Ultrasound-guided Transversus Abdominis Plane (TAP) block

Philips tutorial

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The sensorimotor innervation of the anterior abdominal wall is supplied by the anterior rami of the thoracolumbar spinal segmental nerves T7-L1. These include the lower six thoracic intercostal nerves (T7-T11 and the subcostal nerve T12), and the first lumbar nerve (L1). The intercostal nerves, subcostal and first lumbar nerves, along with their accompanying vasculature, course within a neurovascular plane known as the transversus abdominis plane (TAP). The TAP lies between the internal oblique muscle (IOM) and transversus abdominis muscle (TAM).

The TAP block was initially described by Raffi as a landmark-based technique performed within the iliolumbar triangle of Petit. The triangle of Petit is bounded inferiorly (the base of the triangle) by the iliac crest, posteriorly by the latissimus dorsi muscle, and anteriorly by the external oblique muscle (EOM).
After localization of the triangle of Petit by palpation, a blunt regional anesthesia needle is advanced from superficial to deep while feeling for two tactile pops or a double-loss of resistance. The first pop indicates needle penetration into the fascial plane between the EOM and IOM, followed by a second pop as the needle penetrates into the TAP plane between the IOM and the TAM. The landmark-based technique for bilateral TAP blocks has been demonstrated to be effective and apparently safe in several well conducted randomized controlled trials.

The authors describe localization of the iliolumbar triangle of Petit as “easy and reproducible,” although the average body mass index of the patients in these clinical trials was between 24 and 28. However, recent anatomical studies indicate that position of the triangle of Petit varies widely and is relatively small in surface area. In addition, the external oblique muscle may overlap with and cover the latissimus dorsi in a significant percentage of the population.
Thus, reliable localization of the triangle of Petit may be difficult, especially in obese patients, resulting in incorrect placement of the needle tip. In addition, the variable depth of the TAP within the triangle of Petit may result in placement of the needle within the peritoneal cavity and potential damage to visceral organs.

Real-time ultrasound provides reliable imaging of the three muscular layers of the anterolateral abdominal wall, the TAP, and the underlying peritoneal cavity. Ultrasound also provides real-time assessment of correct needle placement and local anesthetic injection within the TAP, thus potentially increasing the success rate and safety of the TAP block compared to the landmark-based technique.
The TAP block is a relatively new regional anesthesia-analgesia technique that provides sensory and motor block of the abdominal wall via injection of local anesthetic within the TAP. The abdominal wall is a significant source of pain after abdominal surgical procedures and successful blockade of the afferent sensory nerves may supplement intraoperative anesthesia, and provide superior postoperative analgesia compared to traditional systemic opioid-based analgesia.

The TAP block has been utilized for a variety of abdominal surgical procedures including: radical retropubic prostatectomy, large bowel resection, cesarean delivery, total abdominal hysterectomy, open appendectomy, laparoscopic colectomy, laparoscopic cholecystectomy, and laparoscopic ventral hernia repairs with mesh.
Although the majority of case series and randomized controlled trials have reported the placement of the single injection TAP blocks either prior to or immediately after the planned surgical procedure, case reports have described placement of TAP blocks in the intensive care unit after major abdominal surgery in the setting of either contraindications to epidural analgesia or failed epidural analgesia. Case reports have also described placement of TAP catheters as a method to extend the postoperative analgesic benefits of the TAP block. TAP blocks are also gaining increasing indications in the pediatric literature for major abdominal procedures.

Thus, the TAP block holds considerable promise as an integral part of a perioperative multimodal analgesic regimen, which potentially will provide improved analgesia, decrease postoperative morbidity, and improve surgical outcomes by enhancing and accelerating recovery after abdominal surgical procedures.
3 Clinical anatomy

The layers of the anterolateral abdominal wall supplied by the T7-L1 thoracolumbar nerves from superficial to deep are as follows (Figure 1a).

- Skin
- Subcutaneous tissue
- Rectus abdominis muscle (midline)
- Anterolateral muscles
  - External oblique muscle
  - Internal oblique muscle
  - Transversus abdominis muscle
- Transversalis fascia
- Parietal peritoneum
[Figure 1a] Axial drawing of abdominal wall and course of a thoracolumbar nerve through the TAP plane between the IOM and TAM. Note the location of the lateral cutaneous branch along the lateral abdominal wall at the level of the mid-axillary line. The nerve courses further anteriorly and medially to terminate within the midline rectus abdominis muscle.
As the anterolateral muscles course medially toward midline, they give rise to fascial aponeuroses that converge to form the lateral border of the rectus abdominis, the linea semilunaris. The fascial aponeuroses course further medially and form the anterior and posterior rectus sheaths, which envelop the midline rectus abdominis muscles **(Figure 1b and 1c).**
[Figure 1c] Axial and coronal CT scan of the abdomen at the level of the umbilicus. Coronal CT of the abdomen at the level of the anterior-to-mid axillary line. Note how the three muscle layers (EOM, IOM, TAM) form the anterior-lateral wall of the abdomen.
The thoracolumbar nerves course through the anterolateral abdominal wall within the TAP located between the internal oblique muscle and transversus abdominis muscle (Figures 1a, 1b, and 1c). At the level of the mid-axillary line, the segmental nerves give rise to lateral cutaneous branches.

As the nerves course anteriorly and medially toward the midline, they penetrate the lateral margin of the rectus sheath, and subsequently penetrate through the posterior rectus sheath to supply the rectus abdominis muscle. The nerves continue anteriorly and penetrate through the anterior rectus sheath, giving rise to the anterior cutaneous branches.

The lateral and anterior cutaneous branches supply the skin from the midline to the anterior axillary line. As the segmental thoracolumbar nerves course through the TAP, they also supply motor branches to the abdominal wall muscles (Figures 2a and 2b).
[Figure 2a] Anatomy of the transversus abdominis plane. Note the posterior location of the iliolumbar triangle of Petit and the consistent course of the thoracolumbar nerves within the TAP along the anterior-to-mid-axillary line.

This figure was borrowed from Dr. Vincent Chan’s Ultrasound for Regional Anesthesia website (www.usra.ca) with his gracious permission.
[Figure 2b] Segmental cutaneous dermatomes of the thoracolumbar nerves (T7-L1), and segmental distribution of the thoracolumbar nerves as they course toward the midline.
A series of cadaveric and dye injectate studies highlight several key points that are clinically relevant to performance of the block and subsequent spread of local anesthetic injected within the TAP.

1. There is a thin fascial sheath between the internal oblique muscle and transversus abdominis muscle throughout the TAP, which extends as far medially as the linea semilunaris. This fascial sheath is not adherent to the internal oblique, but covers (by its deep surface) the thoracolumbar nerves as they lay on the transversus abdominis muscle.

2. The intercostal thoracolumbar nerves T7-T9 emerge from their respective costal margins to enter the TAP between the midline and the anterior axillary line. T7, T8, and T9 emerge from the costal margins at increasingly lateral positions from the midline (Figure 2b).

3. T9 emerges most often medial, but may occasionally emerge lateral to the anterior axillary line.

4. Segmental nerves T9–L1 are consistently located within the TAP along the mid-axillary line.
5. There is extensive branching and communication of the thoracolumbar nerves within the TAP.

6. Ultrasound-guided posterior TAP injection of 20 ml of dye just above the iliac crest resulted in consistent spread from the T10–L1 nerves, which implies that the TAP block is suitable for lower abdominal surgery at and below the level of the umbilicus to the symphysis pubis (Figure 2b).

7. Ultrasound-guided subcostal TAP injection just below and along the costal margin with single-injection of 20 ml of dye resulted in consistent spread to only T9–T10, while a multi-injection approach resulted in spread from T8–T11. Thus, the subcostal approach may be more suitable for upper abdominal surgery (Figure 2b).

8. It is unknown what the extent of spread is with either the posterior TAP and subcostal TAP approaches if larger volumes (25–30 ml) of injectate are used.
4 Ultrasound anatomy and technique

Posterior TAP approach

- The patient is supine with the abdomen exposed between the costal margins and the iliac crests.

- After appropriate sterile skin preparation, a high frequency (3-12 MHz) linear array transducer, contained within a sterile cover, is positioned just cephalad to the iliac crest in an axial (transverse) plane along the junction of the anterior and mid-axillary lines (Figures 3a and 3b).

- The appropriate depth, frequency range, and focal point(s) are adjusted to optimize the image of the abdominal wall muscles and underlying peritoneal cavity.

- The image is further optimized by transducer manipulation consisting of pressure, alignment, rotation, and tilt-angulation (PART) on the abdominal wall. The depth and quality of image may vary with patient respiratory excursions.

- Identify the layers of the lateral abdominal wall from superficial to deep (Figure 4).
[Figure 3a and 3b] The patient is supine. Note that the transducer is axially oriented just above the iliac crest along the mid-axillary line.
[Figure 4] 2D sonoanatomy of the ultrasound-guided posterior TAP block. Note the hyperechoic fascial planes located between the muscular layers. The TAP is located between the IOM and TAM. The peritoneal cavity is located deep to the TAM.
- There will be a layer of subcutaneous tissue and fat that will vary in depth depending on the body habitus and body mass index of individual patients.

- Deep to the subcutaneous tissue will be the three muscular layers and their corresponding fascial layers. The EOM will be the most superficial: the IOM will be located deep to the EOM, and the TAM will be the deepest muscular layer along the lateral abdominal wall (Figures 1 and 4).

- The thoracolumbar nerves are very small terminal branches and cannot be visualized as discrete structures. The thoracolumbar nerves are located within the TAP between the IOM and TAM layers. The fascial planes separating the muscular layers are specular reflectors. Thus, they appear as very visible bright hyperechoic linear lines located between the hypoechoic abdominal wall muscles.

- Deep to the transversus abdominis muscle is the transversalis fascia and the underlying peritoneal cavity. The peritoneal cavity is identified by the presence of peristaltic movements of the bowel loops.
The 3 layers (EOM, IOM and TAM) of the abdominal wall are identified. Note the clearly visible peristaltic movements of the bowel loops located immediately deep to the TAM. The needle is traveling anterior to posterior targeting the TAP. Note the anechoic expansion enlarging within the TAP and the needle advanced further posterior along the line of hydro-dissection.
• After the optimal image is obtained, a 20- or 21-gauge 100-150 mm needle is inserted 3-5 centimeters medial to the medial edge of the transducer and advanced “in-plane” toward the transducer (Figures 5a, 5b, and 5c).

[Figure 5a] Needle insertion and direction for the ultrasound-guided posterior TAP approach. Moderate to firm pressure is applied to the transducer to keep the abdominal wall from moving too much during respiration. In this illustration, the block is performed with the anesthesiologist standing on the same side of the abdomen that is to be blocked.
Posterior TAP block with the anesthesiologist standing on the opposite side of the side of the abdomen to be blocked. The transducer is positioned just cephalad to the iliac crest. Note the initial needle insertion site is 5–6 cm medial to the medial side of the transducer and advanced in plane in a posterior-lateral direction.
– The needle direction is from anterior to posterior along the lateral wall of the abdomen.

– Insertion of the needle a few centimeters away from the edge of the transducer allows for a decreased needle angle trajectory to the TAP, which optimizes the angle of the incidence of the ultrasound beam relative to the needle approach to the TAP.

– The needle is advanced and observed penetrating through the EO-IO fascial plane and subsequently, into the TAP between the IOM and TAM. Needle passage through fascial planes may be accompanied by tactile and visible pops as the fascia first tents as the needle contacts the fascia, followed by recoil as the needle passes into the fascial plane.

– Once the needle is located in the TAP, a small 1-2 ml dose of local anesthetic (or saline) is injected to confirm correct placement within the TAP. Optimal needle location is indicated by the appearance of an anechoic fluid collection immediately deep to the hyperechoic fascial plane deep to the IOM and above the TAM.
[Figure 6] 2D sonoanatomy of the correct needle-tip location and local anesthetic (LA) distribution within the TAP and deep to the thin fascial plane that lays just superficial to the thoracolumbar nerves.
– After correct local anesthetic distribution is confirmed, 20–30 ml of local anesthetic is incrementally injected while observing for an expanding anechoic fluid collection within the TAP. As the local anesthetic is injected, it will often result in gradual separation (due to hydro-dissection) of the IOM and TAM. Improved local anesthetic spread may be facilitated by advancement of the needle further posterior as the anechoic fluid collection visibly expands the TAP in an anterior-posterior fashion.

– If a catheter technique is desired, a 17-gauge 90 mm needle is used, and after expansion of the TAP with 20 ml of local anesthetic, a 19-gauge-wire reinforced catheter is inserted 4–6 cm beyond the needle tip into the TAP. The correct location of the catheter tip may be confirmed by either direct visualization or via local anesthetic accumulation (via injection through the catheter tip) within the TAP. The needle is withdrawn and the catheter is secured to the skin.
[Figure 7a] 2D sonoanatomy of the posterior TAP catheter approach. The larger Tuohy epidural needle surrounded by local anesthetic (LA) is clearly seen within the TAP.
[Figure 7b] 2D sonoanatomy of the posterior TAP catheter approach. The catheter surrounded by local anesthetic (LA) is clearly seen within the TAP.
Technique (transducer position-orientation) and needle movement for ultrasound-guided posterior TAP approach. Note the direction of the needle from anterior to posterior along the lateral abdominal wall.
Another example of the three layers of the abdominal wall. Note the peristaltic movements of the bowel loops immediately deep to the TAM. The needle is traveling anterior to posterior. Note the anechoic fluid expansion enlarging within the TAP and the needle advanced further posterior along the line of hydro-dissection. Note the needle tip and surrounding local anesthetic deep to both the IOM and the fascial plane.
If a catheter technique is desired, a 17-gauge 90 mm needle is used and after expansion of the TAP with 20 ml of local anesthetic, a 19-gauge wire-reinforced catheter is inserted 4–6 cm beyond the needle tip into the TAP. The correct location of the catheter tip may be confirmed by either direct visualization or via local anesthetic accumulation (via injection through the catheter tip) within the TAP. The needle is withdrawn and the catheter is secured to the skin (Figures 7a, Figure 7b Figure 8, and Video Loop 4).
[Figure 8] TAP catheter secured to the skin after injection of 20 ml of local anesthetic. Note the prominent “bulge” along the lateral wall of the lower abdomen indicative of blockade of the efferent motor nerves to the abdominal wall muscles.
Ultrasound-guided posterior TAP catheter technique. Note the visibly larger Tuohy needle used to locate the TAP, followed by local anesthetic injection, which facilitates easier passage of the catheter into the TAP. Catheter placement within the TAP is confirmed by observing the anechoic fluid expansion within the TAP via the injection of local anesthetic via the catheter tip.
Sub-costal TAP approach

• The patient is supine with the abdomen exposed between the costal margins and the iliac crests.

• After appropriate sterile skin preparation, a high frequency (3-12 MHz) linear array transducer, contained within a sterile cover, is positioned just caudal (below) the costal margin typically along the mid-clavicular line. At this location the transducer is at an axial oblique orientation as it is parallel to the course of the costal margin [Figure 9].

• The appropriate depth, frequency range, and focal point(s) are adjusted to optimize the image of the abdominal wall muscles and underlying peritoneal cavity.

• The image is further optimized by transducer manipulation consisting of pressure, alignment, rotation, and tilt-angulation (PART) on the abdominal wall. The depth and quality of image may vary with patient respiratory excursions.
• Identify the layers of the lateral abdominal wall from superficial to deep.

  – At the medial edge of the ultrasound image, the linea semilunaris will be seen just lateral to the rectus abdominis muscle. At this location, the transversus may be the only muscle layer between the skin and peritoneum; more superficial muscles have become their respective fascial aponeuroses near the midline.

[Figure 9] Transducer position and orientation (just below the costal margin) for subcostal TAP approach.
– At the lateral (and deeper) part of the ultrasound image, the three muscular layers become readily visible as the fascial aponeuroses of the external and internal oblique layers become muscular as they approach the anterior axillary line.

– The three muscular layers and the TAP will appear very similar to the posterior TAP approach.

• After the optimal image is obtained, a 20- or 21-gauge 100-150 mm needle is inserted 3-5 centimeters medial to the medial edge of the transducer and advanced “in plane” toward the transducer.

– The needle direction is from anterior to posterior in an oblique fashion along the course of the costal margin.

– Insertion of the needle further away from the edge of the transducer allows for a lower needle trajectory to the TAP, which optimizes the angle of incidence of the ultrasound beam relative to the needle approach the TAP.
– The needle is advanced and observed penetrating through the fascial plane between the external oblique muscle and internal oblique muscle and subsequently, into the TAP between the internal oblique muscle and transversus abdominis muscle. Needle passage through fascial planes may be accompanied by tactile and visible pops as the needle initially “tents” the fascia, followed by a “recoil” of the fascia as the needle passes into the TAP.

– Once the needle is placed within the TAP, a small 1-2 ml dose of local anesthetic (or sterile saline) is injected to confirm correct needle tip location. Optimal needle location is indicated by the appearance of an anechoic fluid collection immediately deep to the hyperechoic fascial plane, deep to the internal oblique muscle, and above the transversus abdominis muscle.
– After correct local anesthetic distribution is confirmed, 20 ml of local anesthetic is incrementally injected while observing for an expanding anechoic fluid collection within the TAP. As the local anesthetic is injected, it will often result in gradual separation (due to hydro-dissection) of the internal oblique and transversus abdominis muscles. Improved local anesthetic spread may be facilitated by advancement of the needle further posterior as the anechoic fluid collection visibly expands the TAP in an anterior-posterior fashion.

– If a catheter technique is desired, a 17-gauge 90 mm needle is used and after expansion of the TAP with 20 ml of local anesthetic, a 19-gauge-wire reinforced catheter is inserted 4-6 cm beyond the needle tip into the TAP. The correct location of the catheter tip may be confirmed by either direct visualization or via local anesthetic accumulation (via injection through the catheter tip) within the TAP. The needle is withdrawn and the catheter is secured to the skin.
Ultrasound-guided subcostal TAP approach. Note the linea semilunaris located just lateral to the rectus abdominis muscle. The three layers of the anterior abdominal wall located just below the costal margin are easily recognized lateral to the linea semilunaris.
Clinical pearls and tips

- The ultrasound-guided TAP block is described as a “basic level” block in terms of sonoanatomy. While the individual thoracolumbar nerves are not readily visible, the transversus abdominis fascial plane, located between the internal oblique and transversus abdominis muscles, is relatively easy to identify as a bright hyperechoic linear line.

- Novices may initially find the technique more difficult due to the “dynamic nature” of the block. The abdominal wall will move with respiratory excursions and even small movements may displace the needle out of plane. Some practical advice will help keep the needle tip in plane during needle advancement:
  - Since the initial needle insertion site is several centimeters away from the transducer, the transducer position can be adjusted to initially locate the needle after skin insertion. As the needle is advanced further posterior and lateral, the transducer is systematically slid further posterior and lateral so as to keep the needle tip in plane within the center of the screen.
  - The patient can assist by maintaining shallower respirations during the block procedure.
  - An assistant can manually retract the abdominal wall cephalad and caudal to the transducer and needle insertion site to provide a stable field during needle advancement.
Local anesthetic selection

• For single injection posterior TAP blocks, 20–25 ml ropivacaine 0.375% or bupivacaine 0.25% with 1:400,000 epinephrine is used. Epinephrine is recommended to decrease the initial peak plasma concentration, as spread of local anesthetic will encompass a relatively large surface area for potential vascular absorption. This is especially pertinent for either bilateral TAP blocks or a combined posterior and subcostal TAP approach.

• Unilateral TAP blocks are indicated for abdominal surgical procedures that do not cross the midline, such as appendectomy, renal transplantation, and open cholecystectomy.

• Bilateral TAP blocks are indicated for abdominal surgical procedures that require incisions along the midline or cross the midline, as well as for laparoscopic procedures.

The role of ultrasound-guided TAP blocks in multimodal analgesia

• TAP blocks provide somatic anesthesia-analgesia of the abdominal wall. If they are performed before the surgical procedure, they will decrease the analgesic (opioid) requirements intra-operatively. There is high quality evidence that TAP blocks provide superior analgesia compared to conventional opioid-based postoperative analgesia.
• TAP blocks do not provide complete anesthesia-analgesia for major abdominal surgical procedures, as they do not provide visceral analgesia. Thus, TAP blocks should be used as part of a multimodal analgesic regimen that includes NSAIDS or COX-2 inhibitors, acetaminophen, gabapentin, and NMDA antagonists to optimize postoperative analgesia.

• TAP blocks have yet to be directly compared to continuous thoracic epidural analgesia, the current “gold standard” analgesic technique after major abdominal surgery. The value of TAP blocks is when epidural analgesia has failed or is contraindicated due to either hemodynamic status, concerns regarding altered hemostasis and the potential increased risk of central neuraxial hematoma, or sepsis.

• Additional questions that require future clinical investigation include optimal dose (volume and concentration of local anesthetic), for single-injection and continuous TAP blocks, plasma levels, success rate and complications with more widespread use, and efficacy compared to epidural analgesia.
6 References

Monographs

Randomized controlled trials

Anatomical studies
Case series – reports, editorials and letters to the editor


For additional resources related to ultrasound-guided **regional anesthesia and pain medicine** procedures visit: [www.philips.com/RAPMeducation](http://www.philips.com/RAPMeducation)

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