EDITORIAL VIEW

Transversus abdominis blockade: Ready for use in the pediatric population?

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SUMMARY

Postoperative pain and the associated potential adverse effects have been a major concern for the anesthesiologists since the advent of the practice of anesthesiology. The optimal means of providing postoperative analgesia in the pediatric patient has been a challenging task, and various combinations have been tried to lessen the side effects. Regional techniques in pediatric population have seen some crests in popularity in the past but the use of ultrasound and MRI guidance has added precision in the techniques and boosted confidence of the anesthesiologists. Transversus abdominis plane or TAP block has now made its way into the pediatric population and this editorial provided a supplementary source of information to the a review article and two case reports on similar topic in this issue of Anesthesia, Pain & Intensive Care.

Key words: Postoperative pain; Regional analgesia; Transversus abdominis plane block

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Over the last half-century, significant progress has been made in the understanding and treatment of pain in infants and children. The first step was the rejection of previously held myths that neonates, infants, and children do not perceive or react to pain because of the immaturity of their peripheral and central nervous systems. In fact, the opposite has been demonstrated even in preterm neonates as clinical studies have revealed that a painful stimulus results in the elevation of biochemical markers to levels that are several times greater than those seen in the adult population.[1] The inadequate treatment of pain during infancy may have long lasting consequences related to neuroplasticity including the development of chronic pain syndromes or a heightened sensitivity to subsequent painful stimuli.[2] Despite the recognition of the importance of postoperative analgesia and the potential adverse effects of acute and postoperative pain, significant pain occurs during the postoperative period in both the inpatient and outpatients settings.[3-5]

The question then remains what is the optimal means of providing postoperative analgesia in the pediatric patient? The time-honored therapy for pain is the administration of opioids by various routes and techniques, most usually patient or nurse-controlled analgesia for severe pain. Although generally effective, several deleterious adverse effects may occur with opioids including respiratory depression, sedation, and slowing of gastrointestinal motility.[6] These may result in significant morbidity and even mortality in critically ill postoperative patients with co-morbid conditions. In an effort to improve postoperative analgesia while limiting opioid-related adverse effects, there continues to be interest in the use of regional anesthetic techniques. While many of these techniques were initially used and popularized in the adult population, their use was eventually introduced in infants and children.

In the pediatric population, given its simplicity, the caudal epidural block remains the most commonly used regional anesthetic technique. However, there is also an increasing interest in the use of peripheral nerve blockade in infants and children. The literature clearly demonstrates the efficacy and applicability of such techniques even in the youngest pediatric patient.[7-9] The available literature suggests that peripheral nerve blockade may have a lower incidence of adverse effects when compared with neuraxial techniques including caudal analgesia.[10]

Although regional anesthesia in infants and children started with caudal anesthesia, progressing over the years to commonly used adult peripheral techniques such as axillary and femoral blockade, other techniques are now being used in the pediatric population. As illustrated in this issue of *Anaesthesia, Pain, and Intensive Care*, the transversus abdominis plane or TAP block has now made its way into the pediatric population. In this issue, Galante et al provide a thorough and well-written review of the published reports of this novel technique in the pediatric population while Yuratich et al present their anecdotal experience with the use of bilateral TAP catheters to provide intraoperative and postoperative analgesia following urologic surgery in a patient with spinal dysrhaphism which precluded the use of caudal anesthesia.

The TAP Block: History:

The TAP block was first described by Rafi and then later popularized and studied in greater detail by McDonnell et al as a means of providing analgesia following lower abdominal procedures.[11,12] Subsequently, several prospective trials have demonstrated its efficacy in limiting opioid needs following procedures such as Cesarean section, hysterectomy, and prostatectomy.[13-17] The efficacy of the TAP block can be demonstrated by a prospective randomized trial that included a cohort of 50 adults following Cesarean delivery.[15] A bilateral TAP block with 0.2 mL/kg of 0.75% ropivacaine resulted in decreased postoperative pain scores, delayed request for postoperative analgesia, and decreased morphine use during the initial 48 postoperative hours.[14] The median time to first request for postoperative analgesia was 90 minutes in the control group (no block) and 220 minutes in patients who received a TAP block. Morphine use during the initial 48 hour postoperative period was decreased by 70% in patients who received a TAP block (66 ± 26 mg in control patients versus 18 ± 14 mg in patients who received a TAP block, $p < 0.001$).

TAP Block: Anatomy & Technique:

As originally described, the TAP block provides analgesia by the placement of the local anesthetic solution between the internal oblique and the transversus abdominis muscles using an injection in the triangle of Petit. The lateral abdominal wall is composed of 3 muscle layers including the external oblique, the internal oblique, and the transversus abdominis muscles. The thoracolumbar nerve roots of T_8 to L_1, which provide sensory innervation of the skin, muscles, and parietal peritoneum of the anterior abdominal wall, travel in a plane between the internal oblique and the transversus abdominis muscles. A single injection of a local anesthetic agent, administered in the triangle of Petit, can be used to block these nerves and interrupt sensory innervation of the lower abdominal wall. The triangle of Petit is bounded posteriorly by the latissimus dorsi muscle, anteriorly by the external oblique muscle, and inferiorly by the iliac crest.

The TAP block was initially performed using a double-pop or loss of sensation technique which is felt as the needle penetrates the external oblique and the internal oblique muscles, thereby lying in the plane between the internal oblique and transversus abdominis muscle layers. As with other regional anesthetic techniques, ultrasound guidance has greatly facilitated placement of the TAP block. The ultrasound high-frequency probe is placed in the axial plane in the triangle of Petit just above the iliac crest. A needle is inserted in line with the probe so that the needle can be visualized in the correct fascial plane prior to injection of the local anesthetic solution. Alternatively, the probe can also be placed more anteriorly, immediately lateral to the umbilicus so that the rectus sheath can be visualzied.[18,19] This approach is suggested in the pediatric population to allow for a more thorough spread of the local anesthetic solution thereby providing more effective analgesia of the anterior abdominal wall. The ultrasound probe is then moved slightly laterally to delineate the three layers of the abdominal wall: external oblique, the internal oblique, and transverse abdominis. The probe is stationed lateral on the anterior abdominal wall at a 70-90° angle with the patient's bed. A needle is inserted utilizing the 'in-plane' technique from the medial aspect of the probe between the internal oblique and the transversus abdominis. Injection of the local anesthetic agent creates an elliptical opening of the potential space in which the nerves traverse (see below for dosing regimens in the pediatric population).

TAP block: Pediatric Reports:

As outlined nicely by the review article of Galante et al published in this issue of *Anaesthesia, Pain & Intensive* Care, the TAP block is not just for the adult population. However, the TAP block does hold the notoriety of being the most recent regional anesthetic technique to be added to the pediatric anesthesiologist's armamentarium. The first reports of the use of the TAP block in pediatric patients appeared in 2008-2009.[17.22]

Mukhtar and Singh used the TAP block to provide analgesia following laparoscopic appendectomy in 4 patients who ranged in age from 14 to 17 years.[17] A bilateral TAP block was placed using 20 mL of 0.25%

bupivacaine per side with ultrasound guidance. No patient required supplemental analgesic agents for the initial 12 postoperative hours with all having pain scores ranging from 0 to 2. Two patients required no analgesic agents during their entire postoperative course. Tobias reported the successful use of TAP block in a cohort of 10 pediatric patients, ranging in age from 8 months to 10 years.[20] The TAP block was placed bilaterally using 0.3 mL/kg of 0.25% bupivacaine with epinephrine. The surgical procedures included bilateral ureteral reimplantation (n=3), laparoscopy for evaluation of abdominal pain (n=2), colostomy takedown (n=2), laparoscopic appendectomy (n=2), and bilateral inguinal hernia repair (n=1). The TAP block was judged to be successful in 8 of the 10 patient as no postoperative analgesic agents were needed for the initial 7 to 11 postoperative hours.

As with any single shot technique, the most significant drawback may be the duration of action, which can be expected to be twelve hours at best. Although this may be effective for many surgical procedures, more prolonged analgesia may be desirable for more involved procedures. As such, continuous infusions are now being used in selected cases. These infusions may be delivered by standard infusion pumps or disposable, home infusion (elastomeric devices) devices. To date, there is a paucity of such reports in pediatric-aged patients. Taylor et al reported the successful placement of TAP catheters to provide postoperative analgesia in 2 pediatric patients with spinal dysraphism.[23] The report by Yuratich et al in this issue of *Anaesthesia, Pain & Intensive* Care adds to the experience with this novel technique of TAP block and potentially eliminates the drawback of a single shot technique, a short duration.

TAP Block: Caveats and Concerns:

As with any regional anesthetic technique, there are concerns, contraindications, and complications specific to the TAP block. Unlike neuraxial techniques (spinal or epidural anesthesia), the TAP block does not replace opioids, it merely decreases the need. The TAP block provides only superficial analgesia of the abdominal wall and not of the visceral structures. As such, supplemental parenteral opioids are frequently required. Furthermore, the TAP block is a postoperative analgesic technique and unlike many other regional anesthetic techniques, it is not generally meant to be used instead of general anesthesia. Despite this, there are anecdotal reports of the use of a TAP block with intravenous sedation to provide anesthesia during superficial abdominal procedures such as placement of a paracentesis catheter in patients with significant co-morbid conditions.[24,25] Adverse effects have been relatively limited including anecdotal reports of hepatic damage related to the needle.[26,27] One other report describes the inadvertent placement of a catheter into the peritoneal space.[28] It is anticipated that the likelihood of such events should be decreased by the use of ultrasound guidance. As with most regional anesthetic techniques in infants and children, the greatest risk lies in the dose of local anesthetic. General recommendations for single shot techniques include total bupivacaine or ropivacaine in doses of less than 3 mg/kg. For other types of regional blockade, ultrasound has been shown to allow the use of decreased volumes of local anesthetic solution as the mediation is injected using direct visualization thereby ensuring its precise location. However, from the early days of epidural infusions in infants and children, we have learned valuable lessons regarding the significant morbidity that may occur with the use of local anesthetic infusions.[29-31] There are limited data in the adult literature and none in the pediatric literature regarding plasma concentrations of local anesthetic agents following TAP blocks. In a prospective trial of adults undergoing open gynecological surgery, a bilateral TAP block was placed using 3 mg/kg of ropivacaine under ultrasound-guidance.[32] The peak total ropivacaine concentration, which occurred 30 minutes following injection, was 2.54 ± 0.75 μg/mL. The highest measured concentration was 4.00 μg/ml. Mean total concentrations remained above 2.20 μg/mL for up to 90 minutes following injection. The mean unbound peak concentration was 0.14 ± 0.05 μg/mL with a peak of 0.25 μg/mL. The authors concluded a TAP block using 3 mg/kg of ropivacaine produces venous plasma concentrations that are potentially neurotoxic, although generally consistent with plasma levels found after injection at other sites. These data stress the importance of caution when using local anesthetic infusions especially in the pediatric population. Additionally, further pharmacokinetic data are needed for both single shot and continuous techniques in infants and children. Until such studies are completed, we need to be cautious with our dosing of local anesthetic agents and stay within the currently recommended infusion rates for these agents in children.[33] Bolus doses should be limited to 3 mg/kg while infusions should limited to no more than 0.3 mg/kg/hour. Further decreases should be considered in neonates and infants less than 6 months of age or patients with hepatic dysfunction. Given concerns of accumulation of bupivacaine with continuous infusions, until further data are available, ropivacaine may be a more conservative choice.[34]

Following its introduction into the adult population, as summarized in the review article of Dr. Dario

Galante et al, the TAP block has now made its way into the pediatric population. As with any regional anesthetic technique, although easily learned, one must gain proper experience with the technique under appropriate supervision before introducing it into their practice. The use of ultrasound is suggested to facilitate the safe and successful performance of the block. The TAP block may offer an alternative when neuraxial techniques are contraindicated or impossible including bleeding disorders and coagulopathy, spinal dysraphism, bony anatomical abnormalities (VACTERL association), patients who have had previous laminectomy or spinal fusion, and those with altered intracranial compliance. With these caveats in mind, the TAP block appears to be a valuable adjunct to the practice of pediatric regional anesthesia.

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