Anatomical Variations of the Position of the Aortic Bifurcation, Iliocava Junction and Iliac Veins in Relation to the Lumbar Vertebra

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Objective: *To determine the position of the aortic bifurcation and the iliocava junction in relation to the lumbar vertebra, aortic bifurcation angle, interiliac angle, and anatomical variation of the iliac veins anterior to the lumbar vertebra of Thai people.*

Material and Method: *The present study was done on 65 cadavers. The mean ages of the cadavers were 73 ± 10 years (range from 50 to 90 years). The dissections were performed by anterior approach to the lumbar vertebra. The position of the aortic bifurcation and the iliocava junction, aortic bifurcation angle and interiliac angle were measured in relation to the lumbar vertebra. Anatomical variations of the iliac veins were observed anterior to the lumbar vertebra.*

Results: *The aortic bifurcation was between L_3 and L_5, most often at the L_4 vertebral body level (63%), at the middle third in vertical plane of vertebra (31%) and at the median third in horizontal plane of vertebra (57%). The iliocava junction was between L_4 and L_5-S_1 disc, most often at the L_5 vertebral body level (69%), at the upper third of vertebra (28%) and at the right lateral third in horizontal plane of vertebra (60%). The mean aortic bifurcation angle was 54° (male 55°, female 53°). No significant difference in the mean aortic bifurcation angle was observed between male and female at $p > 0.05$ and the mean interiliac angle was 71° (male 73°, female 68°). A significant difference in the mean interiliac angle was observed between male and female at $p < 0.05$. In the abdomen, variation of common iliac vein was found on the left side connecting IVC with left external iliac vein.*

Conclusion: *The anatomical variations of the position of the aortic bifurcation, iliocava junction, and common iliac veins at the anterior of lumbar vertebra can be found in a normal population and cause trouble to vertebral surgery during the operation. Therefore, precaution and full investigation of the anatomical position of the vessels might be required before surgery is performed.*

Keywords: *Aortic bifurcation, Iliocava junction, Lumbar vertebra, Iliac vein, Anatomical variation*

J Med Assoc Thai 2008; 91 (10): 1564-70
Full text. e-Journal: *http://www.medassocthai.org/journal*

Vessel injuries, especially venous bleeding, are the main complications of the anterior transperitoneal approach and anterolateral retroperitoneum approach of lower lumbar vertebra[1-4].

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There have been many reports of vascular and visceral injury during lumbar vertebral surgery since 1945 by Linton and White who reported the first known case of A-V fistula after lumbar dissectomy[5] and then many reports for vascular and visceral injury related to the anterior approach of total disc replacement for lumbar vertebra[6,7].

The anatomical variations of abdominal veins anterior to the lumbar vertebra increase the risk of

vascular injury during surgery and they must be detected at the moment of the approach to these regions. The most common causes of these variations are congenital anomalies of abdominal veins, caval duplication and a left positioned vena cava[8,9] and have been extensively studied by various methods, including cadaveric dissection, computed tomography and magnetic resonance image[10-15].

The exact incidence of the vascular variation of Thai people has not been studied yet. However, nowadays, Thai vertebral surgeons perform their practices frequently. It might cause some problems in approaching the lumbar vertebra anteriorly. Therefore, the incidence of the vascular variation is worth studying and recorded before surgery is performed to decrease the complication.

The objective of the present study was to determine the position of the aortic bifurcation and the iliocava junction in relation to the lumbar vertebra, aortic bifurcation angle, interiliac angle, and anatomical variation of the iliac veins anterior to the lumbar vertebra.

Material and Method

The present study was done on 65 cadavers (28 females and 37 males), ranging from 50 to 90 years (mean 73 $\pm$ 10 years), in the Division of Anatomy, Department of Preclinical Science, Faculty of Medicine, Thammasat University (between January 2006 and December 2007). The position of bifurcation, angle and vascular anomaly were measured and determined by a single investigator (Fig. 1, 2).

The measurement parameter was performed by dividing the vertebral body into three parts according to vertical plane (upper third, middle third, and lower third of body, Fig. 3A) and three parts in the horizontal plane (right lateral third, median third, and left lateral third of body, Fig. 3B). The angle between its bifurcations was measured by goneometer in degree of angulation.

The measured data were subjected to statistical analyses by calculation of mean, standard deviation, range, and using unpaired t-test. The results were considered significant at a value $p < 0.05$.

Results

The aortic bifurcation was between L_3 and L_5 (Table 1, Fig. 4, 5), most often at the L4 vertetral body level (41 cases, 63%). The iliocava junction was between L_4 and L_5-S_1 disc (Table 1), most often at the L_5 vertebral body level (45 cases, 69%).

The relationship of the aortic bifurcation and the iliocava junction to the upper, middle or lower thirds of vertebral body, or to the intervertebral disc are shown in Table 2 and Fig. 6. The aortic bifurcation was found most often at the middle third of L_4 vertebral body (20 cases, 31%). The iliocava junction was found

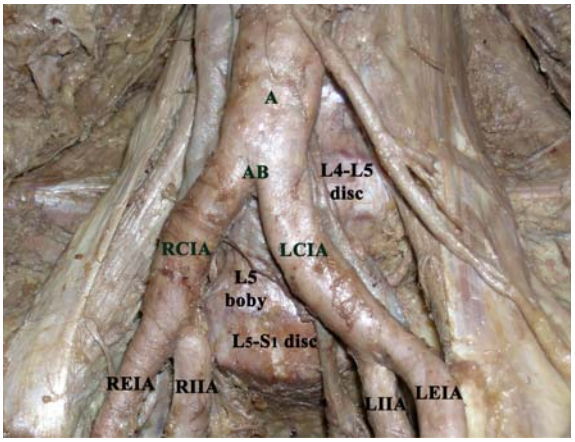

Fig. 1 Picture of the gross specimen, anterior approach to the lumbar vertebra shows position of aortic bifurcation angle in relation to the lumbar vertebra. A, aorta; AB, aortic bifurcation; RCIA, right common iliac artery; LCIA, left common iliac artery; REIA, right external iliac artery; RIIA, right internal iliac artery; LEIA, left external iliac artery; LIIA, left internal iliac artery

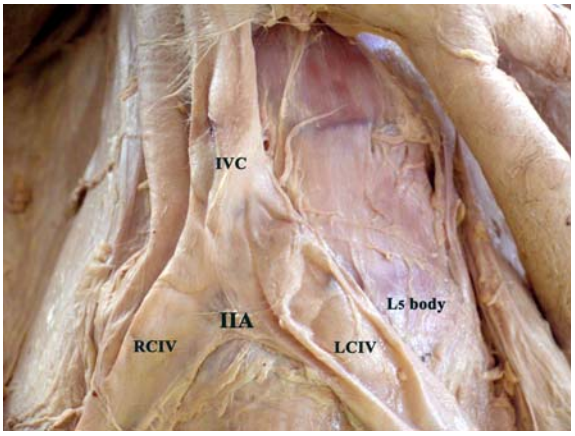

Fig. 2 Picture of the gross specimen, anterior approach to the lumbar vertebra shows position of interiliac angle in relation to the lumbar vertebra. IVC, inferior vena cava; RCIV, right common iliac vein; LCIV, left common iliac vein; IIA, interiliac angle

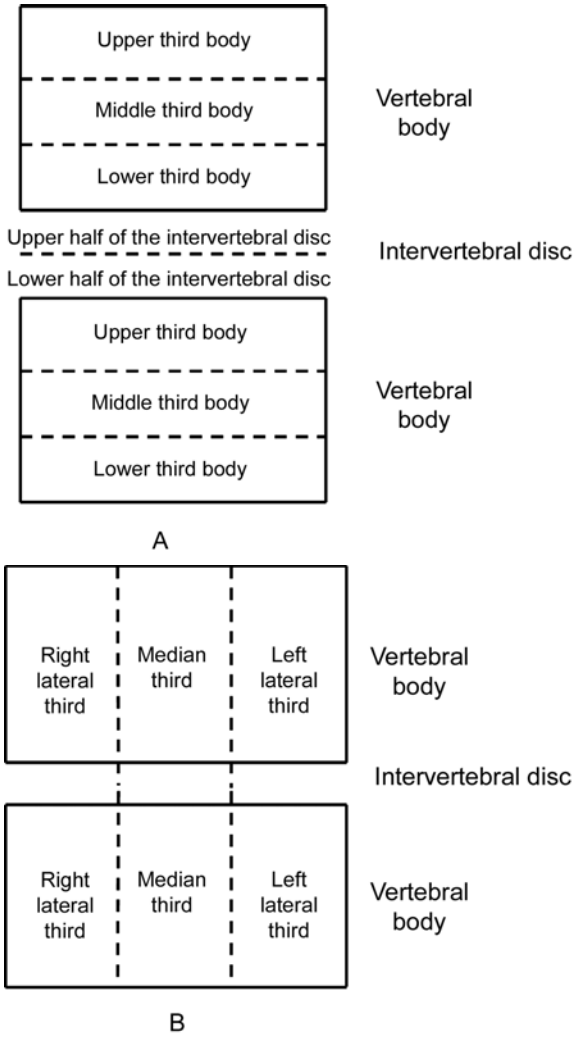

Fig. 3 The diagrams show two adjacent vertebral bodies and the intervertebral disc. A: Each vertebral body is divided into 3 parts in the vertical plane; upper, middle and lower third. B: Each vertebral body is divided into 3 parts in the horizontal plane; right lateral, median and left lateral third

Table 1. Position of the aortic bifurcation and iliocava junction in relation to the vertebral body levels

Vertebral body level	Aortic bifurcation (n = 65)	Iliocava junction (n = 65)
L_3	2 (3%)	0 (0%)
L_{3-4} disc	3 (5%)	0 (0%)
L_4	41 (63%)	6 (9%)
L_{4-5} disc	6 (9%)	9 (14%)
L_5	13 (20%)	45 (69%)
L_5-S_1 disc	0 (0%)	5 (8%)

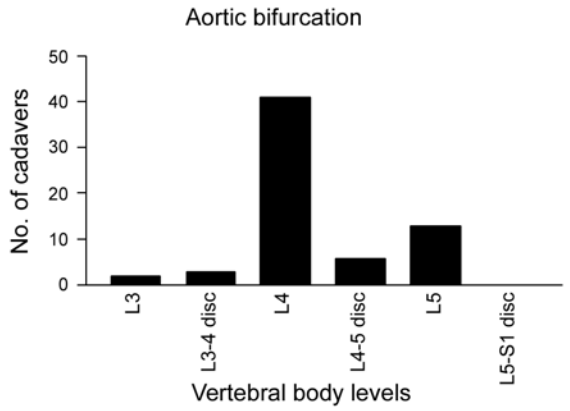

Fig. 4 Position of the aortic bifurcation in relation to the vertebral body levels

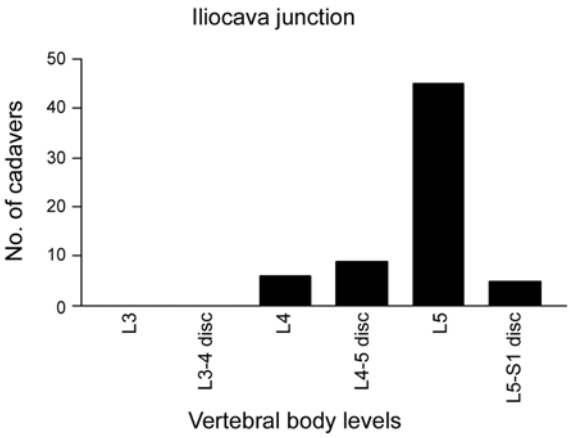

Fig. 5 Position of the iliocava junction in relation to the vertebral body levels

most often at the upper third of L_5 vertebral body (18 cases, 28%).

The relationship of the aortic bifurcation and the iliocava junction to the right lateral, median or left lateral thirds of vertebral body, or to a disc space are shown in Table 3 and Fig. 7. The aortic bifurcation was found most often at the median third of L_4 vertebral body (37 cases, 57%). The iliocava junction was found most often at the right lateral third of L_5 vertebral body (39 cases, 60%). The mean aortic bifurcation angle was 54° (54 $\pm$ 16°, 15-75°), male 55 $\pm$ 15°, female 53 $\pm$ 18°. By using the independence sample t-test, no significant difference in the mean aortic bifurcation angle was observed between male and female at $p > 0.05$ and the mean interiliac angle was 71° (71 $\pm$ 15°, 45-120°), male 73 $\pm$ 20°, female 68 $\pm$ 6°. A significant difference in the

Table 2. Relationship of the aortic bifurcation and iliocava junction to the upper, middle or lower third of a particular vertebral body or to the intervertebral disc (position in vertical plane)

Vertebral body level	Aortic bifurcation (n = 65)	Iliocava junction (n = 65)
Upper third body of L_3	0 (0%)	0 (0%)
Middle third body of L_3	0 (0%)	0 (0%)
Lower third body of L_3	2 (3%)	0 (0%)
Upper half of L_{3-4} disc	0 (0%)	0 (0%)
Lower half of L_{3-4} disc	3 (5%)	0 (0%)
Upper third body of L_4	11 (17%)	2 (3%)
Middle third body of L_4	20 (31%)	2 (3%)
Lower third body of L_4	10 (15%)	2 (3%)
Upper half of L_{4-5} disc	2 (3%)	6 (9%)
Lower half of L_{4-5} disc	4 (6%)	3 (5%)
Upper third body of L_5	8 (12%)	18 (28%)
Middle third body of L_5	2 (3%)	15 (23%)
Lower third body of L_5	3 (5%)	12 (18%)
Upper half of L_5-S_1 disc	0 (0%)	5 (8%)
Lower half of L_5-S_1 disc	0 (0%)	0 (0%)

Table 3 Relationship of the aortic bifurcation and iliocava junction to the right lateral, middle third or left lateral third of a particular vertebral body or to the intervertebral disc (position in horizontal plane)

Vertebral body level	Aortic bifurcation (n = 65)	Iliocava junction (n = 65)
Right lateral third of L_3	2 (3%)	0 (0%)
Median third of L_3	0 (0%)	0 (0%)
Left lateral third of L_3	0 (0%)	0 (0%)
Right lateral third of L_{3-4} disc	3 (5%)	0 (0%)
Median third of L_{3-4} disc	0 (0%)	0 (0%)
Left lateral third of L_{3-4} disc	0 (0%)	0 (0%)
Right lateral third of L_4	2 (3%)	6 (9%)
Median third of L_4	37 (57%)	0 (0%)
Left lateral third of L_4	2 (3%)	0 (0%)
Right lateral third of L_{4-5} disc	0 (0%)	9 (14%)
Median third of L_{4-5} disc	6 (9%)	0 (0%)
Left lateral third of L_{4-5} disc	0 (0%)	0 (0%)
Right lateral third of L_5	0 (0%)	39 (60%)
Median third of L_5	11 (17%)	4 (6%)
Left lateral third of L_5	2 (3%)	2 (3%)
Right lateral third of L_5-S_1disc	0 (0%)	5 (8%)
Median third of L_5-S_1 disc	0 (0%)	0 (0%)
Left lateral third of L_5-S_1 disc	0 (0%)	0 (0%)

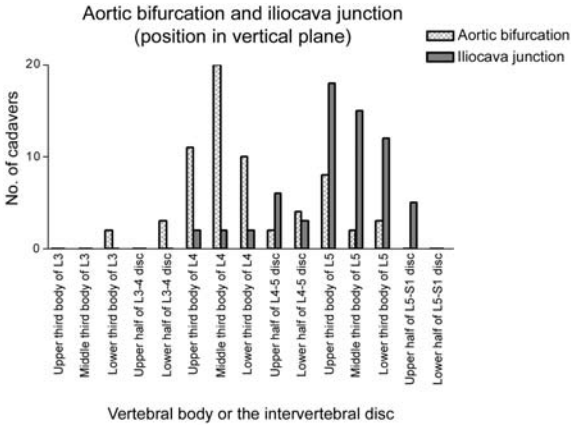

Fig. 6 Position of the aortic bifurcation and iliocava junction to the vertebral body or the intervertebral disc (position in vertical plane)

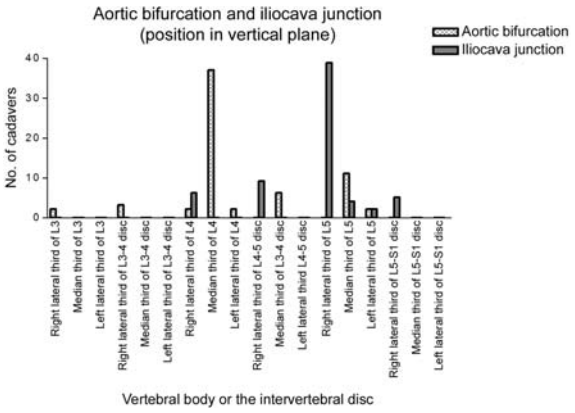

Fig. 7 Position of the aortic bifurcation and iliocava junction to the vertebral body or the intervertebral disc (position in horizontal plane)

mean interiliac angle was observed between male and female at $p < 0.05$.

In the abdomen, variation of common iliac vein was found on the left side connecting IVC with left external iliac vein. This variation connecting IVC at the L_4 vertebral body level and connecting left external iliac vein at the L_5 vertebral body level (Fig. 8).

Discussion

The transperitoneal anterior approach to the lumbar vertebra is a common procedure in vertebral surgery. The aortic bifurcation and the iliocava junction are the main vessels that lie anterior to the lower

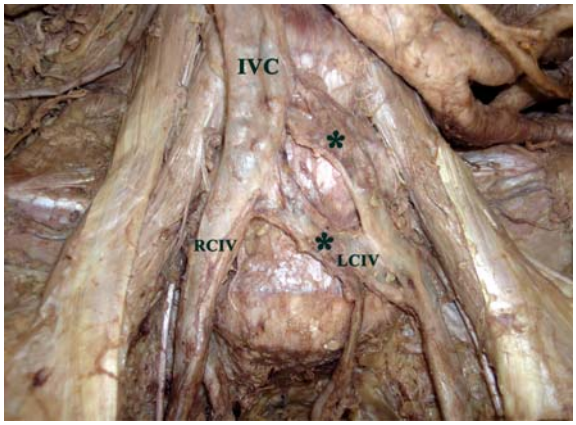

Fig. 8 Anterior view of the lumbar spine shows variation of left common iliac vein (*). IVC, inferior vena cava; RCIV, right common iliac vein; LCIV, left common iliac vein

lumbar vertebra. At this level both the aortic bifurcation and iliocava junction restricts to extensive exposure[16]. According to Gray's anatomy[16], the position of aortic bifurcation was at the front of the L_4 vertebral body level, just to the left of midline at the lower level. Radiological studies[17,18], the position of the aortic bifurcation was found 67-83% at the L_4 and 24% at the middle third and cadaveric study[15] found 50% at the L_4. We found 63% at the L_4 and 31% at the middle third (vertical plane). The position of aortic bifurcation in horizontal plane has not been reported. In the present study, the position of aortic bifurcation was found 57% located at median third. Age or sex imparted no variation to the location of the aortic bifurcation[17]. According to Gray's anatomy and Clinical anatomy by regions[16,19], the position of iliocava junction was at the front of the L_5 vertebral level, just to the right of midline. In a cadaveric study[15], the position of the iliocava junction was found 64% located at the L_5 and at the median third[14]. In the horizontal plane, the position of the iliocava junction has not been reported. In the present study, the position of iliocava junction was found 69% located at the L_5 and 28% at the upper third (vertical plane) and 60% at the right lateral third (horizontal plane).

The authors found that the mean aortic bifurcation angle was 54° (15-75°). This angle has not been reported by others. The mean interiliac angle was 71° (45-120°) which is similar to other studies[10,15,20], but the authors found that there was a significant difference of the mean interiliac angle between male and female at $p < 0.05$ (male 73 ± 20°, female 68 ± 6°).

For the variation of left common iliac vein, the authors found only one case. This variation is the first case report.

Inferior vena cava or left iliac vein injury can occur during surgical dissection as well as implantation. The injuries can cause severe morbidity and even mortality. Therefore, the surgeon must be cognizant of the location and safety of the vessels throughout the entire procedure[21]. Bridwell et al[22] reported 1315 cases of anterior approach to lumbar vertebra that developed left iliac artery thrombosis and 19 cases (1.4%) of left common iliac vein injuries. The report was studied in a normal population without concerning the position variation or abnormality, but the present study emphasized on it, which may increase the surgical risk in anterior lumbar vertebral surgery.

Further studies are necessary to evaluate the anatomical variations of vessels and nerves relation to antero-lateral side of the lower lumbar vertebra.

Conclusion

The high incidence of positional anatomical variations of the aortic bifurcation, iliocava junction, and common iliac veins anterior to the lumbar vertebra can disturb the surgical exploration of lumbar vertebra of these areas and cause complications to the vessels or surgical extension at these areas. Therefore, a vertebral surgeon ought to be aware of preoperative planning if possible. He must identify the abnormality before the operation in order to prevent the difficulty of surgery and the complications that may occurs.

Acknowledgement

This research was supported by the faculty of medicine, Thammasat university research fund.

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ความผันแปรทางกายวิภาคของตำแหน่งของจุดแยกหลอดเลือดแดงเอออร์ตา จุดเชื่อมของหลอดเลือดดำไอลิแอค และหลอดเลือดดำไอลิแอคที่สัมพันธ์กับกระดูกสันหลังส่วนเอว

ขจร ลักษณ์ชยปกรณ์, ยงยุทธ ศิริปการ

***วัตถุประสงค์**: เพื่อหาตำแหน่งจุดแยกหลอดเลือดแดงเอออร์ตาและจุดเชื่อมของหลอดเลือดดำไอลิแอคที่สัมพันธ์กับระดับกระดูกสันหลังส่วนเอว หาค่าเฉลี่ยมุมจุดแยกหลอดเลือดแดงเอออร์ตาและจุดเชื่อมหลอดเลือดดำไอลิแอค และหาความผันแปรทางกายวิภาคของหลอดเลือดดำไอลิแอคบริเวณด้านหน้าของกระดูกสันหลังส่วนเอวในคนไทย*

***วัสดุและวิธีการ**: การศึกษานี้ทำในศพดองทั้งหมด 65 ตัวอย่าง อายุเฉลี่ย 73 ปี (ช่วงอายุระหว่าง 50-90 ปี) ชำแหละศพดอง โดยการเปิดผนังหน้าท้องและเข้าทางด้านหน้าต่อกระดูกสันหลังส่วนเอว จากนั้นทำการตรวจวัดตำแหน่งจุดแยกหลอดเลือดแดงเอออร์ตา และ จุดเชื่อมของหลอดเลือดดำไอลิแอคที่สัมพันธ์กับระดับต่าง ๆ ของกระดูกสันหลังส่วนเอว หาค่าเฉลี่ยมุมจุดแยกหลอดเลือดแดงเอออร์ตาและจุดเชื่อมหลอดเลือดดำไอลิแอค และหาความผันแปรทางกายวิภาคของหลอดเลือดดำไอลิแอคบริเวณด้านหน้าของกระดูกสันหลังส่วนเอว*

***ผลการศึกษา**: พบว่าจุดแยกหลอดเลือดแดงเอออร์ตาอยู่ระหว่างกระดูกสันหลังส่วนเอวชิ้นที่ 3 และ 5 พบมากที่สุดบริเวณกระดูกสันหลังส่วนเอวชิ้นที่ 4 (63%) โดยอยู่บริเวณตรงกลาง 1 ใน 3 ตามแนวตั้งจากบนลงล่างของกระดูกสันหลัง (31%) และอยู่บริเวณตรงกลาง 1 ใน 3 ตามแนวนอนจากขวาไปซ้ายของกระดูกสันหลัง (57%) จุดเชื่อมของหลอดเลือดดำไอลิแอคอยู่ระหว่างกระดูกสันหลังส่วนเอวชิ้นที่ 4 และหมอนรองกระดูกระหว่างกระดูกสันหลังส่วนเอวชิ้นที่ 5 กับกระดูกใต้กระเบนเหน็บชิ้นที่ 1 พบมากที่สุดบริเวณกระดูกสันหลังส่วนเอวชิ้นที่ 5 (69%) โดยอยู่บริเวณตอนบน 1 ใน 3 ของกระดูกสันหลัง (28%) และอยู่บริเวณด้านขวาของกระดูกสันหลัง (60%) ค่าเฉลี่ยมุมจุดแยกหลอดเลือดแดงเอออร์ตาเท่ากับ 54 องศา (เพศชาย 55 องศา และเพศหญิง 53 องศา) ซึ่งไม่มีความแตกต่างกันระหว่างเพศชายและเพศหญิงที่ระดับความเชื่อมั่น 95% ค่าเฉลี่ยมุมจุดเชื่อมหลอดเลือดดำไอลิแอคเท่ากับ 71 องศา (เพศชาย 73 องศา และเพศหญิง 68 องศา) ซึ่งมีความแตกต่างกันอย่างมีนัยสำคัญ ระหว่างเพศชายและเพศหญิงที่ระดับความเชื่อมั่น 95% และพบหลอดเลือดดำคอมมอนไอลิแอคด้านซ้ายมี 2 แห่ง หลอดเลือดดำคอมมอนไอลิแอคที่เพิ่มขึ้นมาจากปกตินี้จะเชื่อมระหว่างหลอดเลือดดำอินฟีเรียเวนาคาวากับหลอดเลือดดำเอกซ์เทอร์นัลไอลิแอค*

***สรุป**: ความผันแปรทางกายวิภาคของตำแหน่งของจุดแยกหลอดเลือดแดงเอออร์ตา จุดเชื่อมของหลอดเลือดดำไอลิแอคและหลอดเลือดดำคอมมอนไอลิแอคบริเวณด้านหน้าของกระดูกสันหลังส่วนเอว พบได้ในคนปกติทั่วไป และก่อให้เกิดความยุ่งยากในระหว่างการผ่าตัดกระดูกสันหลังได้ ดังนั้นก่อนทำการผ่าตัด ควรทำการสืบค้นเพิ่มเติม เพื่อหาตำแหน่งของหลอดเลือดบริเวณด้านหน้ากระดูกสันหลังส่วนเอว ซึ่งจะช่วยป้องกันการบาดเจ็บต่อหลอดเลือดเหล่านั้นได้*