for each sacrum by the following equation according to Hardlika (1939).[2]

$$\text{Sacral index} = \frac{\text{Maximum breadth} \times 100}{\text{Maximum height}}$$

$$\text{Curvature index} = \frac{\text{Maximum height} \times 100}{\text{Midventral curved length}}$$

According to the results of measured sacral indices, sacra were divided into 2 groups based on gender. Sacra with sacral indices ≤ 105% (22 sacra) were considered as male sacra, whereas sacra with sacral indices ≥ 115% (24 sacra) were considered as female sacra. Sacra with sacral indices between 105% and 115% did not belong to either group.

Then SH was evaluated in each sacrum in both groups according to its shape, level of its apex, and base according to sacral and coccygeal vertebrae, length (from its apex to midpoint of the base), AP diameter at its apex, and transverse width at its base (between the inner aspect of inferior limit of sacral cornua). Linear distances were measured between the apex of SH and second sacral foramina [Figure 1]. Also the linear distances between apex of SH and the right and left superior ends of the lateral sacral crests (superolateral sacral crests) were measured. The distance between the 2 superolateral sacral crests also was measured [Figure 1]. The triangle between the 2 superolateral sacral crests and the SH apex was evaluated in both sexes. All these parameters were measured by using the Dial caliper with 0.1 mm accuracy. The results of these parameters were compared with those of other studies on the Egyptian and other populations.

AP lumbosacral spine radiographs

Only radiographs with best alignment and without any evidence of sacral fracture were used in the present study. Radiographs were classified into 2 groups according to gender (30 female and 30 male). SH was assessed in each radiograph for its shape, the level of its apex and base, and these data were compared according to gender. The results of all measured parameters of SH were compared with those of other studies on the Egyptian and other populations.

Statistical analysis

All measurements and frequencies of the data were tabulated and separated according to sacral indices. Statistical Package for the Social Science (version 12) software (SPSS) was used for the analysis. The mean and standard deviation (SD) for each of the measurements were assessed. A comparison of the values of all measurements was made among groups using Student's *t* test. Differences among groups were considered statistically significant at *P* values of less than 0.05.

RESULTS

Sex determination and assessment of sacra

Table 1 shows the mean and standard deviation of maximum height, width, curved length, sacral, and curvature indices in the total, male and female Egyptian adult sacra. The maximum sacral height, maximum curvature length, and curvature index were significantly increased in male than in female sacra, whereas the maximum sacral width was not changed in both groups.

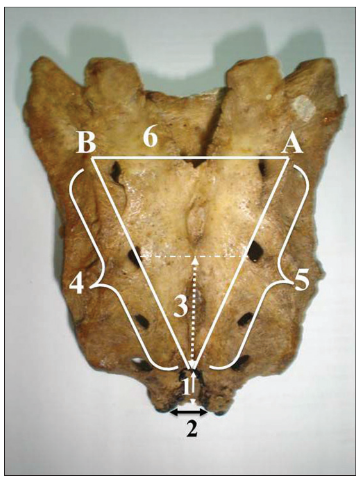

Figure 1: Dorsal surface of human adult dry sacrum shows the measured parameters of sacral hiatus: (1) Length of sacral hiatus measured from its apex to the midpoint of its base. (2) Width of the base of sacral hiatus measured between the inner aspects of inferior limit of sacral cornua. (3) Linear distance from the apex of sacral hiatus perpendicular to a line drawn between the midpoints of the medial margins of the second dorsal sacral foramina. (4) Linear distance between the apex of sacral hiatus and the left superolateral sacral crest (B). (5) Linear distance between the apex of sacral hiatus and the right superolateral sacral crest (A). (6) Linear distance between the right and left superolateral sacral crests

Assessment of sacral hiatus in boney sacra

SH was evaluated in each sacrum according to its shape. There were 5 shapes of SH in examined sacra: Inverted U, inverted V, irregular, dumbbell, and partial sacral agenesis [Table 2 and Figures 2–4]. The inverted U- and V-shaped SH were the most common shapes in both total and male sacra followed by the irregular shaped, whereas the dumbbell-shaped SH was the most common in female sacra followed by irregular and inverted V-shaped SH. The absent SH were observed only in 2 male sacra. Deficient dorsal sacral wall was observed in 1 male examined sacra.

The levels of the apex and base of each SH were determined according to the sacral and coccygeal vertebrae [Tables 3 & 4 and Figures 2–4]. The common location of SH apex was at the level of the 4th SV in all groups of sacra followed by 5th SV in total and male sacra and both 3rd and 5th SV (equally) in female sacra. The 5th SV was the common level for SH base in all groups of sacra.

The values of AP diameter of SH apex ranged from 0.2 to 0.9 cm in total and male sacra and they ranged from 0.2 to 0.6 cm in female sacra [Table 5]. The percentage of narrow SH apex (<0.3 cm) was increased in female sacra (41. 7%) when compared with male sacra (9.1%). Table 6 shows the mean and standard deviation of SH length, AP diameter of its apex, transverse width of its base, linear distances between its apex and other boney landmarks (S2 foramina, right and left superolateral sacral crests), and the linear distance between the right and left superolateral sacral crests in the total, male, and female sacra. The distances between SH apex and the right and left superolateral sacral crests and the distance between the superolateral sacral crests were statistically increased in male sacra. Other parameters showed no significant difference between male and female sacra. The triangle between the two superolateral

Table 1: Measured parameters and calculated indices of Egyptian adult dry sacra

Parameter	Total sacra (*n*=46)	Female sacra (*n*=24)	Male sacra (*n*=22)
Maximum height	10.4±1.47	9.25±1.0**	11.54±0.92**
Maximum width	11.3±0.772	11.5±0.90	11.36±0.57
Maximum curved length	11.4±1.41	10.65±1.30*	12.16±1.17*
Sacral index	110.97±13.54	121.7±9.86**	100. 2±7.03**
Curvature index	91.5±5.89	87.89±5.75**	95.66±2.82**

Student's t test: Significant differences between female and male sacra. *Very significant *P*<0.001, **highly significant *P*<0.0001, Mean±SD sacral crests spines and the SH apex was equilateral in all groups.

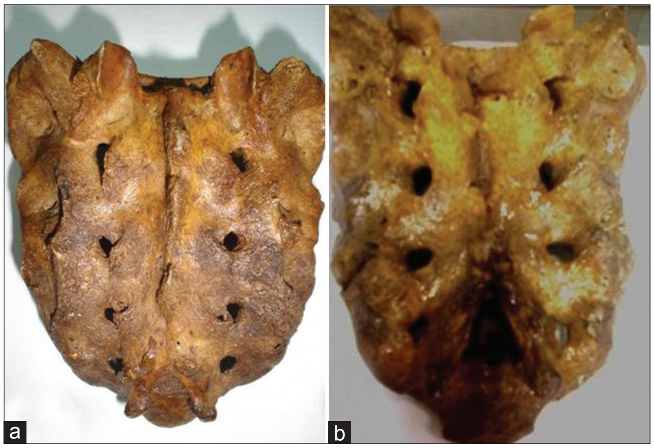

Figure 2: Dorsal views of male adult Egyptian sacra show: (a) Inverted U-shaped SH with its apex at the level of S4 and its base at S5. (b) Inverted V-shaped SH with its apex at the level of S3 and its base at S5

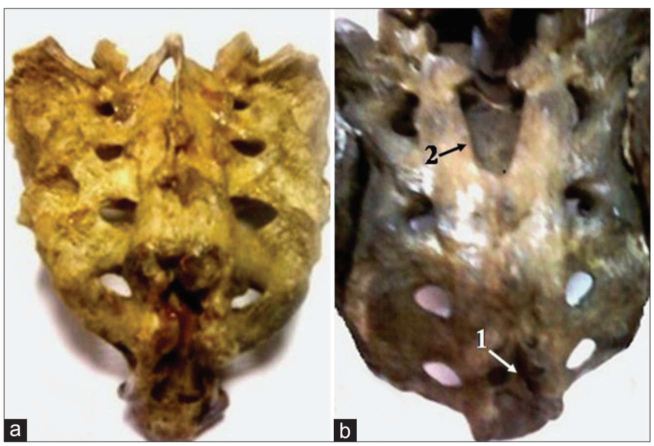

Figure 3: (a) Dorsal view of female adult Egyptian sacrum shows dumbbell-shaped SH with its apex at the level of S4 and its base at S5. (b) Dorsal view of male adult Egyptian sacrum shows partial agenesis of sacral canal

Figure 4: (a) Dorsal view of female adult Egyptian sacrum shows irregular-shaped sacral hiatus with its apex at the level of S4 and its base at S5. (b) Dorsal view of male adult Egyptian sacrum shows absent sacral hiatus

Assessment of sacral hiatus in AP lumbosacral spine radiographs

There were 5 shapes of SH in examined sacra: Inverted U, inverted V, irregular, dumbbell, and absent [Table 7 and Figures 5–8]. The inverted U-shaped SH was the most common shape in male group followed by

Table 2: The frequency of different shapes of sacral hiatus in Egyptian adult sacra

Shape	Total sacra (*n*=46)		Female sacra (*n*=24)		Male sacra (*n*=22)	
	No.	%	No.	%	No.	%
Inverted U	12	26	4	16.67	8	36.3
Inverted V	11	24	6	25	5	22.7
Dumbbell	10	22	8	33.33	2	9.1
Irregular	10	22	6	25	4	18.2
Bifid	0	0	0	0	0	0
Absent	3	6	0	0	3	13.7
Total	46	100	24	100	22	100

Table 3: The frequency of different locations of sacral hiatus apex in relation to sacral vertebrae in Egyptian adult dry sacra

Location of sacral hiatus apex	Total sacra (*n*=46)		Female sacra (*n*=24)		Male sacra (*n*=22)	
	No.	%	No.	%	No.	%
2nd SV	0	0	0	0	0	0
3rd SV	6	13	2	8.33	4	18.2
4th SV	32	70	20	83.34	12	54.54
5th SV	8	17	2	8.33	6	27.26
Total	46	100	24	100	22	100

Table 4: The frequency of different locations of sacral hiatus base in relation to sacral and coccygeal vertebrae in Egyptian adult dry sacra

Location of sacral hiatus base	Total sacra (*n*=46)		Female sacra (*n*=24)		Male sacra (*n*=22)	
	No.	%	No.	%	No.	%
4th SV	4	9	4	16.67	0	0
5th SV	42	91	20	83.33	22	100
1st Coccygeal vertebra	0	0	0	0	0	0
Total	46	100	24	100	22	100

SV: Sacral vertebra

Table 5: Incidence of different values of anteroposterior diameter of sacral hiatus apex in Egyptian adult dry sacra

Anteroposterior diameter of SH (cm)	Total sacra (*n*=46)		Female sacra (*n*=24)		Male sacra (*n*=22)	
	No.	%	No.	%	No.	%
0.2–0.3	12	26	10	41.7	2	9.1
0.4–0.6	30	65	14	58.3	16	72.7
0.7–0.9	4	9	0	0	4	18.2

the inverted V then the dumbbell shape, whereas the dumb-bell-shaped SH was the most common shape in total and female groups followed by inverted V-shaped SH. The absent SH (10%) was observed only in the male group.

The common location of SH apex was at the level of the 3rd SV in all groups of sacra followed by 4th SV [Table 8]. Although the 5th SV was the common level for SH base in all groups followed by 4th SV in female group and 1st coccygeal vertebra (10% and 10%) in male group [Table 9].

Figure 5: Anteroposterior view of male lumbosacral spine radiograph showed inverted U-shaped sacral hiatus and its apex at the level of S3 (arrow) and its base at S5

Figure 6: Anteroposterior view of female lumbosacral spine radiograph showed irregular-shaped sacral hiatus and its apex at the level of S4 (arrow) and its base at S5

Figure 7: Anteroposterior view of male lumbosacral spine radiograph showed dumbbell-shaped sacral hiatus and its apex at the level of S2 (arrow) and its base at S4

Figure 8: Anteroposterior view of male lumbosacral spine radiograph showed partial agenesis of dorsal wall of sacral canal plus irregular-shaped sacral hiatus (arrow)

Table 6: Measured parameters of sacral hiatus in Egyptian adult dry sacra

Parameter	Total sacra (*n*=46)	Female sacra (*n*=24)	Male sacra (*n*=22)
Length of SH	2.1±0.80	2.1±0.81	2.2±1.0
Ant-post diameter of SH apex	0.48±0.19	0.41±0.164	0.55±0.197
Transverse width of SH base	1.7±0.26	1.73±0.21	1.63±0.30
Distance between SH apex and S2 foramina	4.1±1.14	3.67±1.21	4.48±1.01
Distance between superolateral crests	7.55±1.03	7.06±0.47*	8.10±1.3*
Distance between right superolateral sacral crest and SH apex	7.5±1.02	7.03±0.84*	8.07±0.99*
Distance between left superolateral sacral crest and SH apex	7.5±1.02	7.03±0.84*	8.07±0.99*

Student's t test: Significant differences between female and male sacra. *Significant $P<0.05$, Mean±SD

Table 7: The frequency of different shapes of sacral hiatus in anteroposterior lumbosacral spine radiographs of adult Egyptians

Shape	Total (*n*=60)		Female (*n*=30)		Male (*n*=30)	
	No.	%	No.	%	No.	%
Inverted U	14	23.3	5	16.7	9	30
Inverted V	15	25	8	26.6	7	23.3
Dumbbell	18	30	12	40	6	20
Irregular	10	16.7	5	16.7	5	16.7
Bifid	0	0	0	0	0	0
Absent	3	5	0	0	3	10
Total	60	100	30	100	30	100

Table 8: The frequency of different locations of sacral hiatus apex in relation to sacral vertebrae in AP lumbosacral spine radiographs of adult Egyptians

Location of sacral hiatus apex	Total (*n*=60)		Female (*n*=30)		Male (*n*=30)	
	No.	%	No.	%	No.	%
2nd SV	6	10	3	10	3	10
3rd SV	29	48.3	15	50	14	46.7
4th SV	23	38.3	12	40	11	36.6
5th SV	2	3.4	0	0	2	6.7
Total	60	100	30	100	30	100

SV: Sacral vertebra

Table 9: The frequency of different locations of sacral hiatus base in relation to sacral and coccygeal vertebrae in AP lumbosacral spine radiographs of Egyptian adults

Location of sacral hiatus base	Total (*n*=60)		Female (*n*=30)		Male (*n*=30)	
	No.	%	No.	%	No.	%
4th SV	6	10	3	10	3	10
5th SV	50	83.3	27	90	23	76.7
1st Coccygeal vertebra	4	6.7	0	0	4	13.3
Total	60	100	30	100	30	100

SV: Sacral vertebra

DISCUSSION

In the present study, the mean SI was 110.97% in the total sample of sacra and (100.2% and 121.7%) in male and female sacra, respectively. Mishra *et al.* (2003)[12] found that the mean SI in male and female sacra were 98.21% and 117.84%, respectively, in India. The male sacra were significantly longer and more curved than female sacra in the present study, as sacral height, curved length, and curvature index values were elevated in male than in female sacra. These findings were in agreement with Mishra *et al.* (2003),[12] Standring *et al.* (2005),[1] and Marina *et al.* (2008).[5] Regarding the maximum sacral width in the present study, it was not significantly changed in both male (11.36) and female (11.5) sacra. The mean width of male and female sacra in Agra region in India was 10.53 and 10.57,[12] which were in agreement with the present study in the close values between male and female sacra.

The knowledge of SH anatomy is imperative in clinical situations requiring CEB for various diagnostic and therapeutic procedures of the lumbosacral spine to avoid failure and dural injury.[13] The SH is variable in shape and size. The laminae of the entire SV may fuse in the midline resulting in the absence of SH or it may fail to fuse resulting in incomplete bony dorsal wall of the sacral canal. Between these two extremities a number of variations in the SH have been observed.[14]

In the present study, the shape of SH was variable in male and female sacra, which was obvious in boney sacral and AP lumbosacral spine radiographs. There were 5 shapes of SH in the present study: Inverted U, inverted V, irregular, dumbbell, and absent. The most common types of SH were the inverted U and inverted V (in males). These two shapes provide enough space for needle access during CEB; and dumbbell, inverted V, and irregular shaped SH are the most common in females. These shapes provide challenge during CEB. Partially deficient dorsal sacral wall was observed in one examined sacra and radiographs. Kumar *et al.* (1992)[15] noted various shapes of SH in India: Inverted V, inverted U, dumbbell, irregular, bifid, absent, and other shapes and reported that the inverted V shape was the most common shape. Another study showed that the inverted U (41.5%) and inverted V (27.0%) were the most common shapes in Indian sacra followed by dumbbell and irregular shaped SH (13.3% and 14.1%) and bifid hiatus was seen in 1.5% of sacra.[16] Aggarwal *et al.* (2009) stated that inverted U and V shapes were the most common types (70.79%), while other shapes, such as inverted U with projection from lateral wall, irregular, figure-of-eight, and M-shaped sacra were seen in 29.21%.[17] Absent SH was observed in 3 (10%) male AP lumbosacral spine radiographs and 3 (13.7%) male dry sacra in the present study, which is an important result as it may be caused by boney overgrowth and complete fusion the laminae of the 4th and 5th sacral vertebrae, and some authors have reported that one of the anatomic reasons for caudal epidural anesthesia failure was the absence of SH (7.7%).[7]

Strandring *et al.* (2005)[1] stated that the apex of SH is present at the level of 4th SV. In the present study, the most common location of SH apex was at the level of the 4th SV in the total, female, and male dry sacra (70%, 83.34%, and 54.54%). These results were almost similar to those reported by other studies.[7,11,15,16] The level of S3 was the most common location of SH apex in AP lumbosacral spine radiographs in total, males, and females (48.3%, 46.7%, and 50%, respectively) in the present study, which is in agreement with the results of Letterman and Trotter's (1944)[14] study on American sacra. High level of SH apex (S3) is a dangerous site, because of its close relation to the level of dura mater termination at S2. Abd El-Monem *et al.* (2006)[18] reported that the location of SH apex in Egyptian sacra was variable. It varied from the second sacral piece to the lower part of the fifth sacral one. Sekiguchi *et al.* (2004)[7] reported apex at S1 in 1%.

With regard to the base of the SH in the present study, it was found to be located in the level of the 5th SV in 91%, 83.3%, and 100% of total, female, and male dry sacra, respectively, and (83.3%, 90%, and 76.7%) in total, female, and male AP lumbosacral spine radiographs as that was reported in Indian population (83.17%) and (72.6%)[11,16] and in Egyptian population.[18] According to the results of the present study, the location of SH apex was more variable than its base in all examined sacra and AP lumbosacral spine radiographs. So insertion of a needle into the SH for caudal block is suggested to be done at its base to avoid the anatomic variations of its apex.

The mean length of SH in the present study was 2.1±0.80, 2.2±1.0, and 2.1±0.81 cm in total, male, and female sacra, respectively. These results were similar to those reported by earlier studies in different races. Similar results were noted by earlier studies of Letterman and Trotter (1944)[14] in which the mean length of hiatus was 2.48 and 1.98 cm in American male and female sacra, respectively. Also Kumar *et al.* (1992)[15] observed that the mean length of SH in India was 2.0 cm in males and 1.89 cm in females. In Turkey, the average length of the SH was 3.21 cm (range, 1.2–5.3 cm). The length of the SH was mostly between 2.0 and 4.0 cm.[19]

The AP diameter of SH at the apex is important as it should be sufficiently wide to admit a needle in CEB. Various diameters lead to subcutaneous or outside deposition of anesthetic drug. The values of AP diameter of SH apex in the present study were ranged from 0.2 to 0.9 cm in total and male sacra and they were ranged from 0.2 to 0.6 in female sacra. Female sacra showed decreased values of AP diameter of SH apex (41. 7%) when compared with males (9.1%). The mean value of SH apex AP diameter was 0.48±0.19, 0.55±0.197, and 0.41±0.164 cm in total, male, and female sacra, respectively. These values were in agreement with those reported by Aggarwal *et al.* (2009), 0.5 cm,[17] Trotter *et al.* (1944), 0.53 cm,[20] Lanier *et al.* (1944), 0.61 cm,[21] Trotter (1947), 0.5 cm in whites and 0.6 cm in Negro sacra,[22] Kumar *et al.* (1992), 0.48 cm,[15] Nagar *et al.*, (2004), 0.48 cm,[16] Sekiguchi *et al.* (2004), 0.6 cm,[7] and Senoglu *et al.* (2005), 4.46 cm.[19] In our study, it was less than 3 mm in 26% cases. It suggests that in 26% cases it would be difficult to insert needle.

In the present study, the transverse width of SH base was 1.7±0.26, 1.63±0.30, and 1.73±0.21 cm in total, male, and female sacra, respectively. Previous studies reported that the transverse width of SH base was 1.7 cm,[20] 1.93±0.3 cm,[21] 0.5–2.0 cm (in male) and 0.8–1.8 cm (in female),[15] 1.0–1.5 cm,[16] 1.02±0.35 cm,[7] and 1.74 cm.[18] These different results may be attributed to racial diversity.

An important point in CEB is the awareness of the distance between the SH and dural sac anatomically in relation to the risk of dural puncture. The dimensions of the SH may vary, with its apex usually slightly above the distal third of S4, and the distance between the tip of dural sac and hiatal apex around 4.5 cm.[8] The dural sac was reported to terminate at the level of S2 foramina in 83.6% of adult Indian cadavers.[13] Senoglu *et al.* (2005)[19] found that the distance between the S2 foramen and the apex of the SH was 3.54±1.04 cm (range 1.1–6.2 cm). However, the detection of the dura mater just beneath the hiatus has been reported in 1% of cases.[8] In the present study, the distance between the S2 foramen and the apex of the SH was 4.1±1.14, 3.67±1.21, and 4.48±1.01 cm in total, female, and male sacra, respectively. Male values were significantly increased than those of females. So, the needle should be advanced few millimeters (<5 mm) after penetrating the sacrococcygeal membrane during CEB in adults[13,19] and it is more safe to introduce it through the base, which is more far from S2 (by the length of SH 2.1±0.80 cm), in order to reduce the frequency of dural puncture and other possible complications.

The apex of the SH is an important bony landmark in the success of CEB but it may be hard to palpate, particularly in obese patients. Hence other prominent anatomic landmarks may be of use, such as the triangle formed between the posterior superior iliac spines and the apex of SH. Abd El-Monem *et al.* (2006)[18] studied the SH in Egyptian dry sacra and cadavers. They noticed 3 surface depressions on the lower part of the back of human body, which formed an equilateral triangle. The base of that triangle was formed by the upper 2 depressions that represented the 2 posterior superior iliac spines. Its apex was directed below and pointed to the SH. In males it nearly pointed to the apex of the hiatus, whereas in females it descended slightly inside the hiatus. The equilateral triangle could be useful in confirming the palpation of the sacral cornua and hence the base of the SH. Senoglu *et al.* (2005)[19] stated that the posterior superior iliac spines impose on the superolateral sacral crests of the sacrum, and they used them as landmarks in identifying the equilateral triangle in dry sacra. They found that the average distance between the 2 superolateral sacral crests (the base of the triangle) was 6.65±53.5 cm (range, 5.1–7.95 cm). The distance between the right superolateral sacral crest and the sacral apex was

6.71±1.0 cm (range, 4.21–8.9 cm). The distance between the left superolateral sacral crest and the sacral apex was 6.75±9.5 cm (range, 4.6–8.81 cm).

In the present study, the distance between the right and left superolateral crests was 7.55±1.03, 7.06±0.47, and 8.10±1.3 in the total, female, and male sacra, respectively. Whereas the distance between right superolateral sacral crest and SH apex was 7.5±1.02, 7.03±0.84, and 8.07±.99 in the total, female, and male sacra, respectively, which were in the same values to the distance between left superolateral sacral crest and SH apex and the distance between superolateral sacral crests. Male values of these parameters were significantly elevated when compared with those of female sacra. The linear distances between the SH apex and superolateral sacral crests in the present study, formed equilateral triangle as the line distance between each superolateral sacral crest, and the SH apex were equal in length and equal in the linear distance between the 2 superolateral sacral crests. These results were in agreement with those of Senoglu *et al.* (2005)[19] and Abd El-Monem *et al.* (2006).[18] That equilateral triangle can be identified on the body surface by lines connecting 3 depressions on the lower part of the back of human body that represented the 2 posterior superior iliac spines and SH apex.[18]

CONCLUSION

Sacrum and SH showed morphometric variations in adult Egyptians and other populations. Understanding of these variations may improve the success of caudal epidural anesthesia. Identification of single bony landmark may not be helpful in locating SH. The equilateral triangle (which formed from lines connecting the SH apex and the posterior superior iliac crests) is a practical guide, which could be important in the detection of SH easily and increases the success rate of CEB. Insertion of a needle into the SH for caudal block is suggested to be done at its base to avoid the anatomic variations of its apex. Once the needle is introduced into the canal through SH apex, it should not be advanced >5 mm after penetrating the sacrococcygeal ligament to prevent dural puncture. AP diameter of hiatus less than 3 mm in Egyptian females and absent SH in Egyptian males should be taken into consideration before CEB to avoid its failure. Lumbosacral spine radiographs may be helpful in identification of SH absence, other shapes, and level of SH apex and base.

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