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An Overview on Transversus Abdominis Plane Block

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Abstract

Transversus abdominis plane (TAP) block is a regional technique for analgesia of the anterolateral abdominal wall. This review highlights the nomenclature system and recent advances in TAP block techniques and proposes directions for future research. *Recent Findings*. Ultrasound guidance is now considered the gold standard in TAP blocks. It is easy to acquire ultrasound images; it can be used in many surgeries involving the anterolateral abdominal wall. However, the efficacy of ultrasound-guided TAP blocks is not consistent, which might be due to the use of different approaches. The choice of technique influences the involved area and block duration. To investigate the actual analgesic effects of TAP blocks, we unified the nomenclature system and clarified the definition of each technique. Although a single-shot TAP block is limited in duration, it is still the candidate of the analgesic standard for abdominal wall surgery because the use of the catheter technique and liposomal bupivacaine may overcome this limitation. *Summary*. Ultrasound-guided TAP blocks are commonly used. With the unified nomenclature and the development of catheter technique and/or liposomal local anesthetics, TAP blocks can be applied more appropriately to achieve better pain control.

Keywords: Transversus abdominis plane, analgesia, TAP.

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1. Introduction

The abdominal wall is a common source of pain after surgical interventions involving the abdomen. Utilizing ultrasound, transversus abdominis plane (TAP) blocks can provide reliable relief of somatic incisional pain. TAP blocks are a great adjunct to a multimodal analgesic regimen [1]. However, the lack of reliable visceral pain relief with TAP blocks may necessitate additional modes of analgesia [2]. The TAP is a potential anatomical space that lies between transversus abdominis and internal oblique muscles, where local anesthetic can be deposited, creating a non-dermatomal “field block” [3].

1.1. Relevant anatomy

The thoracolumbar nerves are responsible for the segmental cutaneous supply of the abdominal wall. They divide into the anterior primary ramus and posterior primary ramus shortly after exiting from the intervertebral foramen. The posterior ramus travels backward, while the anterior ramus branches into lateral and anterior cutaneous nerves [4]. The anterolateral abdominal wall is mainly innervated by the anterior rami of the thoracolumbar spinal nerves (T6-L1), which become the intercostal (T6-T11), subcostal (T12), and ilioinguinal/iliohypogastric nerves (L1) [5]. These branches further communicate at multiple locations, including large branch communications on the anterolateral abdominal wall (intercostal/upper TAP plexus) and plexuses that run with the deep circumflex iliac artery (DCIA) (lower TAP plexus) and the deep inferior epigastric artery (DIEA) (rectus sheath plexus)[6]. Since these segmental nerves communicate just above the transversus abdominis muscle, the subfascial spread of local anesthetic can provide anterolateral abdominal wall analgesia [7]. The anterior primary rami of T7-T12 spinal nerves pass between internal oblique and transversus abdominis and then perforate rectus abdominis and end as the anterior cutaneous branches, which innervate the anterior abdomen (from midline to midclavicular line). Among these anterior rami, the T12 crosses quadratus lumborum before entering TAP [8]. Lateral cutaneous branches depart near the angle of the rib posteriorly. Lateral cutaneous branches of T7-T11 then divide into anterior and posterior branches: anterior branches supply the abdominal wall toward lateral margin of rectus abdominis; posterior branches pass backward to supply skin over latissimus dorsi. However, lateral cutaneous branch of T12 does not further divide into anterior and posterior branches) [9]. For blockade of lateral cutaneous branches, a TAP block can only cover the T11 and T12 lateral cutaneous branches even with a more posterior injection. Based on the distribution of T9-T12 branches, lateral approach performed at midaxillary line between costal margin and iliac crest could provide mainly periumbilical and infraumbilical analgesia, while posterior approach performed posterior to midaxillary line has potential to provide some degree of lateral abdominal wall analgesia [10]. Paravertebral spread from T5 to L1 has reported only with posterior TAP blocks [11]. The L1 branches, which become ilioinguinal and iliohypogastric nerves, pass into TAP near anterior part of iliac crest [9].

➢ ***Indications***
- Major abdominal surgery
- Colorectal surgeries
- Hernia repairs
- Procedures involving the abdominal wall
- Cesarean section [12].

➢ ***Contraindications***
- Patient refusal
- Active infection over the site of injection
- Practice caution in patients taking anticoagulation, pregnant patient, and in patients where anatomical landmarks are indistinguishable [13-14].
- Avoid local anesthetics in those with known allergies

2. Techniques of TAP Block

I. Landmark-Guided TAP Block

The blunt landmark-guided technique applies loss of resistance as the needle is advanced through the fascia layers of external oblique and internal oblique. After locating the triangle of Petit, the TAP is identified using the subjective double-pop loss of resistance technique [15]. McDonnell et al. suggested that the first pop indicates penetration of the fascia of the external oblique muscle, and the second indicates piercing of the fascia of internal oblique and entry of the needle into the TAP [7-16]. However, it was suggested that first pop indicates needle has reached the plane between internal oblique and transversus abdominis, and second pop indicates needle has passed through transversus abdominis and thus needle went too far [17]. Debates continue regarding adequacy of the “single-pop”, “double-pop”, and structures responsible for the “pop” [7-18]. Currently, landmark-guided technique is no longer recommended because of ambiguity of standard procedure sequence, small size and large variation of lumbar triangle of Petit, and risk of peritoneal perforation during blind technique [19-20].

II. Ultrasound-Guided TAP Blocks

Ultrasound guidance now considered gold standard for peripheral nerve block [21]. Usually, a linear probe is adequate for most TAP blocks. However, a convex probe is preferable for TAP blocks in markedly obese patients [22].

II.A. Ultrasound Identification of TAP

To perform an ultrasound-guided TAP block, identification of the TAP is a priority. The scanning steps are recommended as follows [4-23-25]:
- Put the transducer transversely just below the xiphoid process and locate paired rectus abdominis and linea Alba.
- Rotate transducer obliquely and move laterally, parallel to costal margin. At this level, TAP is between rectus abdominis and transversus abdominis, or TAP is absent here because transversus abdominis ends at lateral end of rectus abdominis in some patients.
- Move transducer along costal margin more laterally until aponeurosis of the linea semilunaris, which is lateral to rectus abdominis, appears. Internal oblique and external oblique are located lateral to linea semilunaris. We can start to identify three muscle layers: transversus abdominis, internal oblique, and external oblique (from deep to superficial). The TAP is located just above transversus abdominis.
- Move the transducer more laterally to midaxillary line, and scan up and down between costal margin and iliac crest. Typically, three muscle layers can be seen. TAP is between internal oblique and transversus abdominis.
- If the transducer is placed posteriorly, we find that internal oblique and transversus abdominis taper off into a common aponeurosis, also called thoracolumbar fascia, which is connected to the lateral border of the quadratus lumborum. The TAP is between internal oblique and transversus abdominis and continuous with aponeurosis.

➢ ***Subcostal TAP Block***

The transversus abdominis is identified as the more hypoechoic muscle layer just beneath rectus abdominis. Deposition of the local anesthetic starts between transversus abdominis and rectus abdominis, medial to the linea semilunaris [26]. If transversus abdominis ends at the lateral end of rectus abdominis, the local anesthetic can be deposited between transversus abdominis and internal oblique lateral to the linea semilunaris, but it might be better to include the injection from beneath rectus abdominis toward the lateral side to achieve a higher success rate[27]. Shibata et al. suggested that only lower abdominal surgery should be an indication for lateral TAP block because of the limited level of sensory block[3]. Hebbard et al. also demonstrated that the lateral TAP block is suitable for surgery below the umbilicus, while the subcostal TAP block is more suitable for supraumbilical and periumbilical analgesia [9].

➢ ***Lateral TAP block***

One can identify typical three muscles layers at midaxillary line b/w costal margin and iliac crest. After measuring depth of TAP, a needle inserted away from transducer at same distance according to principle to make needle in plane for deep regional blocks [28-29]. Needle advanced into transversus abdominis and pulled back incrementally with regular aspiration and then plane is hydrodissected until eye sign, an elliptical, hypoechoic spread of local anesthetic, seen. Otherwise it is also logical to deposit local anesthetic underneath fascial layer to ensure optimal analgesia as nerves bound to transversus abdominis [16].

➢ ***Posterior TAP block***

The posterior approach is similar to lateral approach, but ultrasound transducer is moved more posteriorly. When scanning posteriorly, transversus abdominis tails off and turns into aponeurosis. Quadratus lumborum can be seen posteromedial to aponeurosis. Injection site is superficial to aponeurosis near quadratus lumborum [30-31].

➢ ***Oblique subcostal TAP block***

The oblique subcostal TAP block is modified from the subcostal TAP block, which was first introduced by Hebbard et al. Unlike other approaches, a much longer needle (15–20 cm) and a larger volume of anesthetics (40–80 ml) are required. The oblique subcostal line extends from the xiphoid toward the anterior part of the iliac crest and potentially covers the T6-L1 nerves in the TAP [9]. Thus, local anesthetic injected in the TAP along this line provides both upper and lower abdominal wall analgesia, like a dual TAP block. Compared to a dual TAP block, oblique subcostal TAP block more consistently covers L1 dermatome. Only single penetration is required for oblique subcostal approach [32]. A large volume of local anesthetics is required to hydrodissect the TAP along whole ipsilateral oblique subcostal line. It can provide promising analgesia for abdominal surgeries [33-34] and might be better compared to lateral approach [35-36].

II.B. Other considerations

➢ ***Dual TAP block***

If analgesia is needed for both the supraumbilical and infraumbilical abdomen, dual TAP block could also be considered. Dual TAP block is combination of subcostal and the lateral/posterior TAP block [37-38]. Compared to oblique subcostal TAP block, dual TAP block technically ensures more easily that local anesthetic is deposited throughout plane and provides analgesia for both the upper (T6-T9) and lower (T10-T12) abdomen. The bilateral dual TAP block was first introduced by Borglum et al. as four-point approach [39].

➢ ***Continuous TAP Block***

Petersen et al. reported that anesthetized dermatomes produced by a continuous TAP block employing lateral approach comprised only two segments (T10 and T11) in healthy volunteers [40]. Nevertheless, two previous randomized controlled trials [41-42] have reported that adding continuous TAP blocks to single-injection TAP blocks improves analgesia after laparotomy for gynecological cancer. Both studies employed an oblique subcostal approach for a continuous TAP block[9]. After incremental hydrodissection of TAP along oblique subcostal line, a catheter is threaded through needle into TAP. Yoshida proposed this thorough hydrodissection of TAP and catheter passage might facilitate a wider spread of sensory block by providing a track for local anesthetics along catheter within the TAP [42]. However, this hypothesis should be validated in a future study. In two above-mentioned studies regarding continuous oblique subcostal TAP blocks, a point-source catheter, such as an epidural catheter, used for providing a continuous TAP block [41-42]. A continuous TAP block using a catheter with more extensive holes may produce a wider spread of sensory block and superior analgesia, although there has no research evaluating effectiveness of multi hole catheter compared to point-source catheter [43].

➢ ***Optimal local anesthetic agent***

To date, one randomized controlled trial has investigated optimal local anesthetic for transversus abdominis plane blocks [44]. In 2016, Sinha et al. compared bupivacaine 0.25% and ropivacaine 0.375% for transversus abdominis plane blocks in patients undergoing laparoscopic cholecystectomy. Ropivacaine group displayed lower pain scores during first postoperative hour, both drugs equivalent in terms of 24-h cumulative analgesic requirement [45].

➢ ***Complications***

Complications related to transversus abdominis plane blocks can be attributed to needle or local anesthetic agent [46]. In terms of the needle-related adverse events, abdominal wall sufficiently vascularized to sustain needle trauma, as evidenced by recent report of a (self-resolving) abdominal wall hematoma in an obstetrical patient with HELLP syndrome [47]. During performance of the transversus abdominis plane blocks, needle tip can inadvertently traverse transversus abdominis muscle (and peritoneum) resulting in peritoneal breach and visceral injury [48-49]. Interestingly, if needle tip positioned just b/w transversus abdominis muscle and transversalis fascia (without puncturing peritoneum), local anesthetic injection could result in transient femoral nerve blockade because fascia iliaca constitutes posterolateral continuation of transversalis fascia [50-52]. Preceding complications underscore importance of the visualizing entire length of needle during performance of ultrasound-guided the transversus abdominis plane blocks [53]. Because transversus abdominis plane blocks require relatively large injectates and often carried out bilaterally, the local anesthetic systemic toxicity remains a concern especially in elderly patients or those with decreased muscle mass. There exist multiple reports of local anesthetic systemic toxicity after the administration of (levo) bupivacaine (2.7 to 2.9 mg/kg) [54] as well as the ropivacaine (4.9 to 7.9 mg/kg) [55] for the transversus abdominis plane blocks. In none of these cases did operators use adjunctive epinephrine to curtail local anesthetic plasmatic absorption [56]. In one report, 2.9-mg/kg dose of bupivacaine administered to a patient experiencing acute fatty liver of pregnancy, a condition known to increase free fraction of the plasma bupivacaine (attributable to a decreased production of local anesthetic-binding serum proteins) [54]. Prohibitively the supratoxic dose (7.9 mg/kg) of ropivacaine reported by Sherrer et al. stemmed from a lack of communication between surgeon and the anesthesiologist, as former carried out the intraperitoneal local anesthetic infiltration (using 20 ml of the ropivacaine 0.75%) before latter's performance of the transversus abdominis plane blocks (using 40 ml of ropivacaine 0.75%) [57]. Finally, the local anesthetic injection in the transversus abdominis plane compartment may result in motor block of the thoracolumbar nerves. In turn, this could result in paresis of abdominal muscles as evidenced by a bulge in abdominal wall when patient coughs or bears down. In both reported cases, bulge subsided uneventfully as the transversus abdominis plane block wore off [58-59]. In summary, based on current knowledge, care must be taken to visualize the entire length of needle during performance of the transversus abdominis plane blocks to prevent breaching the transversus abdominis muscle and peritoneum thereby minimizing risk of femoral blockade and visceral injury [44]. Furthermore, a thorough analysis of risks and benefits must be undertaken before performance of transversus abdominis plane blocks in coagulopathic patients. Finally, in addition to respecting ceiling doses of local anesthetic, prudent anesthesiologist should consider using dilute local anesthetic concentrations as well as adjunctive epinephrine to delay local anesthetic plasmatic absorption, especially in subsets of patients at risk for local anesthetic systemic toxicity [47]. Communication between the surgeon and the anesthesiologist is paramount to avoid the supratoxic cumulative doses resulting from concomitant local anesthetic infiltration and transversus abdominis plane blocks [44].

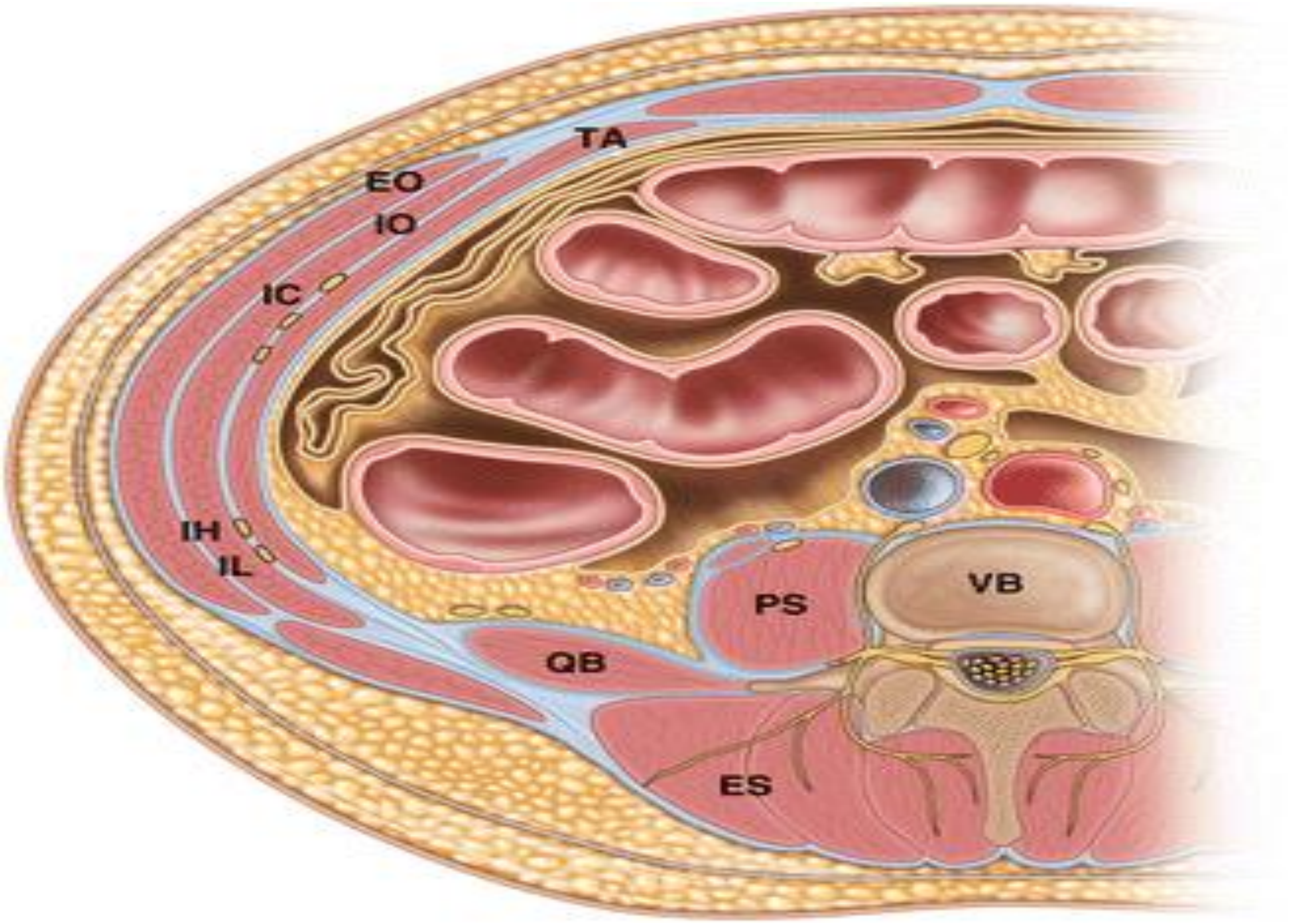

Figure (1): The cross section of the abdominal wall. The nerves are not obvious on the ultrasound image and somewhat discrete between the plane of internal oblique and transversus abdominis muscles. EO external oblique muscle, IO internal oblique muscle, TA transversus abdominis muscle, IC intercostal nerves, IL ilioinguinal nerve, IH iliohypogastric nerve, PS psoas, ES erector spinae, VB vertebral body, QB quadratus lumborum [60].

Table (1): The classification of ultrasound-guided TAP blocks and the corresponding supplied areas [4].

Approach	The main segmental thoracolumbar nerves		Supplied area
Subcostal	T6-9	Anterior cutaneous branches	Upper abdomen just below the xiphoid and parallel to the costal margin
Lateral	T10-12	Anterior cutaneous branches	Anterior abdominal wall at the infraumbilical area, from midline to midclavicular line
Posterior	T9-12	Anterior cutaneous branches (possibly lateral cutaneous branches)	Anterior abdominal wall at the infraumbilical area and possibly lateral abdominal wall between costal margin and iliac crest
Oblique subcostal	T6-L1	Anterior cutaneous branches	Upper and lower abdomen

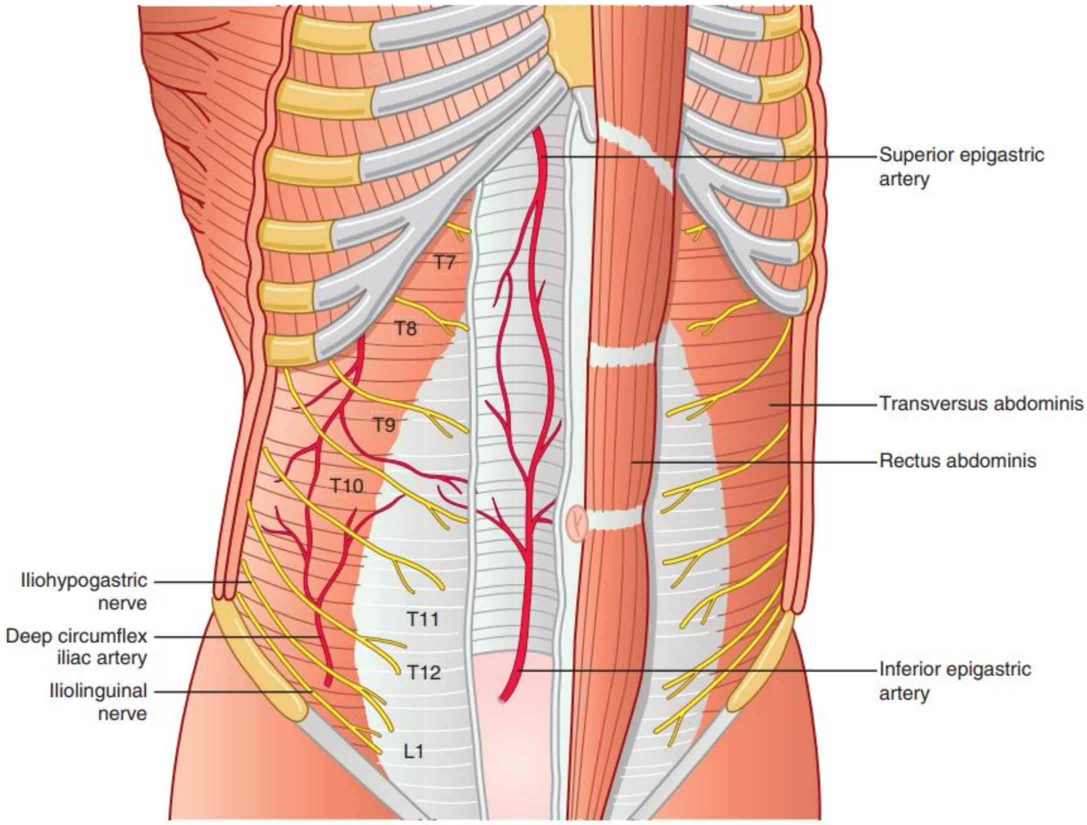

Figure (2): The anatomic basis of the transversus abdominis plane block is the fact that the innervation of the anterolateral abdominal wall is provided by the lower six intercostal nerves and the first lumbar nerve [61].

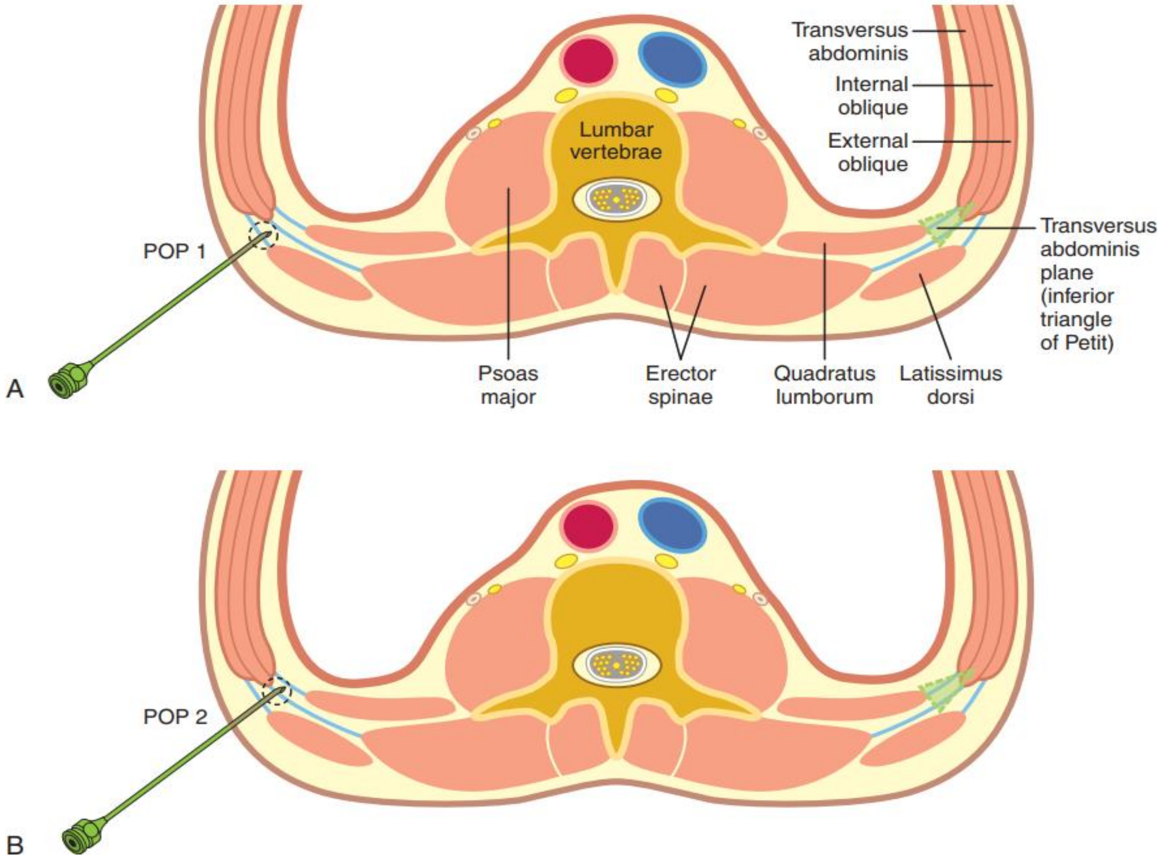

Figure (3): Diagrammatic illustration of the “Two-Pop Technique” [61].

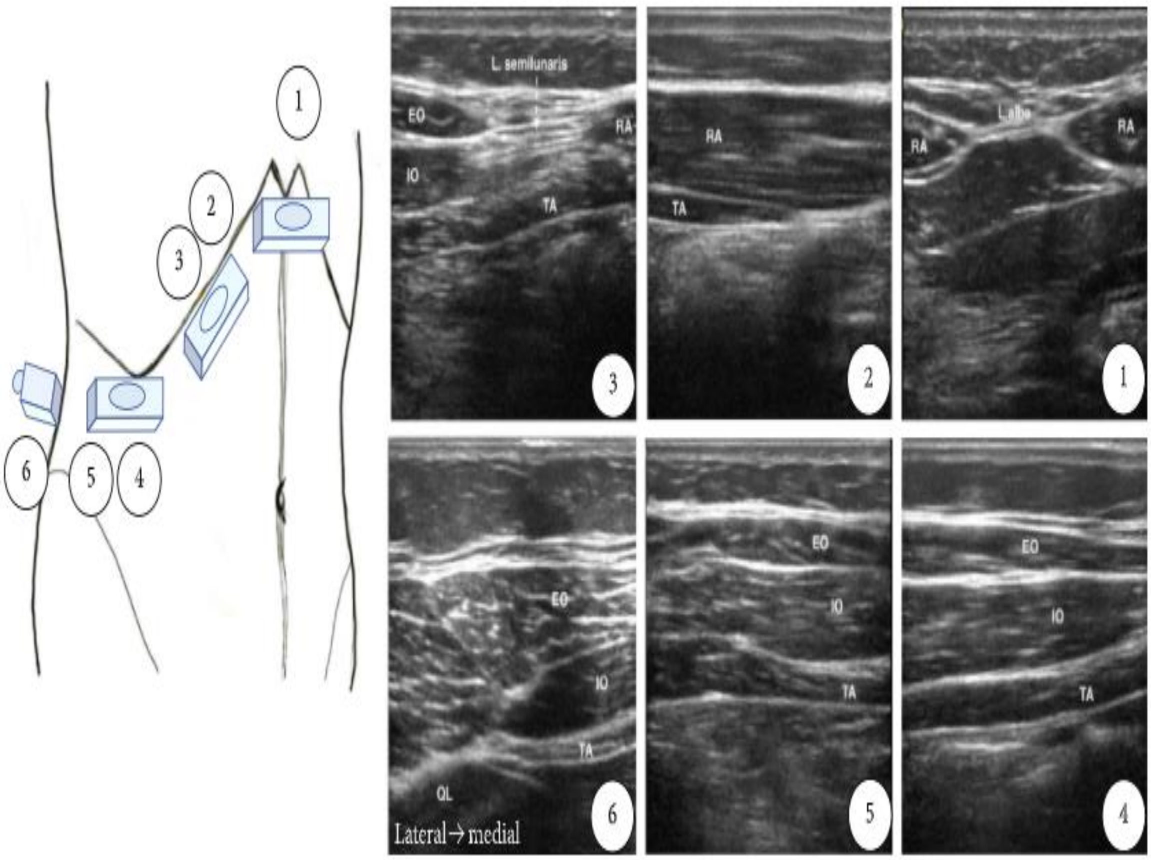

Figure (4): Ultrasound identification of the transversus abdominis plane. RA: rectus abdominis; TA: transversus abdominis; IO: internal oblique muscle; EO: external oblique muscle; QL: quadratus lumborum; L. alba: linea alba; L. semilunaris: linea semilunaris [4].

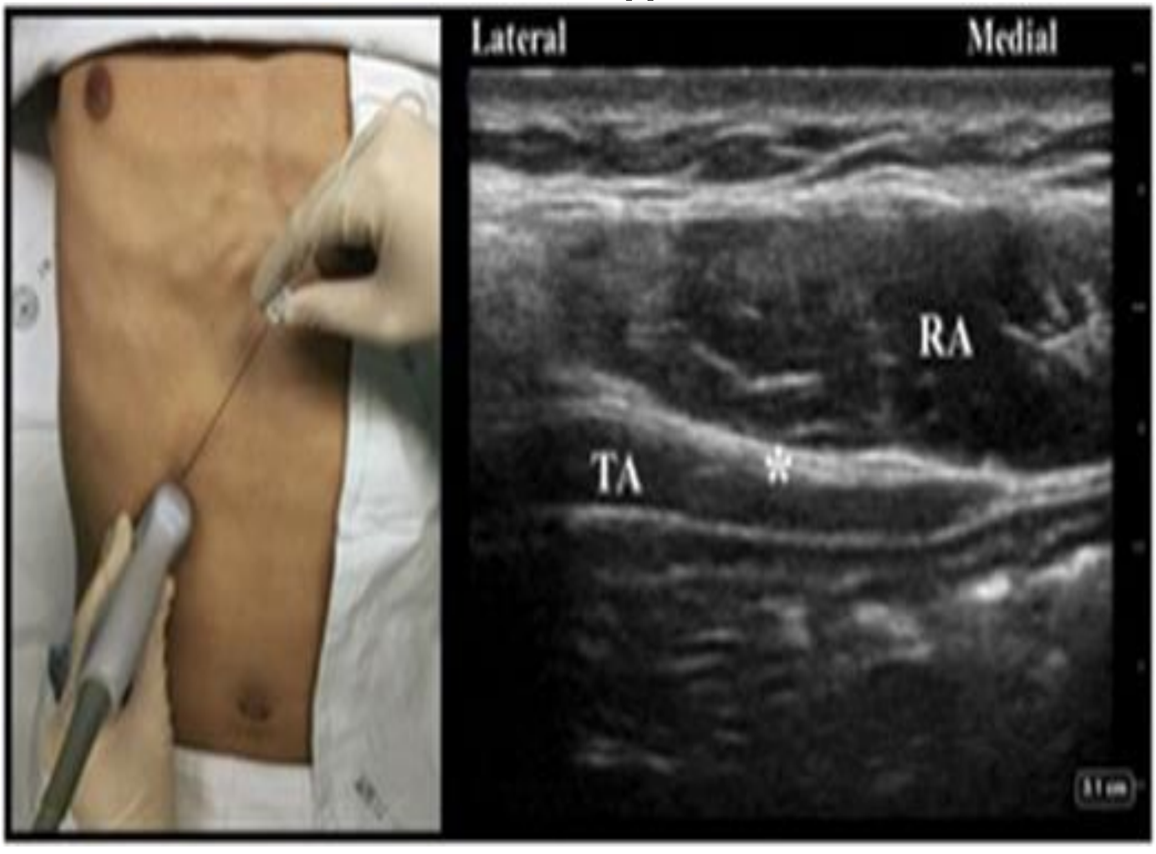

Figure (5): Ultrasound probe position, needle puncture site, and sonographic image of the subcostal transversus abdominis plane block. Asterisk indicates needle target; RA, rectus abdominis muscle; TA, transversus abdominis muscle [44].

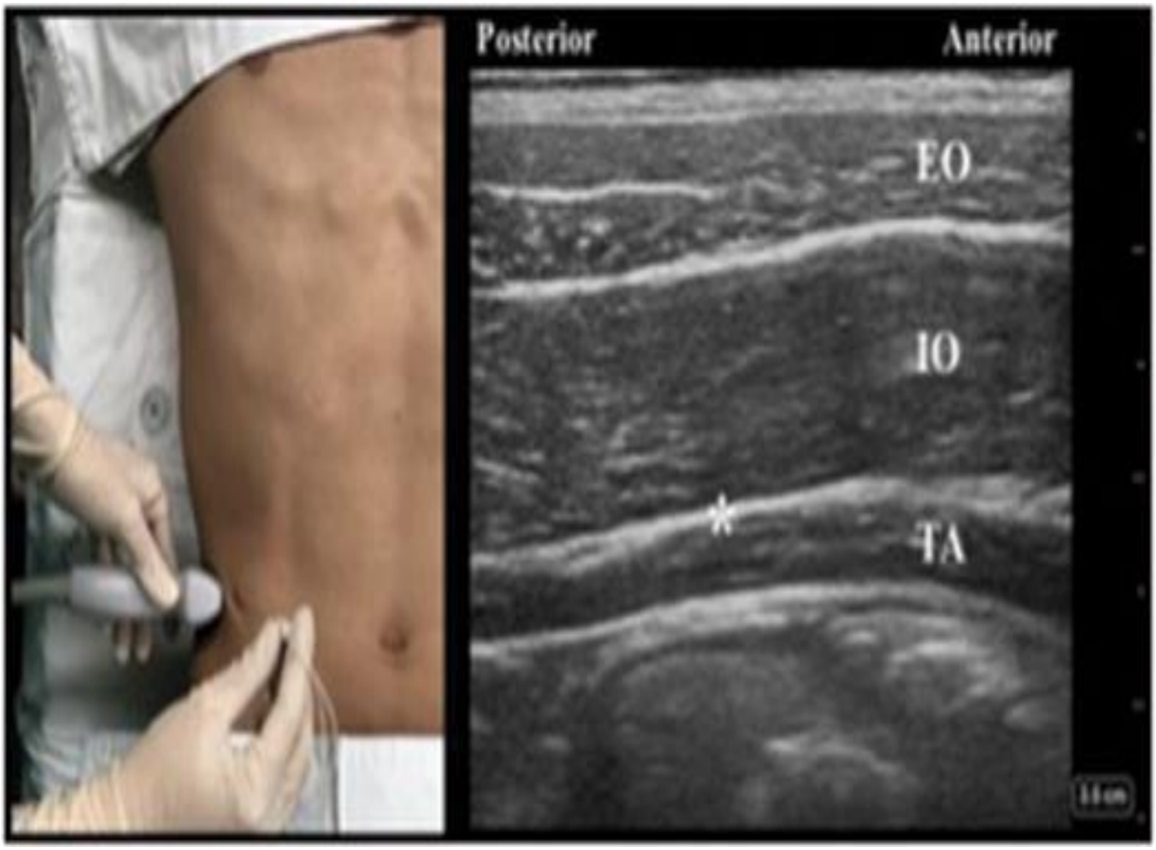

Figure (6): Ultrasound probe position, needle puncture site, and sonographic image of the lateral transversus abdominis plane block. Asterisk indicates needle target; EO, external oblique muscle; IO, internal oblique muscle; TA, transversus abdominis muscle [44].

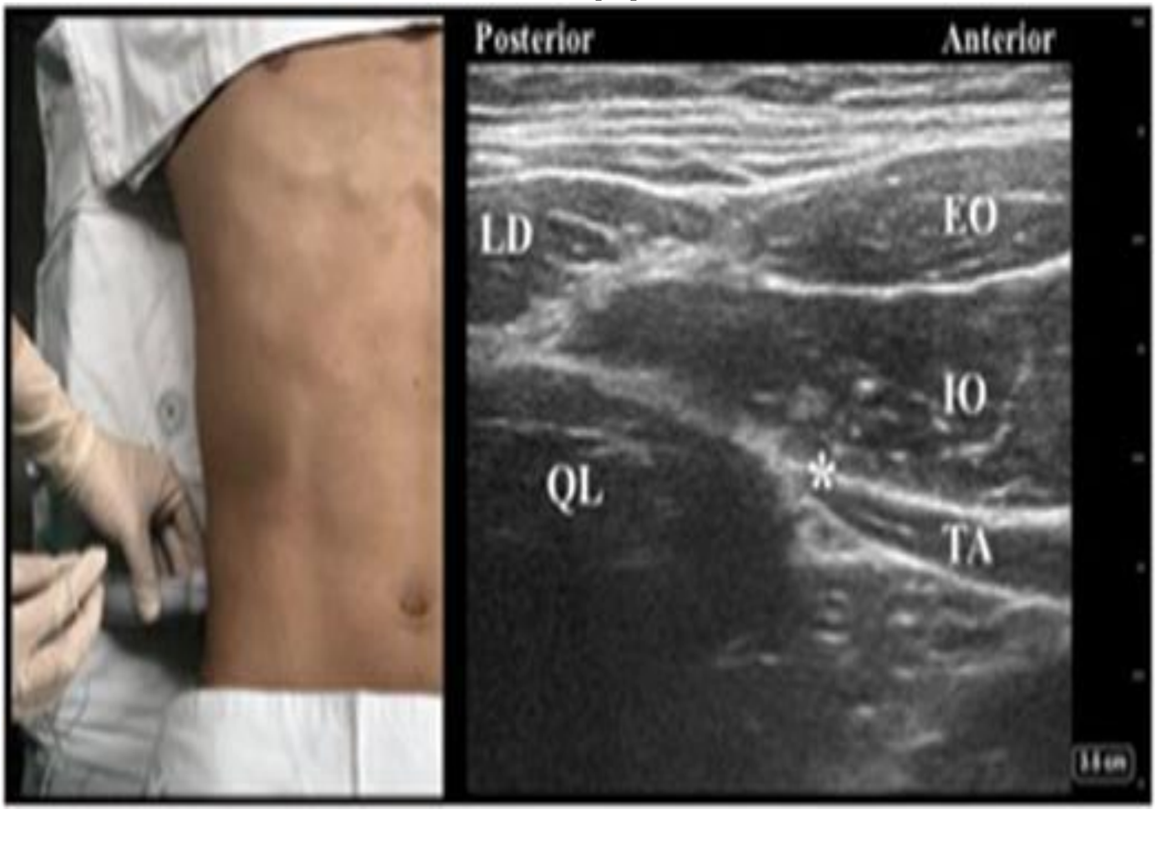

Figure (7): Ultrasound probe position, needle puncture site, and sonographic image of the posterior transversus abdominis plane block. Asterisk indicates needle target; EO, external oblique muscle; IO, internal oblique muscle; LD, latissimus dorsi muscle; QL, quadratus lumborum muscle; TA, transversus abdominis muscle [44].

3. Conclusions

In conclusion, based on current knowledge, care must be taken to visualize the entire length of needle during performance of the transversus abdominis plane blocks to prevent breaching the transversus abdominis muscle and peritoneum thereby minimizing risk of femoral blockade and visceral injury

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