Original Article

The position and size of the sacral hiatus in Thai dry human sacra

Nadthaganya Suwanlikhid*, Kajorn Lakchayapakorn*,
Pasuk Mahakkanukrauh**

Abstract

Introduction: To study the shape, position and size of the sacral hiatus in Thai dry human sacra.

Method: The present study was carried out on 235 dry human sacra, 163 males and 72 females, in Faculty of medicine, Chiangmai and Thammasat university. The ages of dry human sacra ranged from 20–90 years. The shape, position and size of sacral hiatuses were observed. The inter-cornual distance, the distance from sacral hiatal apex to the midpoint of base and the lower border of the 5^{th} sacral vertebra were measured. Data were statistically analyzed and the difference of mean distance was performed by using unpaired t-tests. A p-value of less than 0.05 was considered significant.

Results: The most common shapes of sacral hiatus were inverted U (54.47%), inverted V (19.57%), irregular (11.06%) and elongated (6.81%). The apex and base of sacral hiatus were commonly found at the level of the 4^{th} (62.98%) and the 5^{th} sacral vertebrae (76.6%), respectively. The average distance from sacral hiatal apex to the midpoint of base was significantly different ($p = 0.0002$) between male (19.89 ± 9.05 mm) and female (15.63 ± 5.29 mm). The average distance from sacral hiatal apex to the lower border of the 5^{th} sacral vertebra was significantly different ($p = 0.002$) between male (26.44 ± 11.49 mm) and female (21.75 ± 8.23 mm). The mean inter-cornual distance was no significant difference between male and female.

Discussion and Conclusion: The inverted – U, inverted – V, elongated and agenesis shapes of sacral hiatus were found in 81.28 percent of sacra (male 77.30% and female 90.28%). Thus, this study suggests a high chance of success for the caudal epidural anesthesia in Thai patients, especially in females.

Key words: Sacral hiatus, Sacrum, Caudal epidural anesthesia

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* Division of Anatomy, Department of Preclinical Science, Faculty of Medicine, Thammasat University

** Department of Anatomy, Faculty of Medicine, Chiangmai University

Introduction

Caudal epidural anesthesia is used to relieve pain at specific areas using needles to penetrate skin through posterior sacrococcygeal ligament and sacral hiatus, respectively, before entering sacral canal in proximity of epidural space so the anesthetic can relieve pain during labor and during or after surgery[1, 2]. The penetrated position is in sacral hiatus that exists because there is a gap between lamina of the 4th or 5th sacral vertebra. This position is safe for the spinal cord[2]. Sacral hiatus level varies from person to person. There are studies on position, shape and size of sacral hiatus in the countries in Asia, including India[3, 4, 5, 6, 7], Japan[8, 9], Korea[10] and Africa[11]. The mean distance of measurements varies from one country to another. In Thailand, however, there was no report of the related research to determine position and size of the sacral hiatus. Thus, the researchers were interested to study the shape, position and size of the sacral hiatus in Thai dry human sacra.

Method

The present study was carried out on 235 dry human sacra (163 males and 72 females). The ages were between 20-90 years. These samples were from the Faculty of medicine, Thammasat university and the Faculty of medicine, Chiangmai university. These investigation of the shape and size of sacral hiatus were carried out using vernier caliper with precision of at least 2 decimal places. The 3 measurements were as follows. 1. The inter - cornual distance (A) (Figure 1). 2. The distance between sacral hiatal apex and the midpoint of base (B). 3. The distance between sacral hiatal apex and the lower border of the 5th sacral vertebra (B and C). The data were analyzed by mean and standard deviation (mean ± SD) and the difference of distances between particular points between male and female was performed by using unpaired t-tests from SPSS software. A p – value. of less than 0.05 was considered significant. This research was approved from the human research ethics committee of Faculty of medicine, Thammasat university.

Figure 1 The three methods to measure sacral hiatus

(A) Inter - cornual distance.

(B) Distance between sacral hiatal apex and the midpoint of base.

(B and C) Distance between sacral hiatal apex and the lower border of the 5th sacral vertebra.

Results

The shapes of sacral hiatus were inverted - U, inverted - V, irregular, dumbbell, elongated, bifid, fused and agenesis (Figure 2 to 9; Table 1).

The most common shapes of sacral hiatus were inverted - U shape (male 78 cases; 47.85 %, female 50 cases; 69.44 %). The second most common shape was inverted - V shape (male 33 cases; 20.25 %, female 13 cases; 18.06 %). The inverted - U, inverted - V, elongated and agenesis shapes were found 81.28 percent (male 77.30 % and female 90.28 %).

Table 1 Shape of sacral hiatus (n = 235)

Shape	Male		Female		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
Inverted - U	78	47.85	50	69.44	128	54.47
Inverted - V	33	20.25	13	18.06	46	19.57
Irregular	20	12.27	6	8.33	26	11.06
Dumbbell	5	3.07	0	0	5	2.13
Elongated	14	8.59	2	2.78	16	6.81
Bifid	8	4.91	1	1.39	9	3.83
Fused	4	2.45	0	0	4	1.7
Agenesis	1	0.61	0	0	1	0.43
Total	**163**	**100**	**72**	**100**	**235**	**100**

Figure 2 Inverted - U shaped sacral hiatus

Figure 3 Inverted - V shaped sacral hiatus

Figure 4 Irregular shaped sacral hiatus

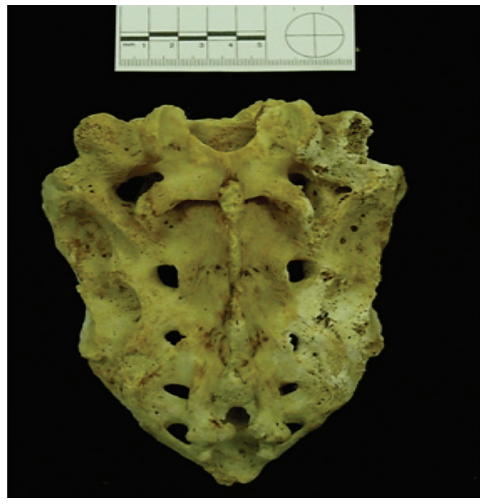

Figure 5 Dumbbell shaped sacral hiatus

Figure 6 Elongated shaped sacral hiatus

Figure 7 Bifid shaped sacral hiatus

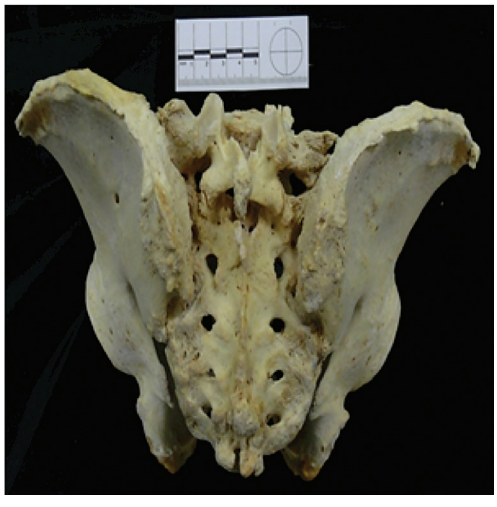

Figure 8 Fused shaped sacral hiatus.

Figure 9 Sacral hiatus without dorsal wall of sacral canal (agenesis of dorsal wall of sacral canal)

Table 2 showed the apex of sacral hiatus was commonly found at the level of the 4th sacral vertebra (62.98 %).

In male, the apex of sacral hiatus was commonly found at the level of lower half of the 4th sacral vertebra (58 cases, 35.58 %).

In female, the apex of sacral hiatus was commonly found at the level of lower half of the 4th sacral vertebra (29 cases, 40.28 %).

Table 2 Level of apex of sacral hiatus (upper and lower half of sacral vertebrae)

Level of apex of sacral hiatus	Male		Female		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
Upper half of S2 body	1	0.61	1	1.39	2	0.85
Lower half of S2 body	1	0.61	0	0	1	0.43
Upper half of S3 body	11	6.75	1	1.39	12	5.11
Lower half of S3 body	25	15.34	4	5.56	29	12.34
Upper half of S4 body	41	25.15	20	27.78	61	25.96
Lower half of S4 body	58	35.58	29	40.28	87	37.02
Upper half of S5 body	16	9.81	14	19.44	30	12.77
Lower half of S5 body	5	3.07	3	4.17	8	3.40
No identified (Fused or agenesis)	5	3.07	0	0	5	2.13
Total	**163**	**100**	**72**	**100**	**235**	**100**

The base of sacral hiatus was commonly found at the level of the 5th sacral vertebra (76.6 %) as shown in table 3.

In male, the base of sacral hiatus was commonly found at the level of upper half of the 5th sacral vertebra (53.99 %).

In female, the base of sacral hiatus was commonly found at the level of upper half of the 5th sacral vertebra (51.39 %).

Table 3 Level of base of sacral hiatus (upper and lower half of sacral and coccyx vertebrae)

Level of base of sacral hiatus	Male		Female		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
Upper half of S4 body	13	7.98	4	5.56	17	7.23
Lower half of S4 body	7	4.29	5	6.94	12	5.11
Upper half of S5 body	88	53.99	37	51.39	125	53.20
Lower half of S5 body	38	23.31	17	23.61	55	23.40
Upper half of Co1 body	13	7.98	9	12.50	22	9.36
Lower half of Co1 body	0	0	0	0	0	0
No identified (Fused)	4	2.45	0	0	4	1.70
Total	**163**	**100**	**72**	**100**	**235**	**100**

In most cases (57.02 %), the distance between sacral hiatal apex and the midpoint of base was 11-20 mm (male 52.15 % and female 68.06 %) as demonstrated in table 4.

The mean distance between sacral hiatal apex and the midpoint of base in male was 19.89 ± 9.05 mm and 15.63 ± 5.29 mm in female. The difference of this mean distance between male and female was statistically significant (p = 0.0002).

Table 4 Distance between sacral hiatal apex and the midpoint of base

Distance between sacral hiatal apex and the midpoint of base	Male		Female		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
0-10 mm	14	8.59	11	15.28	25	10.64
11-20 mm	85	52.15	49	68.06	134	57.02
21-30 mm	48	29.45	12	16.67	60	25.53
31-40 mm	10	6.13	0	0	10	4.26
41-50 mm	5	3.07	0	0	5	2.13
> 50 mm	1	0.61	0	0	1	0.43
Total	**163**	**100**	**72**	**100**	**235**	**100**

In most cases (40.85 %), the distance between sacral hiatal apex and the lower border of the 5th sacral vertebra was 21-30 mm in male (42.94 %) and 11-20 mm in female (45.83 %) (Table 5).

The mean distance between sacral hiatal apex and the lower border of the 5th sacral vertebra in male was 26.44 ± 11.49 mm and 21.75 ± 8.23 mm in female. The difference of this mean distance between male and female was statistically significant (p = 0.002).

Table 5 Distance between sacral hiatal apex and the lower border of the 5th sacral vertebra (S5)

Distance between sacral hiatal apex and the lower border of S5	Male		Female		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
0-10 mm	9	5.52	2	2.78	11	4.68
11-20 mm	34	20.86	33	45.83	67	28.51
21-30 mm	70	42.94	26	36.11	96	40.85
31-40 mm	36	22.09	9	12.5	45	19.15
41-50 mm	8	4.91	2	2.78	10	4.26
> 50 mm	6	3.68	0	0	6	2.55
Total	**163**	**100**	**72**	**100**	**235**	**100**

In most cases (54.04 %), the inter - cornual distance was 16-20 mm (male 52.76 % and female 56.94 %) which was shown in table 6.

The mean inter - cornual distance in male was 16.55 ± 4.52 mm and 16.55 ± 3.21 mm in female. The difference of this mean distance between male and female was not statistically significant (p = 1.00).

Table 6 Inter - cornual distance

Inter - cornual distance	Male		Female		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
0-5 mm	4	2.45	0	0	4	1.7
6-10 mm	14	8.59	3	4.17	17	7.23
11-15 mm	38	23.31	21	29.17	59	25.11
16-20 mm	86	52.76	41	56.94	127	54.04
21-25 mm	17	10.43	7	9.72	24	10.21
26-30 mm	4	2.45	0	0	4	1.7
Total	163	100	72	100	235	100

Discussion and Conclusion

Discussion

The present study found that most common sacral hiatus in male and female had inverted - U shape (54.47 %). The second most common was inverted - V shape (19.57 %). The finding is similar to the result of the studies by Nagar SK[6], Aggarwal et al[3] and Suma et al[7] that most common sacral hiatus had inverted - U shape (41.5 %, 40.35 % and 44 %, respectively). However, the studies by Kumar et al[4] and Kumar et al[5] found that the most common shape was inverted - V and inverted - U shape was the second most common. The five researches were conducted on Indian population. Despite the fact that they were from the same country, the shapes of sacral hiatuses were still different. The present study found that most common sacral hiatus in Thammasat and Chiangmai university were inverted - U and inverted - V shape. This result may be due to the same sources in the north of Thailand. In Africa, the studies by Njihia et al[11] found that the most common shape was inverted – V shape (Table 7). The present study found that 62.98 percent of the positions of the apexes were at the 4th sacral vertebra. This is similar to the studies by Shinohara H[9] (75 %), Sekiguchi et al[8] (65 %), Nagar SK[6] (55.9 %), Kumar et al[4] (76.2 %), Kumar et al[5] (72 %), Njihia et al[11] (62 %) and Suma et al[7] (77.5 %). And the positions of the apexes were found from the level of 2nd to 5th sacral vertebra in accordance with the study by Nagar SK.[6] Additionally, 77.92 percent of the positions of the bases were at the 5th sacral vertebra, which is similar to the studies by Nagar SK[6], Aggarwal et al[3] and Suma et al.[7] Regarding the distance from sacral hiatal apex to the midpoint of base, most measurement was 11-20 mm (57.02 %). The mean value for male was 19.89 ± 9.05 mm and female was 15.63 ± 5.29 mm, similar to the studies by Nagar SK[6] and Kumar et al[4] (Table 8). The distance from sacral hiatal apex to the lower border of the 5th sacral vertebra, in most cases, was in the range of 21-30 mm. The mean value for male was 26.44 ± 11.49 mm and female was 21.75 ± 8.23 mm. The inter - cornual distance, in most cases, was in the range of 16 - 20 mm, which is similar to the study by Roh et al.[10] On the other hand, the studies by Nagar SK[6], Sekiguchi et al[7], Kumar et al[4] and Aggarwal et al[3] found that the values were in the range between 10-15 mm (Table 9). The result of present study of sacral hiatus was different from the results of other researchers. This may be due to racial differences and age ranges. Further studies should be comparison for each age range and gender so that the result will be more accurate.

Table 7 Comparison of the shapes of sacral hiatuses in India, Africa and Thailand

Country	Researcher	Shape of sacral hiatus	Percentage
India	Kumar V, et al. (1992)	Inverted - V (both male and female)	46.53
	Nagar SK. (2004)	Inverted - U (both male and female)	41.5
	Kumar V, et al. (2009)	Inverted - U (male)	39.3
		Inverted - V (female)	50.6
	Aggarwal A, et al. (2009)	Inverted - U (both male and female)	40.35
	Suma HY, et al. (2011)	Inverted - U	44.0
Africa	Njihia BN, et al. (2011)	Inverted - V	32.1
Thailand	The present	Inverted - U (both male and female)	54.47
		Inverted - U (male)	47.85
		Inverted - U (female)	69.44

Table 8 Comparison of the distance between sacral hiatal apex and the midpoint of base in India, Africa and Thailand

Country	Researcher	Length (mm)		
		Male	Female	Both
India	Kumar V, et al. (1992)	20.0 ± 10.2	18.9 ± 7.0	-
	Nagar SK. (2004)	-	-	11 - 20
Africa	Njihia BN, et al. (2011)	-	-	43.1 + 12.9
Thailand	The present	19.89 ± 9.05	15.63 ± 5.29	18.58 ± 8.30

Table 9 Comparison of the inter - cornual distance in other countries and Thailand

Country	Researcher	Length (mm)		
		Male	Female	Both
India	Kumar V, et al. (1992)	13.0 ± 3.8	12.5 ± 3.2	-
	Nagar SK. (2004)	-	-	10 - 15
	Aggarwal A, et al. (2009)	-	-	11.95 ± 2.78
Japan	Sekiguchi M, et al. (2004)	-	-	10.2 ± 0.35
Korea	Roh JH, et al. (2005)	-	-	17.1 ± 0.4
Thailand	The present study	16.55 ± 4.52	16.55 ± 3.21	16.55 ± 4.15

Conclusion

The size of sacral hiatus, the mean distance from apex to the midpoint of base and from apex to the lower border of the 5th sacral vertebra were significantly different between male and female. However, the difference of mean inter - cornual distance in male and female was not statistically significant. In most cases, the apex and base of sacral hiatus were at the 4th and 5th sacral vertebrae, respectively and the most common shape was inverted - U. The inverted - U, inverted - V, elongated and agenesis shapes were found 81.28 percent (male 77.30 % and female 90.28 %, respectively). Thus, this

study suggests a high chance of success for the caudal epidural anesthesia in Thai patients, especially in females. The knowledge of shape, position and size of sacral hiatuses, could be useful in assessing the position of sacral hiatus and planning of caudal epidural anesthesia for Thai patients more accurately.

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บทคัดย่อ

ตำแหน่งและขนาดของ sacral hiatus ในกระดูกใต้กระเบนเหน็บของคนไทย

ณัฏฐกัญญา สุวรรณลิขิต*, ขจร ลักษณ์ชยปกรณ์*, ผาสุก มหรรฆานุเคราะห์**

* สาขากายวิภาคศาสตร์ สถานวิทยาศาสตร์พรีคลินิก คณะแพทยศาสตร์ มหาวิทยาลัยธรรมศาสตร์

** ภาควิชากายวิภาคศาสตร์ คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่

บทนำ: เพื่อศึกษารูปร่าง ตำแหน่งและขนาดของ sacral hiatus ในกระดูกใต้กระเบนเหน็บของคนไทย

วิธีการศึกษา: การวิจัยนี้ศึกษากระดูกใต้กระเบนเหน็บจำนวน ๒๓๕ ชิ้น เพศชาย ๑๖๓ ชิ้น เพศหญิง ๗๒ ชิ้น อายุระหว่าง ๒๐-๙๐ ปี จากคณะแพทยศาสตร์ มหาวิทยาลัยธรรมศาสตร์ และมหาวิทยาลัยเชียงใหม่ โดยศึกษารูปร่าง ตำแหน่ง และขนาดของ sacral hiatus โดยวัดระยะทางระหว่าง sacral cornu ข้างซ้ายและขวา และวัดระยะทางจาก sacral hiatal apex ไปยังจุดกึ่งกลางของ base และขอบล่างของกระดูกใต้กระเบนเหน็บชิ้นที่ ๕ นำข้อมูลที่ได้มาวิเคราะห์และทดสอบความแตกต่างของค่าเฉลี่ยโดย unpaired t-test

ผลการศึกษา: ส่วนใหญ่รูปร่างของ sacral hiatus เป็นรูปตัว U หัวกลับร้อยละ ๕๔.๔๗ ตัว V หัวกลับร้อยละ ๑๙.๕๗ รูปร่างไม่แน่นอนร้อยละ ๑๑.๐๖ และรูปร่างยาวร้อยละ ๖.๘๑ apex และ base ของ sacral hiatus ส่วนใหญ่ตรงกับระดับกระดูกใต้กระเบนเหน็บชิ้นที่ ๔ (ร้อยละ ๖๒.๙๘) และกระดูกใต้กระเบนเหน็บชิ้นที่ ๕ (ร้อยละ ๗๖.๖) ตามลำดับ ค่าความยาวเฉลี่ยจาก apex ถึงจุดกึ่งกลาง base ของ sacral hiatus เพศชายเท่ากับ ๑๙.๘๙ ± ๙.๐๕ มิลลิเมตร และเพศหญิงเท่ากับ ๑๕.๖๓ ± ๕.๒๙ มิลลิเมตร ซึ่งแตกต่างกันอย่างมีนัยสำคัญที่ระดับ ๐.๐๐๐๒ ค่าความยาวเฉลี่ยจาก apex ของ sacral hiatus ถึงขอบล่างของกระดูกใต้กระเบนเหน็บชิ้นที่ ๕ เพศชายเท่ากับ ๒๖.๔๔ ± ๑๑.๔๙ มิลลิเมตร และเพศหญิงเท่ากับ ๒๑.๗๕ ± ๘.๒๓ มิลลิเมตร ซึ่งแตกต่างกันอย่างมีนัยสำคัญที่ระดับ ๐.๐๐๒ ส่วนค่าความยาวเฉลี่ยระหว่าง sacral cornu ไม่มีความแตกต่างกันระหว่างเพศชายและเพศหญิง

วิจารณ์ และสรุปผลการศึกษา: งานวิจัยนี้พบ sacral hiatus รูปตัว U หัวกลับ รูปตัว V หัวกลับ รูปร่างยาว และแบบไม่มีผนังด้านหลังของ sacral canal คิดเป็นร้อยละ ๘๑.๒๘ (เพศชายร้อยละ ๗๗.๓ และเพศหญิงร้อยละ ๙๐.๒๘) ดังนั้นจากการศึกษานี้มีข้อแนะนำว่าการให้ยาระงับความรู้สึกเจ็บปวดเฉพาะที่ในผู้ป่วยคนไทยมีโอกาสประสบความสำเร็จสูงโดยเฉพาะเพศหญิง

คำสำคัญ: ช่องกระดูกก้นกบ, กระดูกใต้กระเบนเหน็บ, การให้ยาระงับความรู้สึกเจ็บปวดเฉพาะที่