Ultrasound-Guided Transversus Abdominis Plane Blockade

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The application of ultrasound in regional anaesthesia has created renewed interest in peripheral nerve blocks for surgery on the thorax and abdomen. This has coincided with a decline in epidural use over the last decade. This trend has resulted from a lack of proven mortality benefit (MASTER trial), a move toward fast track surgery and early mobilisation, reduced access to high dependency beds and specialised care, and growing concerns about the risk of neuraxial complications both in the medical and lay community.

Rather than identifying specific nerves, ultrasound can be used to clearly identify fascial planes, bony landmarks and patterns of local anaesthetic spread to provide effective analgesia while minimising potential complications like vascular puncture or damage to underlying viscera.

TAP blocks have gained widespread use in Australia with the availability of ultrasound. They are useful to provide analgesia for the incisions of abdominal surgery. Local analgesia specific to the incision appears to provide good conditions for mobilising postoperative patients without motor block or hypotension. As the visceral component of postoperative pain is not reliably covered, they should be used as part of a multimodal analgesia regimen including an opioid.

The main approaches to this neurovascular plane of the abdomen are posterior and oblique subcostal. Posterior TAPs are useful for incisions below the umbilicus, usually performed as bilateral single-shot injections. The oblique subcostal approach is often associated with bilateral catheter insertion for ongoing analgesia with supra-umbilical or full length midline incisions.

Anatomy

The TAP is the neurovascular plane of the abdomen, continuous with the thoracic paravertebral space. It contains loose fascia, blood vessels, and the multiple branches of the anterior rami of the spinal segmental nerves from T7 to L1. Nerve plexuses are concentrated around the main vessels, the deep circumflex iliac artery and the superior and inferior epigastric arteries.

The transversus abdominis is the innermost muscle layer of the abdominal wall. The TAP plane is located immediately superficial to this muscle and its aponeurosis. The internal and external oblique muscles and aponeuroses are located superficial to the TAP plane. It is worth noting the surface anatomy of these muscles and their aponeurotic continuations, predicting what is visualized on the US screen. In particular note the lip of transversus abdominis muscle following below the costal margin and extending deep to the rectus muscle; this is the key to the subcostal approach. The oblique aponeuroses join to form the linea semilunaris, which attaches to the rectus sheath. The best appreciation of this anatomy is gained by scanning whole abdomens, as it is a consistent pattern.

Near the midaxillary line the nerves give off a lateral branch which penetrates the overlying muscle to supply the skin of the lateral abdominal wall. The anterior branches continue forward to pierce the lateral rectus sheath to supply this muscle and the skin overlying it. Blocks performed anterior to the midaxillary line would only be expected to
anaesthetise the anterior branches, TAP blocks to encompass the flank region need to be performed more posteriorly.

The nerve runs a variable length deep to the rectus sheath before piercing it; the nerves of T7-9 may run only a short course in the TAP – thus the oblique subcostal approach should be performed close to the costal margin and begin deep to the lateral part of the posterior rectus sheath. It is worth noting the course of the ilioinguinal nerve in the TAP plane is variable. Branches of L1, the ilioinguinal and iliohypogastric nerves, may remain deep to the transversus abdominis and iliac crest and enter the TAP plane after the mid axillary line; TAP blocks intended to include the ilioinguinal nerve should be performed anterior to this line. Beyond the ASIS, these nerves may pierce the internal oblique and run between the oblique muscles. The nerves can often be identified in the plane with an accompanying blood vessel, so colour flow helps. TAP/ilioinguinal blocks for hernia repair and Pfannensteil incisions may be best placed just cephalad to the ASIS.

**Posterior TAP block**

These are usually performed as a single shot blocks for lower abdominal surgery. Unilateral blocks can be used for inguinal hernia repair and appendicectomy, with midline and Pfannensteil incisions requiring bilateral injections. Correctly placed posterior TAPs should provide analgesia from the umbilicus to symphysis pubis. While catheters can be used, studies have demonstrated a duration of action from a single injection beyond 24h. (1)

While originally described as a ‘double-pop’ technique without the use of ultrasound (2), the availability of quality ultrasound systems has greatly increased their popularity in Australia. Ultrasound has been shown to improve the accuracy of injection and may reduce the risk of visceral injury (3,4). There is some debate about which approach is more efficacious. There is some evidence form MRI studies that TAP injectate spreads to the paravertebral space; McDonnell postulates that this explains why TAPs performed more anteriorly may be less efficacious (5). On the other hand, if the inguinal area needs to be covered, placement closer at the anterior axillary line will perhaps more reliably account for the course of the ilioinguinal nerve.

Most anaesthetists get plenty of opportunity to perform these in anaesthetised patients, distant to major vascular/neural structures and viscera – making them an ideal beginner’s block. Time to practice the in-plane technique! Once the learning curve is conquered it should only take a couple of minutes each side.

Ergonomics are important. I stand on one side of the patient with the US machine on the opposite side. While both sides can be blocked from the one approach, it is less ergonomic so while learning, swap sides – it will probably be faster.

I use a high frequency 50mm linear probe set at 8-10MHz. Utilising harmonics/THI (tissue harmonic imaging) often makes the fascial planes more apparent. Angling the probe and using variable probe pressure will also help identify the anatomy. I use a 100–120mm short bevel needle. Sonographic needles such as the Pajunk sonoplex often help as the tip needs to be seen at a depth of >3cm. To help with needle visibility, insert the needle at least 2-3cm away from the probe, allowing a flatter trajectory. ‘Heeling’ the
probe or using a beam steer function, so the US waves are more perpendicular to the needle, is another useful trick.

Aim to fill the plane between the deeper two muscle layers from the costal margin to the iliac crest around the mid axillary line, distending it with at least 20mls of local anaesthetic solution, 0.375 or 0.5% ropivacaine depending on what I consider a safe dose for my patient.

When imaging this area, a few simple rules will help you find the correct plane –

1. Transversus abdominis is the deepest muscle layer. It is thinner and appears darker than the obliques. Occasionally a fat layer may separate the TA from the peritoneum and should be distinguished form muscle.

2. If uncertain, image more anteriorly to identify the linea semilunaris at the edge of the rectus muscle below the umbilicus. As you scan laterally from here you will note the three muscle layers arising from this structure.

3. Subcutaneous fat compressed beneath the probe may appear as another muscle layer. The above manouvre and varying the pressure applied to the probe will help you to identify this.

4. If using a short bevel needle, you should appreciate a subtle pop as you traverse from external into internal oblique muscle. There is another subtle pop as you leave internal oblique and enter the TAP plane. Because the fascia is dragged by the blunt needle tip, you may need to advance the needle further beyond the level of the plane to feel it. On occasion you will not feel a pop but observe tissue recoil on the screen.
5. Pay careful attention to the pattern of spread of the initial injection. If in the TAP plane you will observe spread of injectate along the plane in a lentiform shape. Injecting into muscle causes a more diffuse swelling and highlights muscle fibers. This is usually internal oblique – advance the needle under vision, look and feel for the pop, and try again. If in TA, withdraw slightly while injecting and observe for the change in pattern of spread. While learning it may help to inject saline initially and change to local anaesthetic when the desired spread is observed.

Oblique Subcostal TAP catheter insertion

This technique is better suited to midline incisions that extend above the umbilicus or upper midline incisions compared to posterior TAP block. Compared to epidural, lower limb motor block, hypotension, urinary catheterization, and concerns about neuraxial complications and anticoagulation are avoided - gaining approval with ward nurses and surgeons as well as anaesthetists. In addition, this is a useful technique when a planned laparoscopic procedure has evolved into a midline incision, as the catheters can be safely inserted under anaesthesia. Unilateral subcostal incisions, such as open cholecystectomy, are better suited to paravertebral analgesia.

To date there is one prospective study comparing epidural infusion to subcostal catheter boluses for upper abdominal incisions, demonstrating no difference in pain scores(6), and at least 5 randomised placebo-controlled trials currently underway examining their efficacy for midline abdominal incisions(7).

This is a more advanced technique than posterior TAP block, and can provide a large area of coverage. Hydrodissection- distending the plane with injectate, advancing the needle to the leading edge, and injecting again to open up the plane, allows broader coverage and creates a space for catheter insertion and subsequent injections. It requires a degree of dexterity with probe and needle. I usually insert a catheter, aiming to extend the block for 3-5 days, requiring proper sterile technique.

I usually perform this injection in anaesthetised patients at the end of surgery. It is preferable that the patient be mechanically ventilated, as spontaneous ventilation movements tend to make the procedure more difficult. I request the surgical drapes be left on (if not contaminated) and the surgical dressing not applied (this avoids inserting the catheter through the dressing – with predictable results should the dressing be later changed!). Stoma bags can be a nuisance, depending on their position (gentle skin traction by an assistant may help).

Remember to stay close to the costal margin, this is where you will find transversus below the rectus sheath. The upper nerves only have a short course in the plane in this region before penetrating the rectus sheath. Use colour flow before you begin to identify the superior epigastric artery.

I use a long (11cm) 18G Tuohy needle. Ideally, a 15-20cm needle would provide longer hydrodissection and potentially better coverage. It is helpful to impart a ~20 degree angulation in the distal third of the needle to control the tip on advancement, as it can be difficult to direct the needle anteriorly in the plane once the needle has traversed the abdominal wall.

I introduce the needle from medial to lateral through rectus muscle, close to the costal margin and xiphisternum where transversus can be seen. Upon reaching the posterior rectus sheath, I usually inject a few mls of local anaesthetic solution (thus combining a lateral rectus sheath block to hopefully catch the uppermost nerves) before advancing.
through it. Once a pop is felt, or the layer recoils on the sonogram, begin injecting again. Spread along the TAP should be seen (if transversus swelling occurs, withdraw the needle while injecting to observe for the characteristic spread), then begin hydrodissection along the costal margin. Take care not to enter the plane between the oblique muscles. To extend the block to the lower abdomen, advance along the costal margin and towards the anterior superior iliac spine. Sometimes needle withdrawal and resiting into the plane more distally can help.

Sterile setup for subcostal catheter insertion. Note insertion point and assistant to provide injection.
Diagram of correct plane for subcostal oblique block. Top right diagram shows direction of needle on abdomen. Lower diagram shows incorrect spread between oblique muscles. Note curve on needle - initially faces up then down.
RA (rectus abdominis) TA (transversus abdominis) A (aponeurosis/linea semilunaris) IO (internal oblique) EO (external oblique) IC (iliac crest) LA (local anaesthetic) X=incorrect spread
TAP catheters should be utilized as part of a multimodal analgesic regimen. Patients need an oral or PCA opioid and adjuvants to provide visceral analgesia in the early postoperative period. After the first postoperative day, somatic analgesia becomes more relevant to aid mobilization and the opioid-sparing effect becomes apparent.

Local anaesthetic delivery via bilateral TAP catheters deserves some consideration. The two options are continuous infusion or intermittent bolus. There are advantages and potential problems with each. To date there is no comparative data as to which delivery technique is optimal.

Intermittent bolus has the advantage of providing the patient with minimal attachments, reducing the risk of dislodgement and improving mobility. Spread through the plane is likely more extensive when it is distended by a bolus, potentially offering more complete coverage. The main disadvantage of this approach is the potential for inadvertent intravenous injection and systemic toxicity. While education and hospital protocols help reduce the risk, this concern can be addressed by using unique local anesthetic delivery connectors (such as the Correct Inject from Portex, Smith Medical), recently arrived on the market, with matching pre-filled syringes supplied from pharmacy. Resistance to injection of 20ml down an 18G epidural catheter has been overcome using the Springfusor device (Go Medical).

At Geelong Hospital ward nurses have delivered intermittent bolus for more than 250 patients with TAP catheters, after completing an education package. Patients receive 20mls 0.2% ropivacaine to each catheter, 6 hourly (i.e. 320mg ropivacaine over a 24h period). Most patients report reduced pain, especially with movement, following a bolus. A few selected patients have received 4 hourly injections to improve their analgesia. The results of an audit of these patients are available in poster form at this conference.
Continuous infusion via electronic or balloon infusor devices have been adopted by some other institutions. While the safety concern of inadvertent intravenous bolus is addressed, most have used two local anaesthesia pumps to deliver the infusions (0.2% ropivacaine @ 5-7ml/h each side). This has cost implications as well as increased risk of dislodgement and nursing complexity.

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