The Interlaminar and the Narrowest Distances at the L3/4 and L4/5 Interspinous Spaces and Location of the Intercrestal Line in Thai Cadavers

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Background: *Data on the L3/4 and L4/5 interspinous distances are important in performing a lumbar puncture. This has not been studied in Thais.*

Objective: *To study the interlaminar and the narrowest distances at the L3/4 and L4/5 interspinous spaces and location of the intercrestal line in Thai cadavers.*

Material and Method: *The interlaminar and the narrowest distances at the L3/4 and L4/5 interspinous spaces and location of the intercrestal line were measured in 87 cadavers. Mean age of cadavers was 66.7±10.6 years (range 40-80 years). Measurements were statistically analyzed using unpaired t-tests.*

Results: *The intercrestal line most often intersected at the lower half of the L4 spinous process (32/87, 36.8%), ranging from the lower half of L3 spinous process to the upper half of S1. Mean interlaminar and the narrowest distances at the L3/4 interspinous space were not significantly different from the L4/5 interspinous space: 7.32±2.7 mm vs. 7.05±3.0 mm and 5.27±2.1 mm vs. 5.38±2.4 mm, respectively ($p>0.05$). These interspinous process distances in 71-80 year old cadavers were significantly shorter than 40-60 and 61-70 year age groups ($p<0.05$).*

Conclusion: *The present study confirms that the intercrestal line is most commonly at the lower half of the L4 spinous process. Mean interlaminar and the narrowest distances at the L3/4 and L4/5 interspinous spaces were unrelated to gender or body type. The elderly had more narrow interspinous process distances which may be benefit from having lumbar puncture done in the sitting and feet supported position.*

Keywords: *Lumbar puncture, Lumbar vertebra, Lumbar spine, Intercrestal line, Interspinous space*

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Lumbar puncture is commonly performed for sampling cerebrospinal fluid for diagnostic or therapeutic purposes. Commonly accepted safe sites are the L3/4 or L4/5 interspinous spaces. The vertebral level is ascertained by palpation in the intercrestal line, the line between the two highest points of the iliac crests. This line is also known as the supracristal or intercristal line[1,2].

In adults, lumbar puncture starts with the spinal needle penetrating the supraspinous ligament before traversing the L3/4 or L4/5 interspinous space and ligament, which is attached between adjacent spinous processes. The needle then passes through ligamentum flavum, epidural space, dura mater and arachnoid mater before entering the subarachnoid space containing cerebrospinal fluid[3].

Radiologic studies have found that the intercrestal line crosses the lumbar vertebral column most commonly at the L4 spinous process[4-6] or at the L4/5 interspinous space[7] and the highest level is at the L3 spinous process[4]. There are gender differences in this level tending to be L4 spinous process[4] or L4/5 interspinous space in females and L3 or L4 in males[8]. Cadaver studies have also found that the intercrestal line is most commonly at the L4 spinous process[9] or L4/5 interspinous space with the highest level being at the L3 spinous process[10].

There are no data on the interlaminar and the narrowest distances at the L3/4 and L4/5 interspinous spaces in the Thai population, so we investigated the interlaminar and the narrowest distances at the L3/4 and L4/5 interspinous spaces and location of the

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intercrestal line in Thai cadavers.

Material and Method

Eighty-seven human cadavers (50 males, 37 females) at the faculty of medicine, Thammasat University, Thailand were investigated. Study dates were from April 1, 2011 to April 30, 2012. The sample size was calculated at 95% confidence level and 80% power. Vertebral columns showing any obvious vertebral deformity e.g. vertebral fracture or history of previous vertebral surgery were excluded. Cadavers were identified as ectomorph, mesomorph and endomorph. An ectomorph has a small bone and muscle with little body fat. A mesomorph has a large bone, large muscles and very little body fat. An endomorph has a soft and round body, wide bone and large amounts of body fat. Cadavers were dissected in the prone position. The location of intercrestal line was assessed (Fig. 1). The interlaminar distance and the narrowest distance at L3/4 and L4/5 interspinous spaces were also measured (Fig. 2) using Vernier calipers with an accuracy of at least 0.01 mm.

Means and standard deviations of all values were calculated and results were statistically analysed using unpaired t-tests, taking statistical significance as $p<0.05$.

The present study was approved by the Human Research Ethics Committee of Thammasat university (No. 1) Faculty of Medicine.

Results

Eighty-seven human cadavers (50 males, 37 females) were identified. The mean age was 66.7±10.6 years (range 40-80 years). The intercrestal line crossed the midline of the lumbar vertebral column between the lower half of L3 spinous process and the upper half of S1 spinous process, most often (36.8%) at the lower half of the L4 spinous process (Table 1).

The mean interlaminar distance at the L3/4 interspinous space (7.32±2.7 mm) was not significantly different from the L4/5 interspinous space (7.05±3.0 mm; $p = 0.5335$) and these mean distances revealed no difference when gender (L3/4; $p = 0.4948$, L4/5; $p = 0.5708$) and body types ($p>0.05$) were examined (Table 2). However, the mean interlaminar distances at the L3/4 and L4/5 interspinous spaces in 71-80 year age group (n = 36) were significantly shorter than in the 61-70 and 40-60 year age groups.

The mean narrowest distance at the L3/4 interspinous space (5.27±2.1 mm) was not significantly different from the L4/5 interspinous space (5.38±2.4 mm, $p = 0.7480$) and there was no difference of these mean distances when gender (L3/4; $p = 0.1722$, L4/5; $p = 0.0791$) and body types ($p>0.05$) were examined (Table 3). However, the mean narrowest distances at the L3/4 and L4/5 interspinous spaces in 71-80 year age group (n = 36) were significantly shorter than in the 61-70 and 40-60 year age groups.

The mean narrowest distance at the L3/4 interspinous space (5.27±2.1 mm) was significantly shorter than the mean interlaminar distance at the L3/4 (7.32±2.7 mm; $p<0.0001$). The mean narrowest distance at the L4/5 interspinous space (5.38±2.4 mm) was significantly shorter than the mean interlaminar distance

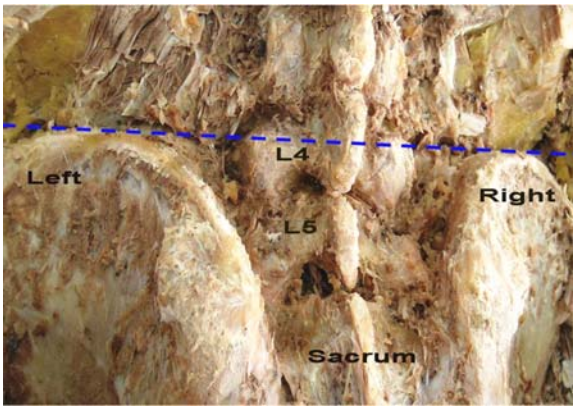

Fig. 1 A cadaver dissection in the prone position showing the intercrestal line crossing the lumbar spine at the L4 spinous process.

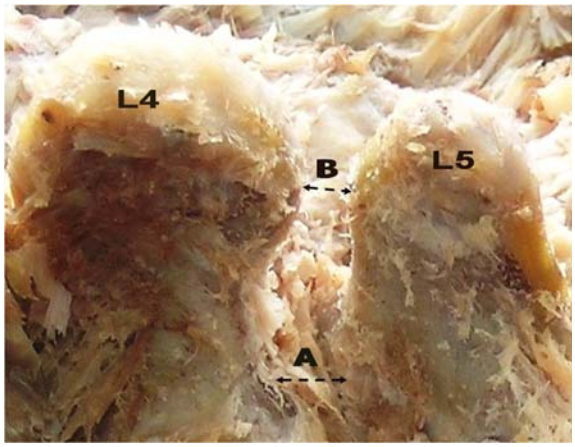

Fig. 2. A cadaver dissection in the prone position showing the interlaminar distance (A) and the narrowest distance between L4 and L5 spinous processes (B).

Table 1. Frequency of location of the intercrestal line in varying gender

Vertebral level	Female, n (%)	Male, n (%)	Total, n (%)
Lower half of L3 spinous process	0 (0.0)	1 (2.0)	1 (1.2)
L3/4 interspinous space	0 (0.0)	2 (4.0)	2 (2.3)
Upper half of L4 spinous process	2 (5.4)	8 (16.0)	10 (11.5)
Lower half of L4 spinous process	11 (29.7)	21 (42.0)	32 (36.8)
L4/5 interspinous space	8 (21.6)	4 (8.0)	12 (13.8)
Upper half of L5 spinous process	10 (27.0)	7 (14.0)	17 (19.5)
Lower half of L5 spinous process	4 (10.8)	7 (14.0)	11 (12.6)
L5/S1 interspinous space	1 (2.7)	0 (0.0)	1 (1.2)
Upper half of S1	1 (2.7)	0 (0.0)	1 (1.2)
Total	37	50	87

Table 2. The mean interlaminar distance at the L3/4 and L4/5 interspinous spaces according to gender, body type and age group

Factor	L3/4 interlaminar distance Mean ± SD (mm)	L4/5 interlaminar distance Mean ± SD (mm)
Gender		
Female (37)	7.55±2.2	7.26±2.7
Male (50)	7.15±3.0	6.89±3.2
Body type		
Endomorph (11)	7.60±2.5	8.18±2.9
Mesomorph (46)	7.45±2.7	6.82±3.2
Ectomorph (30)	7.01±2.6	6.97±2.6
Age group		
40-60 years (23)	9.22±2.1*	7.61±2.5^{++}
61-70 years (28)	7.48±2.5^{+}	7.90±3.5**
71-80 years (36)	6.00±2.4	6.02±2.6
All Groups	7.32±2.7	7.05±3.0

L3/4 level: compared between ectomorph and endomorph (p = 0.5194), ectomorph and mesomorph (p = 0.4833), mesomorph and endomorph (p = 0.8674).
* p<0.0001 (71-80 years vs. 40-60 years); $^{+}$ p = 0.0193 (71-80 years vs. 61-70 years) L4/5 level: compared between ectomorph and endomorph (p = 0.2078), ectomorph and mesomorph (p = 0.8307), mesomorph and endomorph (p = 0.2034); $^{++}$ p = 0.0164 (71-80 years vs. 40-60 years); ** p = 0.0237 (71-80 years vs. 61-70 years)

at the L4/5 (7.05±3.0 mm; p<0.0001).

Discussion

The present study found that intercrestal line most often intersected at the L4 spinous process (48.3%) in agreement with the radiographic studies, Chakraverty et al[4]; Render et al[5]; Wattanaruangkowit et al[6], 56%, 48.5% and 38.9%, respectively. Windisch et al[9] studied embalmed cadavers in left lateral position after flexion of the hip and knee joints and found that the line intersected at the L4 spinous process in 86% of cases. In contrast, Lee et al[7]; Shiraishi and Matsumura[10] studying radiographs of living subjects and cadavers, respectively found that the intercrestal line was most often at the L4/5 interspinous space (38% and 44%, respectively). In the present study, the intercrestal line most often intersected at the lower half of the L4 spinous process in both males and females and this line crosses the highest level at the lower half of the L3 spinous process in males (2%) and the upper half of L4 spinous process in females (5.4%), consistent with the findings of Chakraverty et al[4]. Thus, in performing a lumbar puncture or spinal tap, the intercrestal line can be used as a surface guide-line for L4 spinous process.

Table 3. The mean narrowest distance at the L3/4 and L4/5 interspinous spaces according to gender, body type and age group

Factor	The narrowest distance at L3/4 interspinous space, mean ± SD (mm)	The narrowest distance at L4/5 interspinous space, mean ± SD (mm)
Gender		
Female (37)	5.83±2.1	5.73±2.5
Male (50)	5.22±2.0	4.81±2.3
Body type		
Endomorph (11)	5.59±2.1	6.28±2.4
Mesomorph (46)	5.55±1.9	4.94±2.4
Ectomorph (30)	5.34±2.4	5.72±2.3
Age group		
40-60 years (23)	6.82±1.7*	6.56±2.4^{++}
61-70 years (28)	5.81±1.9^{+}	5.63±2.4**
71-80 years (36)	4.36±1.7	4.43±2.1
All group	5.27±2.1	5.38±2.4

L3/4 level: compared between ectomorph and endomorph (p = 0.7621), ectomorph and mesomorph (p = 0.6727), mesomorph and endomorph (p = 0.9512)

* p = 0.001 (71-80 years vs. 40-60 years), $^{+}$ p = 0.0021 (71-80 years vs. 61-70 years) L4/5 level: compared between ectomorph and endomorph (p = 0.4986), ectomorph and mesomorph (p = 0.1634), mesomorph and endomorph (p = 0.1019)

$^{++}$ p = 0.0007 (71-80 years vs. 40-60 years), ** p = 0.0371 (71-80 years vs. 61-70 years)

The mean interlaminar distance at the L3/4 interspinous space was not significantly different from the L4/5 interspinous space. This finding is in accordance with radiographic studies reported by Jackson et al[11] who studied lateral lumbar radiographs. In addition, the mean narrowest distance at the L3/4 interspinous spaces was not significantly different from the L4/5 interspinous spaces. This finding is in contrast to Sobottke et al[12] who studied CT scans in supine position and Ihm et al[13] who studied lateral lumbo-sacral radiographs, they found that the mean interspinous distance decreased significantly from T12/L1 interspinous space (11.7±3.4 mm) to L4/5 interspinous space (5.5±2.9 mm). Additionally, Xia et al[14] studied MRI scans in the supine position and 45° flexion, they found that the mean narrowest distance at the L3/4 interspinous space (7.5±3.0/8.3±6.1 mm) was significantly greater than that at the L4/5 interspinous space (5.6±3.0/6.4±4.5 mm).

In the present study, the mean interlaminar distance and the mean narrowest distance at the L3/4 and L4/5 interspinous spaces were unrelated to gender or body type which have not been reported by others and in the elderly cadavers (71-80 year age group) were significantly shorter than in the younger cadavers (40-60 and 61-70 year age groups). This finding is compatible with Sobottke et al[12] and Ihm et al[13]. They found that the interspinous distance decreased significantly from T12/L1 to L4/5 interspinous space with advancing age. This could be a result of intervertebral disc degeneration in older subjects.

Our L3/4 and L4/5 interspinous space data, measured in the prone position, were shorter than those recorded by Fisher et al[15] and Sandoval et al[16] who used radiographs in living subjects in three positions: the lateral recumbent position with knees to chest, sitting and bent forward over an adjustable bedside stand, and sitting with feet supported and chest to knees. They found that the interspinous distance was significantly greater in the "sitting, feet supported" position than in the other two positions (p<0.001). The "sitting, feet supported" position may be the optimal position, especially for elderly patients who have narrower interspinous spaces.

Conclusion

The present study confirms that the intercrestal line is most commonly at the lower half of the L4 spinous process. Mean interlaminar and the mean narrowest distances at the L3/4 interspinous space were not significantly different from the L4/5 interspinous space. Mean interlaminar distances and the narrowest distances at the L3/4 and L4/5 interspinous spaces were unrelated to gender or body

type. Elderly cadavers had significantly shorter spaces compared to younger age groups and may benefit from having lumbar puncture done in the sitting and feet supported position.

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Potential conflicts of interest

None.

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ระยะทางระหว่าง lamina และส่วนที่แคบที่สุดระหว่าง spinous process ของกระดูกสันหลังส่วนเอวชิ้นที่ 3 กับ 4 และชิ้นที่ 4 กับ 5 และตำแหน่งของเส้นที่เชื่อมระหว่างจุดสูงสุดของกระดูกปีกสะโพกในศพคนไทย

ขจร ลักษณ์ชยปกรณ์, ณัฏฐกัญญา สุวรรณลิขิต

ภูมิหลัง: ข้อมูลระยะทางระหว่าง spinous process ของกระดูกสันหลังส่วนเอวชิ้นที่ 3 กับ 4 และชิ้นที่ 4 กับ 5 มีความสำคัญในการเจาะน้ำไขสันหลัง ซึ่งยังไม่มีการศึกษาในคนไทย

วัตถุประสงค์: เพื่อศึกษาระยะทางระหว่าง spinous process บริเวณที่ชิดกับ lamina และส่วนที่แคบที่สุดระหว่างกระดูกสันหลังส่วนเอวชิ้นที่ 3 กับ 4 และ ชิ้นที่ 4 กับ 5 และหาตำแหน่งของเส้นที่เชื่อมระหว่างจุดสูงสุดของกระดูกปีกสะโพกในศพคนไทย

วัสดุและวิธีการ: การศึกษานี้ทำในศพตองจำนวน 87 ตัวอย่าง อายุเฉลี่ย 66.7±10.6 ปี (ช่วงอายุระหว่าง 40-80 ปี) ทำการวัดตำแหน่งของแนวที่เชื่อมระหว่างจุดสูงสุดของกระดูกปีกสะโพกและวัดระยะทางระหว่าง spinous process บริเวณที่ชิดกับ lamina และส่วนที่แคบที่สุดระหว่างกระดูกสันหลังส่วนเอวชิ้นที่ 3 กับ 4 และชิ้นที่ 4 กับ 5 นำข้อมูลไปวิเคราะห์และทดสอบความแตกต่างของค่าเฉลี่ยโดย unpaired t-test

ผลการศึกษา: แนวที่เชื่อมระหว่างจุดสูงสุดของกระดูกปีกสะโพกส่วนใหญ่ตรงกับครึ่งล่างของ spinous process ของกระดูกสันหลังส่วนเอวชิ้นที่ 4 (32/87, 36.8%) โดยอยู่ระหว่างครึ่งล่างของ spinous process ของกระดูกสันหลังส่วนเอวชิ้นที่ 3 กับครึ่งบนของกระดูกสันหลังส่วนกระเบนเหน็บชิ้นที่ 1 ค่าเฉลี่ยระยะทางระหว่าง spinous process บริเวณที่ชิดกับ lamina และส่วนที่แคบที่สุดระหว่างกระดูกสันหลังส่วนเอวชิ้นที่ 3 กับ 4 ไม่แตกต่างกับระหว่างชิ้นที่ 4 กับ 5: 7.32±2.7 มิลลิเมตร vs. 7.05±3.0 มิลลิเมตร และ 5.27±2.1 มิลลิเมตร vs. 5.38±2.4 มิลลิเมตร ตามลำดับ ($p>0.05$) ค่าเฉลี่ยระยะทางระหว่าง spinous process ในกลุ่มอายุ 71-80 ปี สั้นกว่าในกลุ่มอายุ 40-60 ปี และ 61-70 ปี อย่างมีนัยสำคัญ ($p<0.05$)

สรุป: การศึกษานี้ยืนยันว่าเส้นที่เชื่อมระหว่างจุดสูงสุดของกระดูกปีกสะโพกส่วนใหญ่ตรงกับครึ่งล่างของ spinous process ของกระดูกสันหลังส่วนเอวชิ้นที่ 4 ค่าเฉลี่ยระยะทางระหว่าง spinous process บริเวณที่ชิดกับ lamina และส่วนที่แคบที่สุดระหว่างกระดูกสันหลังส่วนเอวชิ้นที่ 3 กับ 4 และชิ้นที่ 4 กับ 5 ไม่แตกต่างกันในด้านเพศและรูปร่าง ค่าเฉลี่ยระยะทางระหว่าง spinous process ในผู้สูงอายุแคบ หากจัดให้อยู่ในท่านั่งและมีที่รองเท้าจะช่วยให้การเจาะน้ำไขสันหลังมีโอกาสประสบความสำเร็จเพิ่มขึ้น