An Anatomical Study of the Transversus Abdominis Plane Block: Location of the Lumbar Triangle of Petit and Adjacent Nerves

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BACKGROUND: The transversus abdominis plane (TAP) block is a new technique for providing analgesia to the anterior abdominal wall. Most previous studies have used the lumbar triangle of Petit as a landmark for the block. In this cadaveric study, we determined the exact position and size of the lumbar triangle of Petit and identified the nerves affected by the TAP block.

METHODS: The position of the lumbar triangle of Petit was assessed unilaterally in 26 cadaveric specimens relative to reliably palpable surface landmarks. In addition, a series of dissections were performed to explore the course of the nerves blocked by the TAP.

RESULTS: The mean distance from the midaxillary line along the iliac crest to the center of the base of the lumbar triangle of Petit at the level of the subcutaneous tissue and over the skin surface was 6.9 cm (range, 4.5–9.2 cm) and 9.3 cm (range, 4–15.1 cm), respectively. The center of the lumbar triangle of Petit was 1.4 cm above the iliac crest. The depth of the TAP at the lumbar triangle of Petit position was 0.5–4 cm and at the midaxillary line it was 0.5–2 cm. The average size of the lumbar triangle of Petit was 2.3 cm × 3.3 cm × 2.2 cm, with an average area of 3.63 ± 1.93 cm^2. The three cadaveric specimens we explored showed the nerves blocked by TAP passed lateral to the triangle. An incidental finding was that in 66% of specimens the lumbar triangle of Petit contained small branches of the subcostal artery.

CONCLUSIONS: The lumbar triangles of Petit found in the specimens in this study were more posterior than the literature suggests. The position of the lumbar triangle of Petit varies largely and the size is relatively small. The relevant nerves to be blocked had not entered the TAP in the specimens in this study at the point of the lumbar triangle of Petit. At the midaxillary line, however, all the nerves were in the TAP.

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The transversus abdominis plane (TAP) is an anatomical space between the internal oblique and the transversus abdominis muscle and spans the abdomen wherever these two muscles exist. The TAP block is a new, rapidly expanding regional anesthesia technique that involves a single large bolus injection of local anesthetic into this anatomical compartment to saturate somatic afferents before they leave the TAP to supply the anterior abdominal wall from T8 to L1 dermatomes.[1] Initially, the TAP block was described as easy to perform and without major complications.[1] However, with increasing use, different techniques emerged, serious complications occurred, and high failure rates were reported.[2–5]

The lumbar triangle of Petit is an anatomical area that in theory provides a reliable reference point for inserting the needle into the TAP compartment.[6–8] The triangle is formed posteriorly by the lateral border of the latissimus dorsi muscle and anteriorly by the posterior free border of the external oblique muscle, with the iliac crest as the base. The floor of the triangle from superficial to deep is formed by subcutaneous tissue, internal oblique muscle, and transversus abdominis muscle, respectively.[9] However, the precise location of the lumbar triangle of Petit remains controversial.

This study defined the exact position and size of the triangle relative to palpable surface landmarks. In addition, a series of dissections were explored to show the course of the nerves that would be affected by the TAP block.

METHODS

Twenty-six cadaveric specimens (14 women and 12 men), age 72–102 years and mean height 161.8 ± 9.9

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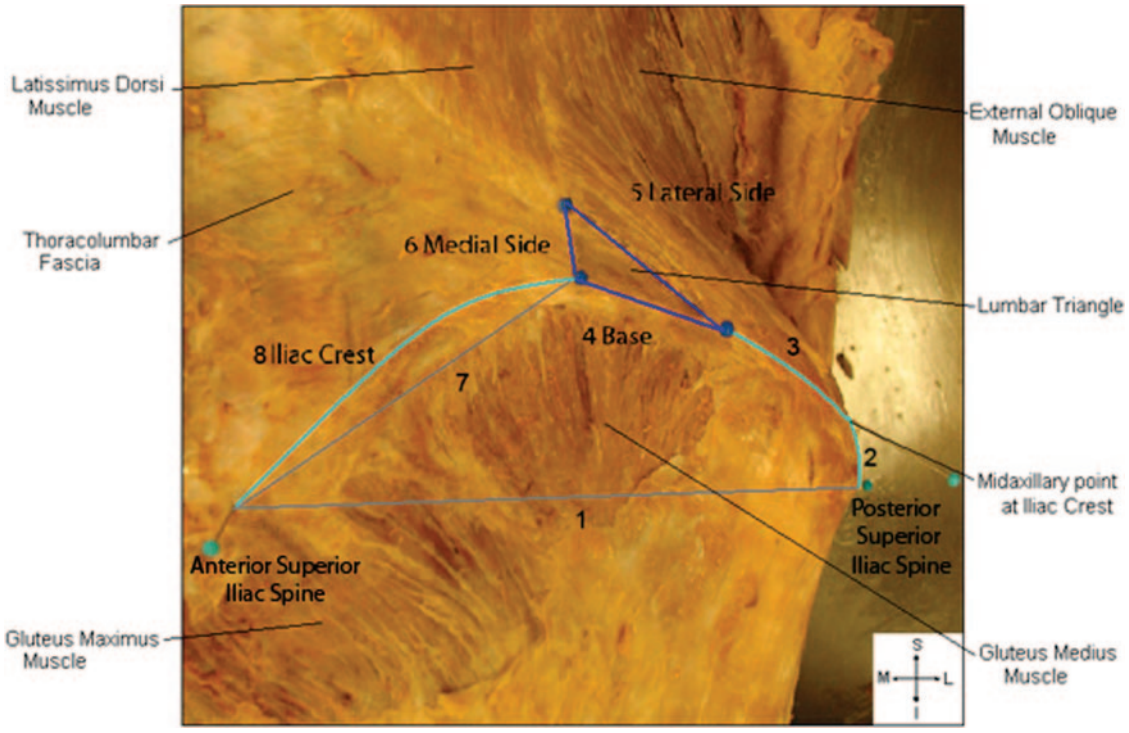

Figure 1. Specimen 1: Identification of the lumbar triangle of Petit (relative to bony landmarks). (S = superior; I = inferior; L = lateral; M = media). 1: midaxillary point at the iliac crest to the lateral base of the lumbar triangle of Petit; 2: base of the lumbar triangle of Petit; 3: lateral side of the lumbar triangle of Petit (the posterior attachment of the external oblique to the iliac crest); 4: medial side of the lumbar triangle of Petit (the anterior attachment of the latissimus dorsi muscle to the iliac crest); 5: medial base of the lumbar triangle of Petit; 6: anterior superior iliac spine to posterior superior iliac spine along the iliac crest.

cm, were dissected. The cadavers were preserved using 75 L of embalming fluid (consisting of 756 mL industrial methyl, 125 mL phenol, 40 mL formaldehyde, 22 mL glycerol, and 57 mL water per liter of fluid) introduced into the common carotid artery by gravity feed and were then refrigerated for at least 4 wk. All cadavers were in the prone position for the quantitative study and in the supine position for the qualitative study.

Quantitative Study

To measure the precise position of the lumbar triangle of Petit, pins were inserted at the anterior superior iliac spine, the posterior superior iliac spine, the midaxillary point at the iliac crest, and at the angles of the lumbar triangle of Petit as shown in Figure 1. A flexible tape measure was used to measure the distances between the points to the nearest millimeter. The measurements taken from the lumbar triangle of Petit position are as follows.

1. Distance from the midaxillary point at iliac crest to the lateral base of the lumbar triangle of Petit.
2. Base of the lumbar triangle of Petit.
3. Lateral side of the lumbar triangle of Petit (the posterior attachment of external oblique muscle to the iliac crest).
4. Medial side of the lumbar triangle of Petit (the anterior attachment of latissimus dorsi to the iliac crest).
5. Medial base of the lumbar triangle of Petit to posterior superior iliac spine.
6. Anterior superior iliac spine to posterior superior iliac spine along the iliac crest.

In 24 of the specimens, the superficial position of the triangle was also measured from the outside of the skin and subcutaneous tissue and from the midaxillary line to the middle of the lumbar triangle of Petit base along the iliac crest.

We calculated the distance between the midaxillary line and the middle of the lumbar triangle of Petit base along the iliac crest by adding half the length of the lumbar triangle of Petit base to the distance between the midaxillary line at the level of the iliac crest and the lateral base of the lumbar triangle of Petit. We calculated the height of the lumbar triangle of Petit triangle corresponding to its base for all cadavers (Fig. 2).

Qualitative Study

Specimens 1, 2, and 3, women aged 97, 92, and 83 years, respectively, were dissected to examine the position of the lumbar triangle of Petit in relation to the iliohypogastric and ilioinguinal nerves.

Statistical Tests

A paired *t*-test was used to determine whether there was any significant difference in the position of

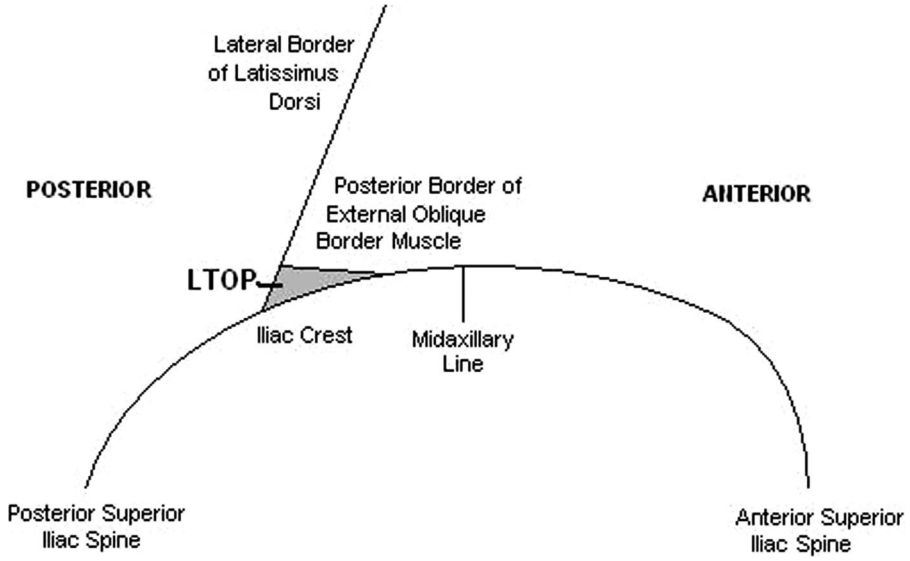

Figure 2. Diagram of lumbar triangle of Petit depicting landmarks.

Table 1. Lumbar Triangle of Petit: Measurements in 26 Cadavers

	Range (cm)	Mean (cm)	Standard deviation (cm)
Midaxillary to lateral base of lumbar triangle of Petit (n = 26)	2.5–9.0	5.8	1.56
Base of lumbar triangle of Petit (n = 26)	1.2–4.5	2.3	1.03
Lateral side of lumbar triangle of Petit (n = 26)	1.7–7.5	3.3	1.36
Medial side of lumbar triangle of Petit (n = 26)	0.8–7.5	2.2	1.38
Medial base of lumbar triangle of Petit to posterior superior iliac spine (n = 26)	6.8–13.5	9.7	1.96
Anterior superior iliac spine to posterior superior iliac spine along iliac crest (n = 26)	20.0–30.0	25.2	2.8
Superficial position of lumbar triangle of Petit Midaxillary line to middle of the triangle at the base of the triangle (n = 24)	4.0–15.1	9.3	2.46

the lumbar triangle of Petit between male and female cadavers.

RESULTS

Quantitative Results

There were no significant differences in any measured variables between male and female cadavers (Table 1). A wide variation in the distance from the midaxillary line at the iliac crest to the center of the base of the lumbar triangle of Petit was found both deep to the subcutaneous tissue (mean, 6.9 cm; range, 4.5–9.2 cm) and over the skin surface (mean, 9.3 cm; range, 4–15.1 cm).

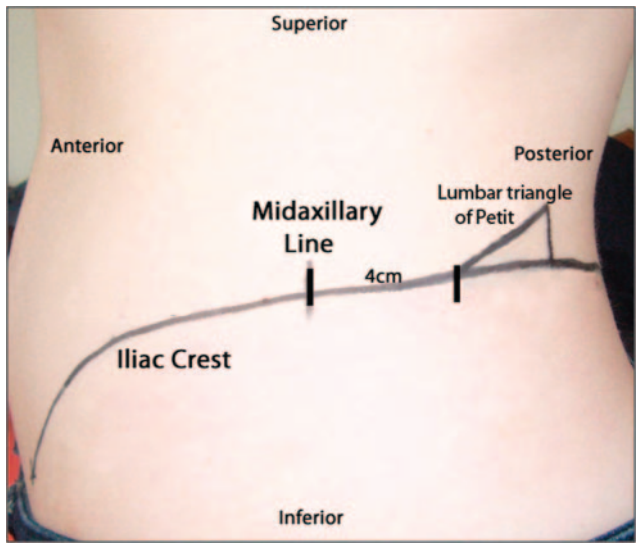

Figure 3. Position of the most anterior lumbar triangle of Petit (Specimen 3) (2.5 cm posterior to the midaxillary line) shown in a lateral view marked on the surface of the skin.

The center of the lumbar triangle of Petit was a mean of 1.1 cm (range, 0.2–3.6 cm) above the iliac crest at the subcutaneous level and 1.4 cm (0.3–4.5 cm) at the skin surface level. The depth of the TAP at the lumbar triangle of Petit position was 0.5–4 cm and at the midaxillary line it was 0.5–2 cm.

The surface position and dimensions of the most anterior lumbar triangle of Petit found in this study (Specimen 3) were drawn onto a live subject (Fig. 3). The iliac crest was drawn onto the surface, anterior superior iliac crest to posterior superior iliac crest, and the midaxillary point on the iliac crest was marked and used to show the lumbar triangle of Petit 4 cm posterior to the midaxillary line.

The lumbar triangle of Petit measurements presented in Table 1 were used to produce a diagram of lumbar triangle of Petit shapes and sizes found in the cadavers (Fig. 4). The mean size of the lumbar triangle of Petit was 2.3 cm at the base, 3.3 cm at the lateral

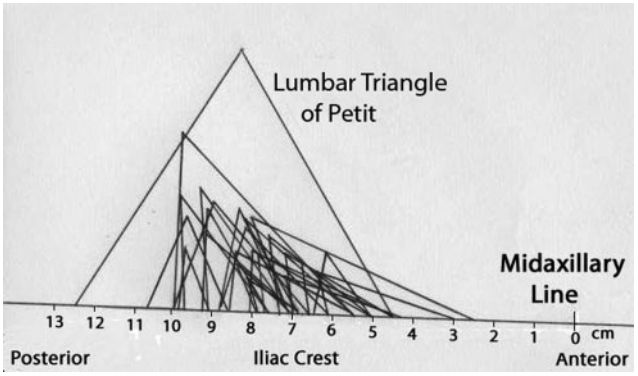

Figure 4. Comparison of sizes and shapes of the lumbar triangle of Petit and the distance of each posterior to the midaxillary line.

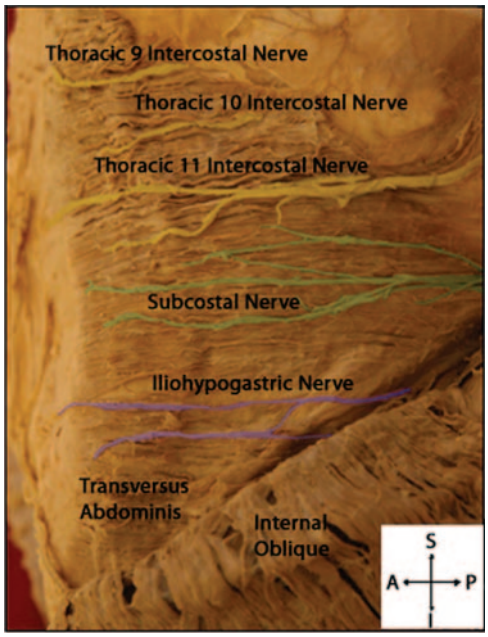

Figure 5. Lateral view of the nerves in the left transversus abdominis plane (TAP). The internal oblique muscle has been reflected to show the transversus abdominis muscle and nerves in the TAP. The intercostal nerves (T9, T10, and T11) are shown in yellow, the subcostal nerve (T12) is shown in green, and the iliohypogastric nerve is shown in blue.

side, and 2.2 cm at the medial side. The average area of the triangle was 3.63 ± 1.93 cm^2.

Qualitative Results

The iliohypogastric, subcostal, and intercostals nerves had a constant course in the TAP in relation to the midaxillary line in the three cadavers studied (Fig. 5). At this point, the nerves have not yet branched extensively. In Part A of Figure 6, the first lumbar nerve (in purple) branches into the iliohypogastric (blue) and ilioinguinal (pink) nerves, whereas in Part B of Figure 6, the first lumbar nerve is already divided as it exits the psoas major compartment. In all three dissections, the nerve branches do not enter the TAP until lateral to the lumbar triangle of Petit. An incidental finding was that in 16 of 24 specimens the lumbar triangle of Petit contained small blood vessel branches of the subcostal artery.

DISCUSSION

The TAP block technique was developed recently as a result of the clinical need for a simple and efficient analgesic technique for abdominal procedures, including inguinal hernia repair, hysterectomy, cesarean delivery, colectomy, and suprapubic prostatectomy.[6,8–10]

Lumbar triangle of Petit has been used as a landmark for TAP block in many studies because the TAP is directly accessible through the lumbar triangle of Petit. This study found the center of the lumbar triangle of Petit to be an average of 6.9 cm (4.5–9.2 cm) posterior to the midaxillary point at the iliac crest and 9.3 cm (4–15.1 cm) posterior to the midaxillary line when skin surface position is measured, which is considerably more posterior than is suggested by the literature.[1,6] The center of the lumbar triangle of Petit is 1.4 cm above the iliac crest at skin level. Because of tissue shrinkage in the cadavers, this distance could be even longer in the patient population.

The location of the lumbar triangle of Petit in patients has been identified differently in several

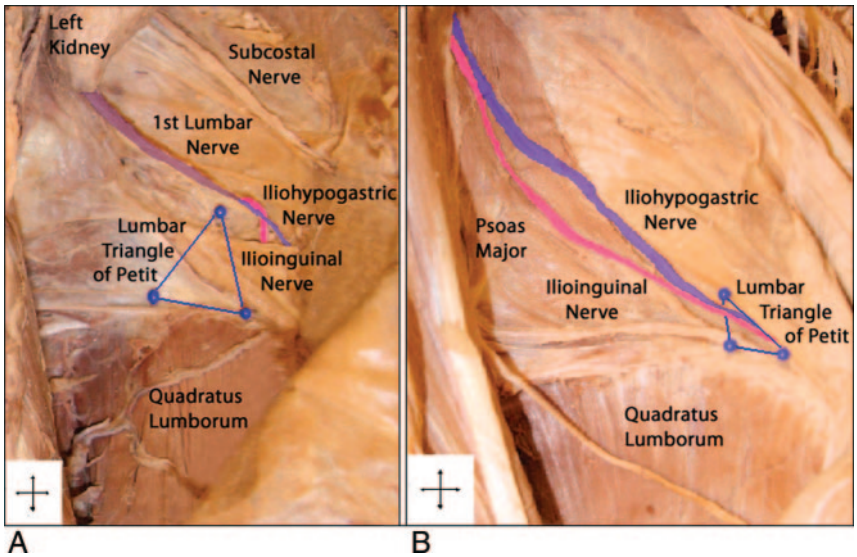

Figure 6. (A). Position of the lumbar triangle of Petit relative to the first lumbar nerve (purple), the iliohypogastric nerve (blue), and the ilioinguinal nerve (pink) as they enter the transversus abdominis plane (TAP) lateral to the lumbar triangle of Petit; the angles of the triangle are indicated by the blue pins. (S: superior; I: inferior; L: lateral; M: medial.) (B) Specimen 2 (supine). The first lumbar nerve has branched before exiting the psoas major compartment; the ilioinguinal and iliohypogastric nerves are shown entering the TAP at the lateral edge of the lumbar triangle of Petit.

clinical studies using the lumbar triangle of Petit as a landmark for TAP block. Rafi[2] states that the point of needle insertion should be at the dip of the lateral border of the latissimus dorsi muscle along the iliac crest. Rafi found this position to be close to the midaxillary line at the level of the L3–4 intervertebral space. McDonnell et al.[1] located the lumbar triangle of Petit by palpating the iliac crest from anterior to posterior until the latissimus dorsi muscle was felt and the lumbar triangle of Petit was taken to be just anterior. However, Petit lumbar hernias are described to be medial to a vertical line between the end of the 12th rib and the iliac crest.[11] It is possible that the great variability in the distance from the midaxillary line to the center of the lumbar triangle of Petit found in this study (4–15.1 cm along iliac crest and 1.4 cm above iliac crest) can explain the difficulty in determining the lumbar triangle of Petit position. The depth of TAP at the position of the lumbar triangle of Petit was between 0.5 and 4.0 cm, dependent on adipose tissue. When performing the block, the variation in depth needed to reach the TAP should be considered.

The iliohypogastric, subcostal, and intercostals nerves had a constant course in the TAP in relation to the midaxillary line in the three cadavers studied. At this point, the nerves have not yet branched extensively, as has been confirmed in a recent study by Rozen et al.[12] The iliohypogastric nerves were not in the TAP at the lumbar triangle of Petit. However, lumbar triangle of Petit is an access point for injecting local anesthetic into the compartment and therefore the iliohypogastric nerve should be effectively blocked by TAP block. The optimal volume of local anesthetic cannot be inferred from this study.

In more than half of the specimens, the lumbar triangle of Petit contained small vessels entering the TAP. The other blood vessels (the subcostal artery and the ascending branch of the deep circumflex iliac artery) in the area were found to be along the iliac crest in the TAP.

As shown in Figure 4, the lumbar triangles of Petit in this study vary in angle, shape, and size among individuals, making identification of the lumbar triangle of Petit difficult. The average size of the lumbar triangle of Petit is relatively small, and the presence of adipose tissue makes lumbar triangle of Petit identification even more difficult. Thus, the lumbar triangle of Petit is a misleading landmark for anterior abdominal wall anesthesia. These results presented here are from adult cadavers and the conclusions drawn from this study should not be applied to children.

In conclusion, the lumbar triangle of Petit is more posterior than the literature suggests. The lumbar triangle of Petit varies greatly in its position and its size is relatively small; the presence of adipose tissue significantly changes the position. As a result, it is difficult to find the lumbar triangle of Petit solely on palpation. The posterior position of the lumbar triangle of Petit would make the TAP block less convenient to perform on supine patients.

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