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Useful Points of Geometry and Topography of the Lumbar Triangle for Transversus Abdominis Plane Block

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Background: A new look at the topography of the lumbar triangle becomes a challenge for modern anesthesia. The aim of this study was to redefine the topography of the lumbar triangle for transverse abdominis plane block.





Material/Methods: We explored 74 lumbar regions in 37 preserved cadavers (17 F and 20 M).

Results: The lumbar triangle was identified in 66 (89%) out of all explored cadavers' lumbar regions. The predominant triangle was the acute-angled shaped. It was identified in 39 (59%) out of all explored lumbar regions. The second type of dissected triangles had the obtuse-angled shaped. Most triangles of acute-angled shaped and obtuse-angled shaped (36) had medium surface (range from 3 cm² to 6 cm²), which accounted for 55% of all dissected lumbar triangles. The mean surface of the lumbar triangle was 3.6±2.2 cm². Based on other measurements, we demonstrated that the majority of the lumbar triangles (62 triangles) were beyond the posterior axillary line.

Conclusions: According to the obtained results, the randomized searching for lumbar triangle should be limited to the area situated beyond of the posterior axillary line. The region situated anteriorly to the midaxillary line was defined in the study as the critical area for finding the lumbar triangle. Outcomes from the study revealed that the size and the location of the lumbar triangle as the gate for the transverse abdominal plane block may be responsible for difficulties encountered by anesthetists. Thus, establishing the area with the highest probability of localization of the lumbar triangle can improve both safety and efficiency of transversus abdominis plane block.

MeSH Keywords: **Analgesia • Anatomy • Lumbosacral Region • Topography, Medical**

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Background

The rapid development of anaesthetic techniques required to redefine some of anatomical structures. One such structure is the lumbar triangle, currently focusing much interest on it in the context of transversus abdominis plane block (TAP block) [1–4]. An important issue associated with this procedure is finding a safe approach to perform TAP block with the lowest risk of complications. Within the lumbar triangle there are no major neurovascular complexes, and a layer of fatty tissue directly separates its bottom from the peritoneum and deeper abdominal organs, so apparently the triangle is the safest place for injecting anaesthetic into the area of the transverse abdominal plane [5–7]. Moreover, even ultrasound-guided TAP block did not eliminate the risk of complications. Nevertheless, the number of publications on the topography of the lumbar triangle and analyzing its suitability for access to TAP block is limited [8,9]. These facts confirm the importance of choosing an optimum access point to the transverse abdominal plane. The concerns of some researchers about the use of TAP block especially beyond of lumbar triangle, indicating this method as low-effective and associated with complications, provides the incentive for the careful anatomical re-examination of the lumbar triangle and topographical regions, which would enable more precise anatomical location of its [10]. The anatomical revalidation of topography of lumbar triangle would allow for the indication of region with the highest probability of its localization and the highest probability of so called random access for TAP block. This also could improve not only the efficacy of anaesthesia but would reduce the number of complications [5–7,10].

The aim of our study was to analyze the geometrical dimensions of the lumbar triangle and identify the topographic borders of the region where the lumbar triangle can be found with the highest probability.

Material and Methods

We explored 74 lumbar regions in 37 preserved cadavers (17 F and 20 M) kept at the Department of Normal and Clinical Anatomy. The mean time of cadaver preservation was 10 ± 4 years. The exclusion criteria included presence of any pathology of lumbosacral region or previous surgery on this region. The scheme of the study presents Figure 1. Each cadaver was placed on a dissecting table in the pronated position (Figure 2), and two osteometric points were identified: the anterior superior iliac spine (ASIS) and the posterior superior iliac spine (PSIS). Then, on each iliac crest bone line were designated two points of intersection, one with the posterior axillary line – labelled as the point P and next one with midaxillary line – labelled as the point M. Additional following distances were calculated:

one between the ASIS and the point P, labelled as distance X and next one between the ASIS and point M labelled as the distance Y. Next, the lumbar triangles were dissected and their vertices and edges were also explored. On each lumbar triangle three vertices have been distinguished: two of them were situated on the iliac crest bone line – so called parabasal vertices: the vertex labelled as A, which was the closest to the ASIS, the next labelled as B – was the closest to PSIS and the last one labelled as C was beyond out of the line. After dissecting the lumbar triangle we plotted the distances between the parabasal vertices of the triangle and the closest identified osteometric point: ASIS and PSIS. This allowed for the calculation of two distances: between ASIS and a vertex A – labelled as distance AS and between PSIS and B vertex – labelled as distance BP. The next were compared the location of the vertex A of lumbar triangle with respect to the midaxillary and posterior axillary line. For this analysis was utilized early calculated both distances X and Y and compared them with distance AS. This comparison allowed for the positioning of lumbar triangle in respect to both distinguished axillary lines. The calculated lengths of a triangle's edges were used for the measurement of surface area of the triangle. Each parameter was analyzed in a computer program using projection technique [11]. The surface of area for each dissected triangle was also calculated using *Heron's formula* [12]. All statistical calculations were performed in MS Office Excel 2007 and Statistica 7.0 (data analysis software system) [13,14]. Fisher's exact test was used to verify the hypothesis on the correlation between the presence or absence of the lumbar triangle in respect to the side of the body [13]. The statistical significance was adopted at $p < 0.05$. The study has been approved by the Ethics Committee of the Pomeranian Medical University in Szczecin.

Results

The triangle was identified in 66 (89%) out of all explored cadavers' lumbar regions. In 32 (43%) cadavers the triangle was identified on the right side, and in 34 (46%) on the left side. The triangle was not identified in 8 (11%) explored lumbar regions, of which 5 (7%) concerned the right side and 3 (4%) the left side of the body. Fisher's exact test was used to verify the zero hypothesis on the correlation between the presence/absence of the lumbar triangle and the explored side of the body. No statistical significances were revealed by Fisher's test ($p = 0.7105$).

Acute-shaped triangle was predominant and identified in 39 (59%) out of all 66 dissected lumbar triangles. Acute-shaped triangle on the right side of the body was more frequent and identified in 21 (32%) versus 18 (27%) on the left side. Obtuse-shaped triangle was found in remaining cases 27 (41%), with diversification 16 (24%) on the left side and 11 (17%) on the right side. The statistical analysis of the type-shape of triangle

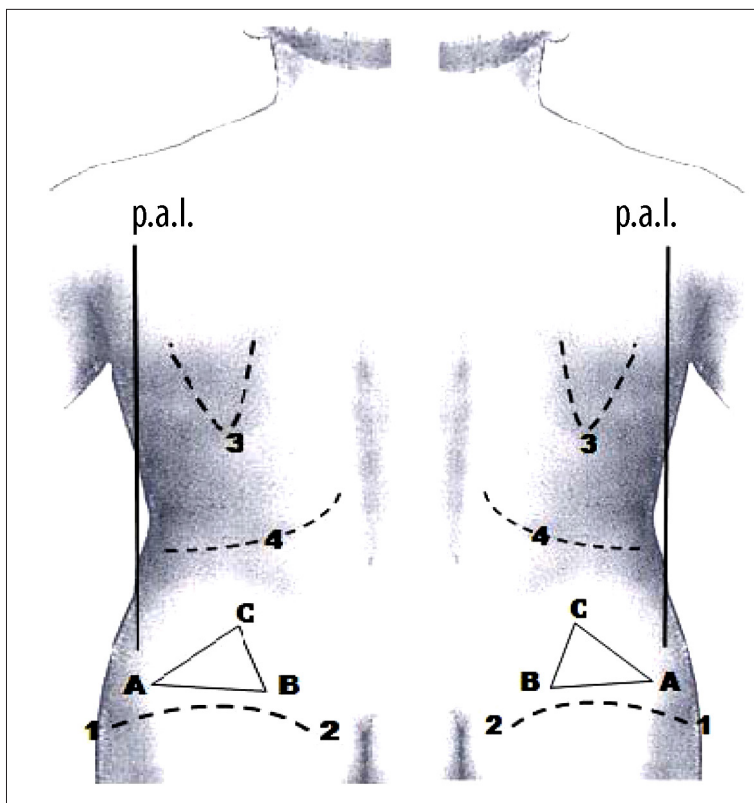


Figure 1. The algorithm of the designed study which includes principal topographical points of the lumbar triangle and its location for both sides (point 1 – means ASIS, point 2 – means PSIS, point A, B and C – means vertex of the triangle, point 4 – is the XII-th rib, point 3 – is the lower angle of scapula and p.a.l. – means posterior axillary line).



Figure 2. Typical position of the body during dissection of the lumbar triangle.

revealed a higher frequency of occurrence of acute-shaped of triangle (the differences reached the statistical significance level $p < 0.05$). There were no statistically significant differences in terms of side of the body.

The following three types of surface area of the lumbar triangle were observed: small surface (up to 3 cm² max.), medium surface (3 cm² to 6 cm²), and large surface (over 6 cm²) (Table 1). Most acute-shaped and obtuse-shaped triangles – 36 of all (55%) had medium surface area. Medium surface area was identified more frequently for acute-shaped triangles (in 22/33% of all) than for obtuse-shaped triangles (only in 14/22%). Large surface area was identified in 17 (25%)

cases, and 10 of these (15%) were acute-shaped triangles and 7 (10%) were obtuse-shaped. Small surface area was the least frequent, and was identified for 13 (20%) of acute-shaped and obtuse-shaped triangles (7/11% and 6/9% respectively). The mean surface area of the lumbar triangle was 3.6 ± 2.2 cm². Analysis of variance demonstrated that the triangle of a medium surface was identified more frequently (the differences reached the statistical significance level $p < 0.03$) (Table 2).

The next were analyzed the distances between parbasal vertices of the lumbar triangle and selected osseous anatomical landmarks. The distance AS was 140.3 ± 28.0 mm for the right side and 134.2 ± 27.1 mm for the left side ($p = ns$). The BP distance was 64.8 ± 16.0 mm for the right side and 65.0 ± 14.0 mm for the left side ($p = ns$). This analysis was a proof for similar location of the lumbar triangle on the left side and right side of the cadaver's body in respect to chosen of osseous points.

In Table 3 was set out the position of the lumbar triangle in respect to both midaxillary and posterior axillary line. In this purpose was put two calculated distances: X and Y. The distance X is the distance between the anterior superior iliac spine and the point of intersection posterior axillary line with crest bone line. The distance Y is the distance between the anterior superior iliac spine and the point of intersection midaxillary line with crest bone line. The distance AS is the distance between anterior superior iliac spine and vertex A of lumbar

Table 1. Total number of identified lumbar triangles in selected topographic regions of explored cadavers.

Explored region	In front of the midaxillary line	Between the midaxillary line and posterior axillary line	Behind the posterior axillary line
Lumbar triangle	0	4	62

Table 2. The surface area of the lumbar triangles (p – statistical significance with respect to small and large triangles).

Type of surface area of the triangle	General number of				Total
	Acute-angled		Obtuse-angled		
Small surface (ranged up to 3 cm ² maximum)	7	(11%)	6	(9%)	13 (20%)
Medium surface (ranged from 3 cm ² to 6 cm ²)	22	(33%)	14	(22%)	36 (55%) p<0.03
Large surface (ranged over 6 cm ²)	10	(15%)	7	(10%)	17 (25%)
Total	39	(59%)	27	(41%)	66 (100%)

Table 3. Comparison of mean length between selected distances. The distance X is the distance between the anterior superior iliac spine and the point of intersection posterior axillary line with crest bone line. The distance Y is the distance between the anterior superior iliac spine and the point of intersection midaxillary line with crest bone line. The distance AS is the distance between anterior superior iliac spine and vertex A of lumbar triangle (p – statistical significance with respect to the distance AS).

Side of the body	The measured length of [mm]		
	Distance X X±SD	Distance Y Y±SD	Distance AS AS±SD
Right	129±10 p<0.05	53±10 p<0.001	141±16
Left	130±14 p<0.05	54±12 p<0.001	142±15

triangle. Comparison of mean length between selected distances with the distance AS allowed us to discover the right position of the lumbar triangle.

Both the right and left side the distance of AS was greater than distance X and distance Y (differences reached the statistical significant level at p<0.05 and p<0.001, respectively). Results presented in the table indicate that the lumbar triangle is located behind the posterior axillary line.

In Table 1 were presented all explored triangles in respect to the midaxillary and posterior axillary lines. These findings confirmed previously carried out statistical analysis indicating the location of most lumbar triangles in the posterior position to the posterior axillary line. None of the triangles was located in front of the midaxillary line. In the analyzed material it was very unlikely to find the lumbar triangle in the anterior region to the midaxillary line, and this region was defined as the critical area for finding the lumbar triangle.

Discussion

The exploration of 74 lumbar regions in 37 cadavers revealed the presence of the lumbar triangle in 66 (89%) of cases. The lumbar triangle was not identified in 8 (11%) out of all the explored regions. Muti et al. found a similar incidence of the lumbar triangle [4].

The exploration revealed the lumbar triangle in 32 (43%) cases on the right side, and in 34 (46%) on the left one. It was not found in 5 (7%) on the right side, and in 3 (4%) on the left side. Statistical analysis did not reveal any significant differences between the side of the body and the presence or absence of the lumbar triangle. We also analyzed the surface area of the lumbar triangle to visualize its size and estimate the probability of locating it with reference to the established osseous anatomical landmarks.

Acute-shaped triangle was predominant and identified in 39 (59%) out of all 66 dissected lumbar triangles. All dissected lumbar triangles were classified to one of three categories: small surface area (up to 3 cm² max.), medium surface area (3 cm² to 6 cm²), and large surface area (over 6 cm²). Lumbar triangles with medium surface area were most common and accounted for 29 (44%) of all the analyzed triangles. The calculated differences were statistically significant both with respect to small surface area and large surface area of triangles ($p < 0.03$ in both cases). Loukas et al. also classified lumbar triangles according to their surface area [16]. The lumbar triangles most frequently identified by them had small surface (max. 8 cm²), which in our study were classified as medium-size [17]. Loukas et al. analyzed the risk of developing lumbar hernia depending on the surface of the lumbar triangle and found it was greatest in subjects with large triangles [16,17]. In another study Jankovic et al. estimated the mean surface area of the lumbar triangle at 3.63 ± 1.93 cm², which corresponded with the category of medium-size triangles in our study. In our opinion manual location of such a triangle is very difficult, particularly in seriously obese patients [18]. It seems reasonable to conclude that in preserved cadavers tissues shrink, and so the actual dimensions may be slightly greater *in vivo*. This fact should be considered when locating the lumbar triangle in patients. Our cadaveric study provided interesting findings on the location of the lumbar triangle with respect to the posterior axillary line. The study revealed that most dissected lumbar triangles were located in the posterior position to the posterior axillary line. Only 4 triangles were located beyond the posterior axillary line, which could be clearly identified in cadavers placed in the pronated position. A similar shift of the lumbar triangle towards the spine was found by Jankovic et al., but they used the midaxillary line as the topographic reference [18]. Moreover, none of the lumbar triangles identified in their study was located beyond the midaxillary line [18]. Results from the study indicate the probability of locating the lumbar triangle is the lowest in the region anterior to the midaxillary line. This region was defined as the critical area for locating the lumbar triangle, and has serious implications for clinical practice, by eliminating other regions during exploration and allowing for safe transverse abdominal plane block. Rafi also reported that topographic landmarks established on the patient's skin are more useful when choosing an access point to the transverse abdominal plane [19].

Currently, this method is used by anesthetists during surgical treatment of hernias, abdominal surgeries, Caesarean sections and many other procedures [10,20–25]. The optimal access point to the transverse abdominal plane is still a subject

of debate [5,18,26]. According to some researchers the transverse abdominal plane block via the lumbar triangle offers low efficiency due to difficult diffusion of anaesthetic in patients positioned horizontally, thus disabling a successful block of all nerve trunks and branches [19,21,22]. Both minor and major complications (liver trauma or colonic puncture) caused by blind anaesthesia or secondary to ultrasound-guided transverse abdominis plane block have been reported [8,9,27,28].

Recently, concerns have been raised with regards to the transverse abdominis plane block without direct visualization, as some clinical trials revealed a high rate of incorrect needle placement, particularly in pediatric patients [29]. Therefore, some researchers have doubts about the use of blind transverse abdominis plane block, first described by Rafi, supporting their standpoint by frequent failures of the procedure [10]. Nevertheless, many other researchers, including Dr Rafi, consider access via the lumbar triangle as the safest option, associated with the lowest risk of trauma to internal abdominal structures [19]. The risk of serious bleeds or abdominal organ trauma secondary to the transverse abdominal plane block via the lumbar triangle is very low, but the penetration of anaesthetic may be difficult due to the horizontal placement of the patient on the operating table. Therefore, the patient should be turned on the table to enable better penetration of the anaesthetic within the transverse abdominal plane.

The safety of the transverse abdominal plane block, complementary to either general anaesthesia or central block, and the post-operative comfort of the patient justify any possible effort to carry out intensive research in this area and to implement findings in clinical practice. Obviously, much still needs to be explained with respect to the TAP block, its duration, side effects, drug dose and techniques for performing this procedure [26,30,31].

Conclusions

The lumbar triangle can be located with the highest probability in the region posterior to the posterior axillary line. The region anterior to the midaxillary line was defined in the study as the critical area for locating the lumbar triangle. The midaxillary line is a demarcation line between areas with present or absent lumbar triangle. Findings from the study indicated that the location and size of the lumbar triangle may be responsible for difficulties associated with the transverse abdominal plane block via the lumbar triangle. Moreover, the identification of topographic landmarks for the lumbar triangle can improve the efficiency of both blind and ultrasound-guided blocks.

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