

## Update for Nurse Anesthetists

### Transversus Abdominis Plane (TAP) Blocks

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*Transversus abdominis plane (TAP) blocks are a relatively new regional anesthetic technique used in a multimodal approach to provide postoperative analgesia of the anterolateral abdominal wall. The technique for placing TAP blocks has evolved from a landmark technique to an ultrasound-guided technique. There are 3 common approaches for accessing the TAP: subcostal, midaxillary, and ilioinguinal-iliohypogastric. The distribution of local anesthetic and the extent of sensory blockade differs with each of these approaches. The approach used is contingent on the type and location*

*of the surgical procedure. Overall, TAP blocks reduce postoperative pain and opioid requirements, resulting in fewer side effects such as nausea and vomiting, respiratory depression, and sedation. Future studies should examine which type, concentration, and volume of local anesthetics are most effective.*

**Keywords:** Hydrodissection, neurofascial plane, somatic and visceral pain, transversus abdominis plane, ultrasound-guided.

#### Objectives

At the conclusion of this educational activity, the reader should be able to:

1. Describe the benefits of multimodal analgesia.
2. Describe the muscles and innervation of the abdominal wall.
3. Compare the various approaches to placing a transversus abdominis plane (TAP) block and their impact on distribution.
4. Compare TAP blocks to epidural analgesia.
5. Identify the risks and complications associated with performing TAP blocks.

#### Introduction

The perioperative management of pain following abdominal surgery can pose a challenge to anesthesia providers. Conventional practice has involved the use of opioids as well as neuraxial analgesic techniques. Unfortunately, these therapies are not without potential risks and side effects. These include nausea, vomiting, pruritus, urinary

retention, constipation, respiratory depression, and sedation.<sup>1</sup> As a result, the goal to reduce perioperative pain has taken on a multimodal approach.

Multimodal or “balanced” analgesia uses a combination of opioid and nonopioid analgesics to improve pain control and minimize opioid related side effects.<sup>2</sup> These include the use of nonsteroidal anti-inflammatory drugs, local anesthetics, peripheral nerve blocks, gabapentinoids, and  $\alpha_2$  adrenergic agonists.<sup>3,4</sup> Any combination of these therapies can help reduce the surgical stress response and improve patient outcomes such as pain control, patient satisfaction, time to discharge, and return to daily activities.<sup>2,5,6</sup>

One method used in this multimodal approach is the transversus abdominis plane (TAP) block. This block, as first described by Rafi<sup>7</sup> in 2001, provides analgesia to the anterolateral abdominal wall. In 2007, McDonnell et al<sup>8</sup> further studied this technique in patients undergoing large-bowel resection. He discovered a reduction in postoperative pain and morphine consumption in the

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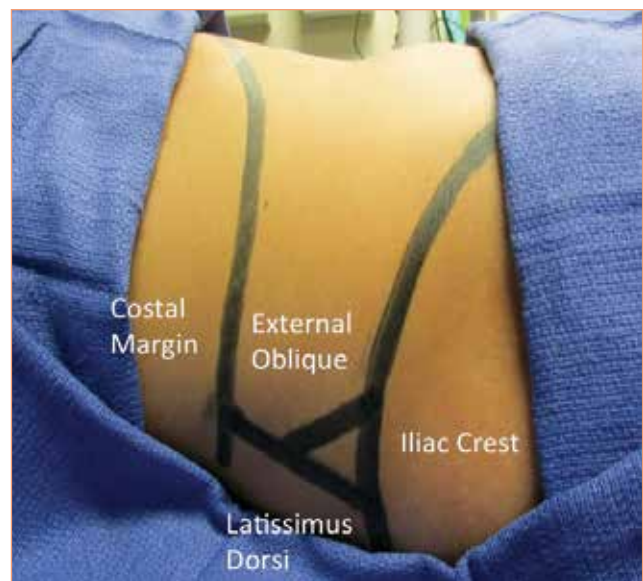
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first 24 hours postoperatively, resulting in fewer opioid-mediated side effects. In this same year, Hebbard et al<sup>9</sup> described the use of ultrasound guidance to provide real-time imaging of the muscle layers and needle placement to improve TAP block accuracy. In 2008, Hebbard<sup>10</sup> described the subcostal approach of TAP blocks, to target the nerves of the upper abdomen. Transversus abdominis plane blocks continue to be studied and developed as an effective method for providing analgesia for numerous types of abdominal surgeries.<sup>11-24</sup>

- **Anatomy.** The lateral abdominal wall is composed of several layers. These include, from anterior to posterior, the skin, superficial fascia, external oblique muscle, internal oblique muscle, transversus abdominis muscle, transversalis fascia, and peritoneum. The medial aspects of the 3 muscles are aponeurotic and form the linea semilunaris.<sup>25</sup> This tendinous groove in the external abdominal wall travels along the lateral edge of the rectus abdominis muscle from the ninth rib to the pubic tubercle. Located between the internal oblique and transversus abdominis muscles is a neurofascial plane, known as the transversus abdominis plane (TAP). This layer contains the anterior rami of the intercostal nerves T7 through T11, subcostal nerve T12, and the ilioinguinal and iliohypogastric nerves L1.<sup>26</sup> These nerves travel within the TAP and undergo multiple divisions before providing sensory innervation to the skin, muscles, and parietal peritoneum of the anterolateral abdominal wall.<sup>27</sup>

- **Landmark Technique.** In a 2001 letter, Rafi<sup>7</sup> described the TAP block using a landmark technique. He identified surface anatomical landmarks to locate the triangle of Petit as a way to introduce local anesthetic into the TAP. The triangle is formed by the external oblique muscle, latissimus dorsi muscle, and the iliac crest (Figure 1). After identification of the triangle of Petit, a blunt-tip, 24-gauge, 5.08-cm (2-in) needle is inserted perpendicular to the skin just cephalad to the iliac crest.<sup>7</sup> As it is advanced, a double “pop” sensation should be appreciated, indicating passage of the needle through the fascia extensions of the external and internal oblique muscles. After the second “pop,” the needle tip should be within the TAP and the local anesthetic can be deposited.

Early reports of the landmark technique<sup>7,8</sup> showed the results were inconsistent because of difficulty locating anatomical landmarks, especially in obese patients. Furthermore, the nerves to be blocked were not present in the TAP at this location. A cadaveric study by Jankovic et al<sup>28</sup> showed the position of the triangle of Petit varied in size and shape, and was more posterior than previously reported. The success rate with this approach had been reported as high as 85% when administered by an experienced provider.<sup>29</sup> However, McDermott et al<sup>30</sup> in 2012 found that the needle tip and local anesthetic spread were inaccurately placed in 76% of patients who



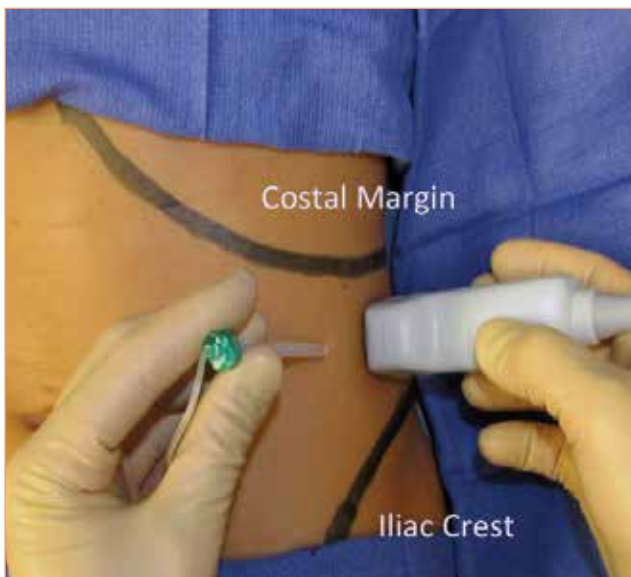
**Figure 1.** Anatomical Landmarks Used for the Identification of the Triangle of Petit



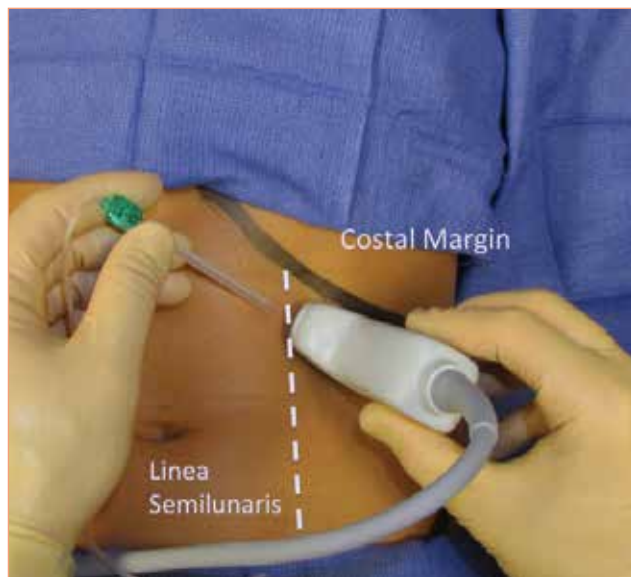
**Figure 2.** Ultrasound Image of the Lateral Abdominal Wall Muscles Using the Mid-Axillary Approach

received a TAP block with the landmark technique. Of these, 18% were found to be intraperitoneal.

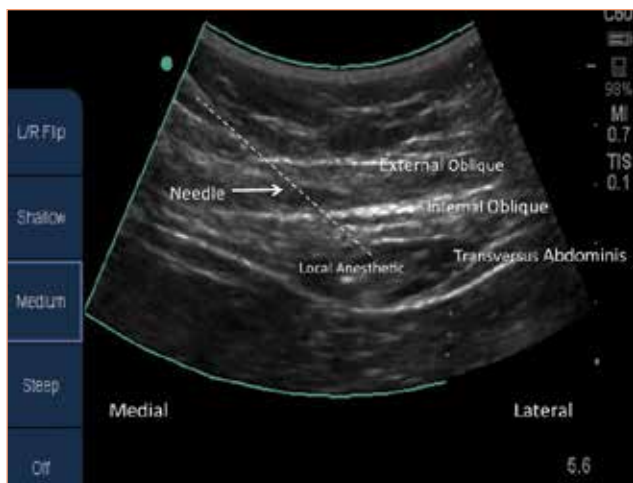
- **Ultrasound-Guided Midaxillary Approach.** In 2007, Hebbard et al<sup>9</sup> described the use of ultrasound guidance for the placement of TAP blocks. This allows for the identification of the muscle layers as well as accurate placement of the needle and local anesthetic (Figure 2). The ultrasound probe is placed in a transverse position along the midaxillary line between the costal margin and iliac crest where the nerves are located before extensive branching occurs<sup>28</sup> (Figure 3). The needle is inserted medial to the ultrasound transducer and advanced in a medial to lateral direction using an in-plane approach.<sup>27</sup> This allows for real-time imaging of the needle as it advances through the muscle layers. Once the needle tip reaches the TAP, 1 to 2 mL of normal saline or local



**Figure 3.** Positioning of the Ultrasound Transducer and Needle for Performing a Mid-Axillary TAP Block



**Figure 5.** Positioning of the Ultrasound Transducer and Needle for Performing a Subcostal TAP Block

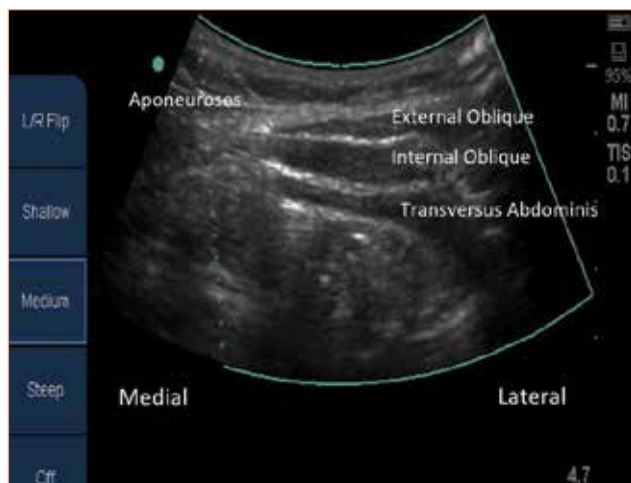


**Figure 4.** Ultrasound Image of Local Anesthetic After It Has Been Injected into the TAP Using the Mid-Axillary Approach. *Note the hydrodissection.*

anesthetic can be injected to confirm needle placement. The injected solution will appear as a hypoechoic or dark area between the fascial layers (Figure 4). The remaining volume of local anesthetic is injected, and further hydrodissection of the fascial layers can be appreciated with ultrasonography.

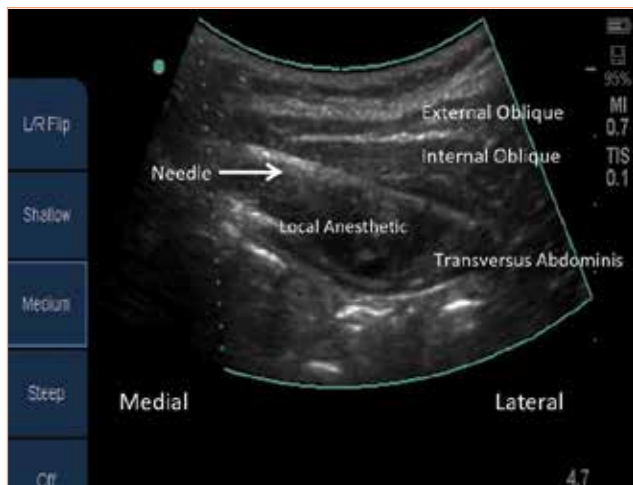
The TAP block may be performed with several different needle sizes and types. Factors such as patient size, type of block, and user preference should be considered. Needle lengths range from 50 to 110 mm with a gauge of 18 to 22. Needle tips may be of the Tuohy, Sprotte (Teleflex), or facet types. The anesthesia provider can also elect to use a nonstimulating, echogenic needle to improve needle visualization during ultrasound imaging.

- **Ultrasound-Guided Subcostal Approach.** As an al-

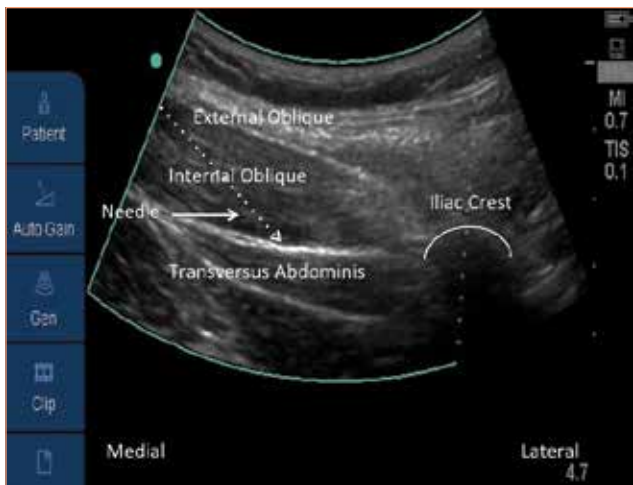


**Figure 6.** Ultrasound Image of the Lateral Abdominal Wall Muscles Using the Subcostal Approach

ternative to the midaxillary approach, Hebbard<sup>10</sup> introduced the subcostal approach to provide analgesia for supraumbilical surgical procedures. With this approach, the ultrasound transducer is placed immediately inferior and parallel to the costal margin near the linea semilunaris (Figure 5). Ultrasonography should reveal the aponeuroses of the external oblique, internal oblique, and transversus abdominis muscles<sup>31</sup> (Figure 6). The needle is inserted medial to the transducer and is advanced in an inferolateral direction, parallel with the costal margin, until the needle tip reaches the TAP. Placement is confirmed and local anesthetic is administered in incremental doses to help hydrodissect and distend the TAP (Figure 7). After each dose, the needle is advanced along the costal margin within the TAP to assist with the spread of the local anesthetic around the intercostal nerves.<sup>25</sup>



**Figure 7.** Ultrasound Image of Local Anesthetic After It Has Been Injected into the TAP Using the Subcostal Approach. Note the hydrodissection.



**Figure 9.** Ultrasound Image of the Lateral Abdominal Wall Muscles Using the Ilioinguinal-Iliohypogastric Approach



**Figure 8.** Positioning of the Ultrasound Transducer and Needle for Performing the Ilioinguinal-Iliohypogastric Approach

- **Ultrasound-Guided Ilioinguinal-Iliohypogastric Approach.** The first lumbar spinal nerve divides and gives rise to a superior branch, the iliohypogastric nerve, and an inferior branch, the ilioinguinal nerve. Both nerves pierce the transversus abdominis muscle and enter the TAP just medial and superior to the anterior superior iliac spine.<sup>26</sup> They innervate the skin over the inguinal area as well as the upper and medial aspect of the thigh.<sup>27</sup>

When performing this block, the ultrasound transducer is placed perpendicular to the skin approximately 2 cm superior and 2 cm medial to the anterior superior iliac spine (Figure 8). The external oblique, internal oblique, and transversus abdominis muscles are identified (Figure 9). The needle is inserted medial to the transducer and advanced in plane using a medial to lateral direction until the needle tip reaches the TAP and local anesthetic is deposited. This provides analgesia for inguinal herniorrhaphy; however, the hernia sac is innervated by visceral

nerves and may require supplemental local anesthetic by the surgeon.<sup>26</sup>

- **Local Anesthesia.** The analgesic effect of the TAP block is dependent on the surgical procedure, block technique, local anesthetic dose and volume, and timing of injection.<sup>32</sup> There is no clear consensus regarding the optimal local anesthetic type, dose, or volume of injection. This has led some investigators to use a weight-based dose of local anesthetic, whereas others use a predetermined injection volume. This may increase the risk of local anesthetic toxicity in patients with low body weight. According to Hebbard,<sup>25</sup> a typical local anesthetic dose of ropivacaine in adults is 200 mg (or the maximum subtoxic dose) diluted with 40 to 80 mL of 0.9% saline. A larger volume is used to facilitate hydrodissection of the TAP and improve the spread of the block. Based on recommendations from the manufacturer, the maximum dose of ropivacaine is 2.5 mg/kg up to 300 mg. When patients are heavier than 100 kg, the maximum dose may be subtherapeutic, making the block ineffective.<sup>32</sup>

The addition of dexamethasone and/or epinephrine may prove beneficial to the TAP block. One study showed that adding dexamethasone (8 mg) to the local anesthetic agent prolonged the duration of the block and decreased the incidence of nausea and vomiting.<sup>33</sup> Another study demonstrated that the addition of epinephrine 5 µg/mL to the local anesthetic reduced the peak plasma concentration after unilateral TAP blocks, with no remarkable effects on block characteristics or duration.<sup>34</sup> The onset of the sensory block appears to be relatively slow, requiring as long as 60 minutes to reach maximal effect. If possible, the block is placed before surgery or at the start of surgery to give adequate time for the onset of analgesia.<sup>26</sup>

- **Block Distribution.** Sensory afferent nerve branches of the lower 6 thoracic and upper lumbar nerves innervate the anterior abdominal wall and are the therapeutic

target of local anesthetics.<sup>32</sup> The distribution and spread of local anesthetics within the TAP are dependent on the site of injection. According to McDonnell et al,<sup>35</sup> a sensory block was achieved from T7 to L1 via the triangle of Petit. Further clinical studies showed a lower level of sensory block from T10 to L1 using the triangle of Petit and ultrasound-guided midaxillary approaches.<sup>27</sup> These appear most useful for lower abdominal surgery. When a higher level of sensory blockade is preferred, the subcostal approach described by Hebbard<sup>10</sup> should be chosen. The author demonstrated a sensory block up to T7, with some sparing of the L1 segment noted.<sup>10</sup>

Magnetic resonance imaging (MRI) analysis revealed a significant time-dependent expansion of injectate. In addition, MRI findings and the degree of dermatomal anesthesia confirmed that the upper and lateral TAP compartments do not appear to communicate. Separate injections at the subcostal and midaxillary plexuses are necessary to block the entire abdominal wall.<sup>36</sup> In a study by Milan et al,<sup>37</sup> local anesthetic spread in cadaver models showed that dye injected through subcostal, midaxillary, and lumbar triangle of Petit approaches demonstrated different nerve involvement. The subcostal approach was associated with a larger and more cephalad spread compared with the midaxillary and lumbar triangle of Petit approaches. The area of dye spread for the subcostal approach was 85.1 cm<sup>2</sup> and covered dermatomes T7 through T12. Dye spread for the midaxillary approach was 58.9 cm<sup>2</sup> and covered dermatomes T10 through L1, and dye spread for the lumbar triangle of Petit approach was 77.9 cm<sup>2</sup> and covered dermatomes T10 through L1.<sup>37</sup> This study supports that the lumbar triangle of Petit and midaxillary approaches are more appropriate for lower abdominal surgery, covering dermatomes T10 through L1 and that the subcostal approach is better suited to upper abdominal surgery, covering dermatomes T7 through T12.<sup>37</sup>

• **Indications.** The analgesic efficacy of TAP blocks has been described for numerous abdominal surgeries, including abdominal hysterectomy, inguinal hernia repair, bariatric surgery, colorectal surgery, renal transplant, laparoscopic cholecystectomy, cesarean delivery, prostatectomy, and appendectomy.<sup>11-23</sup> These blocks can be administered as a unilateral or bilateral block for midline incisions and laparoscopic surgeries.<sup>38</sup> In cases requiring prolonged analgesia, an indwelling catheter may be placed to provide a continuous infusion of local anesthetic.<sup>17,21</sup>

Transversus abdominis plane blocks provide somatic pain relief by blocking nerves that innervate the skin, muscles, and parietal peritoneum of the anterolateral abdominal wall. However, they do not provide visceral pain relief when the surgical procedure traverses the peritoneum into the abdominal cavity. As a result, TAP blocks should be used as a component of multimodal analgesia. Studies have demonstrated a 70% reduction in the consumption of morphine during the first 24 hours

postoperatively, as well as a 50% reduction in postoperative nausea and vomiting.<sup>8</sup> In addition, TAP blocks can be used as a rescue block after surgery when other methods of pain therapy have been unsuccessful.<sup>39</sup>

• **Transversus Abdominis Plane Block versus Epidural Analgesia.** Epidural analgesia has been considered the gold standard for providing pain relief following major abdominal surgery.<sup>40</sup> This technique has the advantage of providing both visceral and somatic pain relief, whereas the TAP block provides only somatic pain relief. Despite this limitation, TAP blocks have minimal hemodynamic effects, making them an acceptable technique for the hypotensive patient.<sup>41</sup> The motor and sensory functions of the lower limbs are spared and the technique is nonsedating, resulting in earlier ambulation following abdominal surgery.<sup>41</sup> The TAP block should be considered an alternative approach to providing postoperative analgesia when an epidural is contraindicated.

• **Risks and Complications.** Absolute contraindications to TAP blocks include patient refusal, infection of the abdominal wall and skin, or abnormality at the needle insertion site.<sup>42</sup> Obesity may make both the landmark and ultrasound approaches more challenging, but it is not a contraindication to the TAP block. According to Young et al,<sup>42</sup> despite a relatively low risk of complications and a high success rate using modern techniques, TAP blocks remain overwhelmingly underutilized. Even with the high safety profile, recent reports of vascular, visceral, and nerve injuries following TAP block, both with and without ultrasound guidance, have been documented. One study showed that the needle and local anesthetic placement using the landmark approach (without ultrasound guidance) is often inaccurate, and the incidence of peritoneal placement is “unacceptably high.”<sup>30</sup> Other potential complications, including inadvertent intravascular injection of local anesthetic, infection, and catheter breakage, have also been cited.<sup>32</sup> In a recent systematic review of 9 randomized controlled trials by Johns et al,<sup>32</sup> there were no reported complications following TAP blocks. Seven of the 9 studies used ultrasound guidance, 1 study utilized direct visualization by the surgeon, and 1 study used a blind technique.<sup>32</sup> Block failure and allergic reactions to local anesthetics should also be considered.

There are no published reports in the English language of local anesthetic toxicity following a TAP block. Although direct intravascular injection of local anesthetics is unlikely with a TAP block, studies suggest that systemic toxicity is possible, and caution should be exercised throughout drug delivery.<sup>42</sup> Reports of liver lacerations caused by right-sided TAP blocks have been noted in the literature with both the landmark and ultrasound techniques. The liver should be palpated before a right-sided TAP block is performed with continuous needle visualization using ultrasound guidance.<sup>42</sup> Theoretically, the spleen and/or kidneys are at risk during the TAP

block, although no reports of injuries to these organs were found during a thorough literature search.<sup>42</sup> Partial or complete femoral nerve block can occur inadvertently as the local anesthetic injected into the TAP tracks along the transversalis fascia to the fascia iliaca, which passes over the femoral nerve.<sup>42</sup>

## Conclusion

Transversus abdominis plane blocks are a relatively new technique used in a multimodal approach to provide postoperative analgesia following abdominal surgery. It is considered a technically simple block to perform, with a high margin of safety, especially with ultrasound guidance.<sup>42</sup> Studies have shown that the consumption of intravenous morphine has been reduced with use of this block, resulting in fewer opioid-mediated side effects. Further studies should focus on which type, volume, and concentration of local anesthetic is most beneficial. In addition, more research should assess which approach to a TAP block provides the best level of sensory blockade.

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