Ultrasound-Guided Continuous Oblique Subcostal Transversus Abdominis Plane Blockade

Description of Anatomy and Clinical Technique

Peter D. Hebbard, FANZCA,*†‡ Michael J. Barrington, FANZCA,§ and Carolyn Vasey, MB, BS†

Background: Recently, ultrasound-guided transversus abdominis plane blockade for abdominal wall analgesia has been described, and it involves injection of local anesthetic into the transversus abdominis plane. The posterior approach involves injection of local anesthetic in the lateral abdominal wall between the costal margin and the iliac crest and is suitable for surgery below the umbilicus. The subcostal approach is suitable after abdominal surgery in the peri-umbilical region. The subcostal block can be modified, and the needle can be introduced along the oblique subcostal line from the xyphoid process toward the anterior part of the iliac crest.

Objective: The purpose of this brief technical report was to describe in detail the anatomy and the technique of continuous oblique subcostal blockade. The goal of this approach was to produce a wider sensory blockade suitable for analgesia after surgery both superior and inferior to the umbilicus.

Conclusions: A catheter can be placed along the oblique subcostal line in the transversus abdominis plane for continuous infusion of local anesthetic. Multimodal analgesia and intravenous opioid are used in addition because visceral pain is not blocked. Continuous oblique subcostal transversus abdominis plane block is a new technique and requires both a detailed knowledge of sonographic anatomy and technical skill for it to be successful.

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The transversus abdominis plane (TAP) lies superficial to the transversus abdominis muscle in the anterolateral abdominal wall. The thoracolumbar nerves (T6–L1) are located in the TAP and they may be blocked by a local anesthetic for postoperative analgesia. Recently, ultrasound-guided TAP blockade has been described.1 The posterior TAP block involves injection of local anesthetic in the TAP in the lateral abdominal wall between the costal margin and the iliac crest and is suitable for surgery below the umbilicus.2,3 The subcostal TAP block involves injection of local anesthetic into the TAP lateral to the linea semilunaris immediately inferior and parallel to the costal margin and is suitable for abdominal surgery in the peri-umbilical region. The subcostal TAP block can be modified, and the needle can be introduced into the TAP near the costal margin but medial to the linea semilunaris with subsequent needle advancement and hydrodissection occurring along a line from the xyphoid toward the anterior part of the iliac crest.4,5 We refer to this line as the oblique subcostal line and its associated block as the oblique subcostal TAP block. The goal of this approach was to produce a wider analgesic blockade suitable for surgery both superior and inferior to the umbilicus.

Continuous oblique subcostal TAP block is a new technique and requires both a detailed knowledge of sonographic anatomy and technical skill for it to be successful. The purpose of this brief technical report was to describe the relevant anatomy and the clinical technique in detail.

Anatomic Description

There are 4 paired muscles of the anterior and lateral abdominal wall. The anterior rectus abdominis muscles, and from deep to superficial, the 3 lateral muscles: transversus abdominis, internal oblique, and external oblique muscles. It is only in the lateral abdomen that the 3 fleshy muscle bellies overlie one another because, medially, they become aponeurotic.6 The aponeuroses form the linea semilunaris lateral to the rectus abdominis muscle, which is often widened immediately proximal to the costal margin. The shape and location of the muscular bellies and the linea semilunaris helps identify the layers (Fig. 1). The rectus muscle arises from the anterior surface of the ribs and costal cartilages. In contrast, the transversus abdominis muscle attaches to the deep surface of the continuous cartilaginous costal margin superior to the 10th rib.

The innervation of the abdominal wall is derived from anterior divisions of the thoracolumbar nerves (T6–L1). T6 to T11 commence as intercostal nerves, T12 is the subcostal nerve, and L1 is the iliohypogastric and ilioinguinal nerves. The T6 nerve supplies a small area below the xyphoid. T7 and T8 pass toward the xyphoid, almost parallel to the costal margin. The 3 uppermost nerves (T6–T8) emerge beneath the rectus muscle and pass for a variable distance between the posterior rectus sheath and the transversus abdominis muscle in the TAP before penetrating anteriorly through the rectus sheath. After a further course between the rectus sheath and rectus muscle, they pass into the muscle.6 However, T6 to T8 nerves may pass directly into the rectus muscle near the costal margin, and a block placed between the rectus abdominis muscle and the posterior rectus sheath close to the midline may miss these nerves6 (Fig. 2). There are often extensive anastomoses between the segmental nerves emerging from the costal margin such that they rapidly lose their segmental origin.7,8 Nerves T9 to T12 leave the TAP medially by passing through the lateral part of the rectus sheath. After a short course posterior to rectus abdominis muscle, they penetrate through the muscle to supply the skin from the midline to the midclavicular line. In the minority of cases, the nerves
penetrate directly through the lateral edge of the rectus abdominis muscle and are not present deep to the muscle.\textsuperscript{8} T9 has a transverse course, and T10 and T11 pass progressively more inferiorly to areas around and inferior to the umbilicus.\textsuperscript{8} T12 enters the TAP posterolaterally near the end of the 12th rib\textsuperscript{6,7} (Fig. 3). Each segmental nerve has a lateral branch that leaves the main nerve posterior, near the angle of the rib, and passes with it a short distance.\textsuperscript{7} The lateral branch then emerges obliquely through the overlying muscles around the midaxillary line. These branches arise before the nerve enters the TAP, although the T11 and T12 lateral branches may have a short course within or through the TAP. The ilioinguinal and iliohypogastric nerves have a different course than the thoracic nerves in that they generally remain deep to the transversus abdominis muscle until the middle one third of the iliac crest (measured from anterior superior iliac spine to posterior superior iliac spine); anterior to this, they are usually found in the TAP.\textsuperscript{9}

The vascular supply of the abdominal wall is from the superior and inferior epigastric arteries, the ascending terminal branch of the deep circumflex iliac artery, and segmental intercostal arteries. The superior epigastric artery emerges from the costal margin near the xyphoid and into the TAP before penetrating into rectus abdominis.\textsuperscript{6} The ascending branch of the deep circumflex iliac artery is located in the TAP above the iliac crest.
The inferior epigastric artery is not imaged performing the subcostal TAP block.

Description of Technique

Probe selection is not critical for TAP block, and usually either a high- or an intermediate-frequency linear probe of 35 to 40 mm will provide adequate imaging. We have used either an 18-gauge Touhy (Contiplex touhy; B. Braun, Bethlehem, PA) or a 17-gauge facet tip (I-Flow Corporation, Lake Forest, CA) needles; however, needles of up to 15 to 20 cm in length may be required. The operator can stand on the left side of the patient in the supine position, and both sides are blocked from this position, starting from the xyphoid with the right hand holding the needle and the left hand holding the probe (Fig. 4). In our practice, full aseptic precautions are maintained during block placement, and catheter insertion including sheathing the ultrasound probe and antiseptic solution is also used for ultrasound probe-skin coupling.

The transversus abdominis muscle has 2 key features on ultrasound imaging. It is usually darker (more hypoechoic) than the other muscles, and it passes beneath the rectus abdominis muscle when followed superiorly along the costal margin. Adjacent to the costal margin, a slip of transversus abdominis muscle usually extends almost to the xyphoid process (Fig. 5).

To perform the block, we recommend that the rectus abdominis and underlying transversus abdominis muscles be identified near the costal margin and xyphoid. Local anesthetic is injected incrementally in the TAP (hydrodissection) by a needle passing along the oblique subcostal line illustrated as an interrupted line in Figure 5 and the hatched area in Figure 4. The oblique subcostal line extending inferolaterally from the xyphoid toward the anterior part of the iliac crest potentially crosses the location of T6–L1 nerves in the TAP. The location of the oblique subcostal TAP blockade can be matched to the surgical incision. For blocks above the umbilicus, the recommended insertion point is through the rectus muscle avoiding the superior epigastric arteries, which may be imaged with color or power Doppler emerging from under the costal margin close to the midline (Fig. 6). We prefer to puncture the skin 2 to 3 cm from the probe and then move the probe toward the needle to image it in-plane. In our practice, most blocks have commenced near the

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**FIGURE 4.** Photograph of the needle, ultrasound machine, and sheathed probe position for oblique subcostal TAP block illustrated using a volunteer. Note the curved needle, the position of the hands that can be moved to block both sides, and the local anesthetic syringe that is being held by an assistant. The area for deposition of local anesthetic is cross hatched. CM, costal margin; IC, iliac crest; U, umbilicus; X, xyphoid process.

**FIGURE 5.** Sonograms of the anterior abdominal wall near the costal margin showing the continuity of transversus abdominis (T) posterior to the rectus abdominis (R) and the internal oblique (I) muscles. Between the lateral edge of rectus abdominus and the medial edge of internal oblique, there is an aponeurotic area (A), with transversus (T) the only muscle belly deep into the skin and subcutaneous tissue (SC). The central diagram shows the scan positions (1–4), xyphoid process (X), iliac crest (IC) and umbilicus (U). External oblique (E) is shown overlying internal oblique in the lateral scans.
xyphoid, passing toward the iliac crest. One technique is to bend the needle into a slight curve with concave side initially away from the skin to align the tip of the needle with the initial hydrodissection. As the needle passes along the oblique subcostal line, it is rotated in the opposite direction to follow the curve of the body (Fig. 7). The long needle becomes relatively fixed in the tissue as it advances, however, changing pressure by the probe moves the surrounding tissues, and this can change the needle direction to assist placement. Large patients may need the needle removed and reinserted further along the costal margin to complete the block.

Typical local anesthetic dosage in adults is ropivacaine 200 mg (or the maximum subtoxic dose) diluted to 40 to 80 mL with 0.9% saline. Our preference is to use this larger volume to facilitate hydrodissection, which may improve the spread of the block. An assistant injecting local anesthetic through the extension tubing to the needle allows the operator to hold the needle and probe without interruption. Initially, a 1- to 2-mL volume of local anesthetic can be injected between the rectus abdominis and the transversus abdominis muscles to confirm correct placement of the needle tip. To extend the length of the block beyond the needle position, 10 to 15 mL of local anesthetic can be injected at both the superior and the inferior limits of the hydrodissection. The remainder of the local anesthetic is then used in the hydrodissection along the oblique subcostal line. Usually, the plane is opened in front of the needle by the hydrodissecting fluid; however, sometimes restrictions to the hydrodissection are encountered. The needle can be pushed through the restricted area, staying in the TAP, and the hydrodissection continues.

On the basis of the known anatomy (Fig. 3), the most reliable site to block the uppermost nerves is between the posterior rectus sheath and the transversus abdominis muscle immediately adjacent to where the nerves emerge from deep to the costal margin. However, if the incision is close to the xyphoid, the transversus abdominis muscle may not be present, and the injection is placed superficial to the posterior rectus sheath.
Medial spread of local anesthetic may be required to block all the nerves; however, more medial placement of the needle may miss nerves that have penetrated into the rectus abdominis muscle laterally as was observed in a cadaver study. Our technique is to use a 10- to 15-mL volume to block the uppermost nerves, taking into account the variability in their course.

During hydrodissection along the oblique subcostal line, the needle passes lateral to the edge of rectus, beneath the widened aponeurosis of the linea semilunaris, and continues in the TAP deep into the internal oblique. Sometimes, in passing beyond the linea semilunaris, the hydrodissection extends between the internal and the external oblique muscles rather than in the deeper TAP (Fig. 7). This may be caused by the initial dissection starting superficial to the posterior rectus sheath. The needle should be retracted, the lateral edge of the rectus sheath pierced to the TAP, and hydrodissection continues.

For maintenance of block a catheter is passed through the needle to lie in the TAP. Blocks performed to date have been placed at the conclusion of surgery or as rescue blocks postoperatively. Epidural catheters (20-gauge Portex; Smiths Medical, Watford, UK), nerve block catheters (20-gauge Cointempex; B. Braun), or multiholed wound catheters (On Q painbuster soaker; I-Flow Corporation) can be positioned in the midzone of the required block area with blockade maintained up to 5 days. Infusions were generally commenced at 5 mL/hr bilaterally, and wound pain on subsequent days was treated with a 10-mL bolus of ropivacaine 0.2% bilaterally, and wound pain on subsequent days was treated with a 10-mL bolus of ropivacaine 0.2% and an increase in the infusion to 7 mL/hr bilaterally.

DISCUSSION

Ultrasound-guided TAP blocks are evolving, but currently, there seem to be 3 main approaches: posterior, subcostal, and oblique subcostal. Posterior block positioned laterally above the iliac crest results in sensory block below the umbilicus. Subcostal block positioned under the costal margin lateral to the rectus muscle blocks the periumbilical region. The oblique subcostal TAP block with hydrodissection was developed because of the limited spread associated with the posterior and subcostal approaches. In a cadaver model, a multiple-injection technique similar to our oblique subcostal technique resulted in spread of dye over a wider area and involved more segmental nerves compared with a single subcostal TAP injection with no hydrodissection. In the clinical setting, injecting local anesthetic along the entire oblique subcostal line may result in anesthesia of thoracolumbar nerves (T6–L1). In particular, injection medial to the linea semilunaris between the rectus abdominis and the transversus abdominis muscles close to the costal margin may increase the likelihood of blocking T6 and T7. L1 block is facilitated by injecting in the TAP close to the anterior part of the iliac crest.

Continuous catheter techniques are associated with excellent postoperative outcomes, therefore, continuous oblique subcostal TAP block may improve postoperative analgesia compared with a single-injection technique, although clinical outcomes are not part of this technical report. We have used continuous bilateral subcostal oblique TAP blocks in 42 consecutive cases between May 2007 and March 2009. Permission to report these clinical cases has been given by the ethical review committee of Northeast Health Wangaratta. The surgical case load included gastric and intestinal surgery, other open abdominal cavity surgery, and large incisional hernia repair with midline incisions usually extending above and below the umbilicus. Eight cases involved placement of blocks after the failure of other analgesic techniques. As a rescue technique, TAP blockade may be attractive to anesthesiologists in comparison to reinsertion of an epidural catheter in the postoperative period when low-molecular weight heparin may have been recently given. In addition, there are no special requirements in patient positioning. In most patients, multimodal analgesia, including intravenous patient controlled analgesia opioids was required because the segmental nerves do not innervate the visceral and the retroperitoneum. In this series, if wound pain was evident in the immediate postoperative period, a supplemental TAP block at one or both ends (depending on location of pain and/or tenderness on palpation) of the wound was given. The pattern of sensory block to ice was also used to guide therapy. Because the cutaneous sensory block only extends to the midclavicular line, more laterally placed drains or other puncture sites may not be covered. The optimal catheter position is unknown as is the relative advantages of end hole versus extensively fenestrated catheters. Technical difficulties that have been encountered include an inability to follow the TAP because of limitations in needle movement, having a needle too short to pass along the subcostal oblique line, and a distorted anatomy due to previous surgery. Dressings, previous abdominal surgery, air in the tissues, edema, wasting of the abdominal musculature, and obesity may make identification of the anatomy more difficult. Hence, the importance of describing the abdominal wall anatomy in detail in this current article.

Because initial injectates of up to 40 mL were used bilaterally, the concentration of local anesthetic was reduced to stay within known safe dosage limits for single-injection techniques. However, the optimal infusion regimen including the method of maintaining the analgesic block (by infusion or intermittent bolus) is not defined. Infusion rates in this series were limited to 28 mg/hr of ropivacaine, which has been shown to produce stable unbound plasma levels during prolonged epidural infusion. After ultrasound-guided posterior TAP block with lidocaine in 12 patients, plasma levels peaked at 30 minutes, although the highest individual level observed was at 15 minutes possibly by a more rapid absorption after intramuscular injection. Therefore, TAP block generally produces absorption similar to infraclavicular and axillary brachial plexus blocks, where ropivacaine reaches a peak plasma level in a mean time of 25 minutes, and slower than epidural and interscalene block, where ropivacaine reaches peak plasma levels in less than 20 minutes. As with other in-plane ultrasound-guided techniques, strict attention should be given to maintaining imaging of the needle tip, particularly when working with long needles. Maintaining an aseptic technique with respect to the ultrasound equipment is important. There were no complications associated with the use of continuous oblique subcostal TAP blockade in these 42 patients.

Our experience in teaching and performing oblique subcostal TAP block indicates that a detailed knowledge of the abdominal wall anatomy and competency in advancing the needle in-plane are required. Applying this knowledge and using the generic skills of ultrasound-guided regional anesthesia provide anesthesiologists with an opportunity to offer an alternative form of postoperative analgesia to patients after abdominal surgery. This brief report has reviewed the relevant anatomy and has described a new technique for continuous oblique subcostal TAP block. The role of this block versus more traditional epidural block or systemic analgesia should be the subject of future randomized controlled trials.

REFERENCES


