Beyond the caudal: truncal blocks an alternative option for analgesia in pediatric surgical patients

Jodi-Ann Oliver and Lori-Ann Oliver

**Purpose of review**
To discuss and compare the more commonly used truncal blocks with neuraxial techniques in children undergoing a variety of thoracic, abdominal, and urological procedures.

**Recent findings**
Owing to the advent of ultrasonography and its increasing use in regional anesthesia, there has been a renewed interest in implementing these techniques in children for intraoperative and postoperative pain management.

**Summary**
The use of regional anesthesia, particularly with ultrasound guidance, is an integral part of pain management during the intraoperative and postoperative period in children who undergo surgery. Its use is essential in improving patient pain control and overall satisfaction as well as decreasing hospital stay and reducing hospital admission after surgery. Truncal blocks serve as an excellent alternative to neuraxial blockade, in patients who have a contraindication to neuraxial blockade, patients undergoing a unilateral procedure and those in an outpatient ambulatory setting undergoing routine procedures, wherein the adverse effects of neuraxial blockade such as motor weakness, difficulty ambulating, urinary retention, increased nausea and vomiting, may delay same day discharge.

**Keywords**
neuraxial anesthesia in children, pediatric regional anesthesia, peripheral nerve blocks, truncal blocks

---

**INTRODUCTION**
The use of regional anesthesia is now at the forefront of management of intraoperative and postoperative pain in pediatric patients undergoing a variety of surgical procedures. This renewed interest in pediatric regional techniques is largely because of two reasons: improvement in postoperative pain scores and improvement in safety of these procedures. Firstly, regional anesthesia has been associated with a reduction in postoperative pain scores, improvement in overall patient satisfaction, decreased opioid use and associated side-effects, reduction in hospital length of stay and remission rates for uncontrolled postoperative pain [1]. Secondly, the advent and use of ultrasonography has improved visualization of needle placement and vital structures, which has improved the safety profile of these invasive procedures and significantly reduced procedure-related complications [2].

Despite the increased use of peripheral nerve blocks in pediatric surgical patients, the caudal, a form of neuraxial block, still remains the gold standard and is the most widely used regional technique for this patient population for a variety of abdominal, thoracic, and orthopedic procedures. However, the use of neuraxial blocks has been associated with side-effects such as urinary retention, nausea, vomiting, and difficulty ambulating, which can delay hospital discharge especially following routine outpatient ambulatory procedures [3]. As a result, peripheral nerve blocks particularly truncal blocks have been used more in this patient population with equivalent if not superior analgesia and minimal side-effects. The aim of this review is to compare the use of truncal blocks with the current gold standard, neuraxial blockade especially the caudal block, in pediatric patients undergoing abdominal and thoracic surgery.

Department of Anesthesiology, Yale New Haven Hospital, New Haven, Connecticut, USA

Correspondence to Jodi-Ann Oliver, MD, Yale-New Haven Children’s Hospital, 1 Park Street, 3rd Floor, New Haven, CT 06510, USA. Tel: +1 (203) 785 2802; fax: +1 (203) 785 6664; e-mail: jodi-ann.oliver@yale.edu

Curr Opin Anesthesiol 2013, 26:644–651
DOI:10.1097/ACO.0000000000000021
The truncal blocks can be divided into two categories: anterior and posterior, with the anterior division consisting of TAP, rectus sheath block, and ilioinguinal and iliohypogastric blocks (IL/IH). The posterior truncal blocks consist of paravertebral (PVB) and intercostal blocks. In this article, we will focus on the most widely used truncal blocks for intraoperative and postoperative analgesia in the pediatric surgical population: TAP block, rectus sheath block, ilioinguinal and iliohypogastric blocks and paravertebral block.

**TRANSVERSUS ABDOMINIS PLANE BLOCK**

TAP block has been increasingly used to provide postoperative analgesia that is comparable with the gold standard, caudal epidural analgesia, in children undergoing abdominal procedures, with none of the side-effects such as urinary retention, limited mobility and increased opioid use often associated with neuraxial blockade. The posterior truncal blocks consist of paravertebral (PVB) and intercostal blocks. In this article, we will focus on the most widely used truncal blocks for intraoperative and postoperative analgesia in the pediatric surgical population: TAP block, rectus sheath block, ilioinguinal and iliohypogastric blocks and paravertebral block.

**ANATOMY AND TECHNIQUES**

The TAP block was first described as a landmark technique by Rafi in 2001 involving placement of blunt needle in the triangle of Petit, an area bounded posteriorly by the latissimus dorsi muscle, anteriorly by external oblique muscle and the iliac crest inferiorly [4]. The abdominal wall consists of three muscle layers: external oblique, internal oblique and transversus abdominis muscles, from superficial to deep, respectively. Sensory innervation for the anterolateral abdominal wall is provided by the anterior rami of T6–L1 and intercostal nerves (T7–11), the subcostal nerve (T12), iliohypogastric and ilioinguinal nerves (L1), which travel in this plane between the transversus abdominis and internal oblique muscles (Fig. 1) [5,6].

A blunt needle is advanced perpendicular to the skin until a single pop or tactile sensation of loss of resistance was felt, indicating proper needle placement, and local anesthetic is then injected. McDonnell et al. in 2006 ascribed the double pop technique in which loss of resistance is noted by needle penetration first through the external oblique fascia and internal oblique muscles with final entry into the plane between internal oblique and transversus abdominis muscles [7,8]. The use of ultrasound guidance using a high-frequency linear probe is now the preferred technique for TAP block placement under general anesthesia. The needle is visualized with real-time ultrasound with in-plane technique, in which the probe is placed in the axial plane of the triangle of Petit or lateral to the umbilicus following visualization of the rectus sheath [9**]. The needle is then inserted in the plane between the internal oblique and the transversus abdominis muscles and local anesthetic is incrementally injected (Fig. 2) [10].
INDICATIONS

TAP blocks have been used in children for a variety of urologic and abdominal procedures [11] and in situations, in which neuraxial procedures are contraindicated or considered too risky [12]. Visoiu et al. [13] showed in a small retrospective study that TAP catheters could be effectively used to provide adequate postoperative analgesia in infants with low body weight and in which neuraxial techniques were contraindicated or with difficult placement secondary to sacral-spinal abnormalities. Bielsky et al. [14] also demonstrated the efficacy of TAP block in two case reports involving two infants weighing 2.5 and 3.1 kg, respectively, in which TAP blocks were used to effectively manage pain after urgent colostomy; one patient had congenital anomalies that included imperforated anus with club feet and seventh cranial nerve paralysis, whereas the other had only anal atresia. TAP blocks can also be used in cases, in which there are relative contraindications to neuraxial blockade such as bleeding disorders, in patients after laminectomies and in patients with potential bony anatomical abnormalities such as VATER syndrome [15,16].

TAP blocks have been shown to provide postoperative analgesia in children undergoing abdominal surgeries with reduced postoperative opioid use. Sahin et al. [17] demonstrated, in a randomized comparative study, involving 60 patients, ages 2–8 years, that ultrasound-guided TAP blocks provided superior postoperative analgesia when compared with wound infiltration performed by the surgeons. Patients in the TAP block group had longer intervals before the need for breakthrough analgesia and a significantly lower cumulative dose of total analgesics when compared with those in the wound infiltration group. Though a greater volume of local anesthetic was used for patients undergoing TAP block, the results are consistent with other studies that show that TAP blocks provide a longer duration of analgesia in comparison with wound infiltration, and wound infiltration is only effective in the immediate postoperative period, whereas TAP block remains effective for up to 24 h [17].

COMPLICATIONS

The TAP block is associated with perforation of abdominal viscera, peritoneal puncture and intravascular injection, which is of particular concern in small infants and children [18]. These risks are significantly reduced with the use of ultrasound guidance and in fact a review of the literature indicates that these complications are relatively rare, when the block is performed under ultrasound guidance [9].

RECTUS SHEATH BLOCK

Schleich [19] first described the use of the rectus sheath block in 1899 in adult patients, to provide relaxation of the anterior abdominal wall. Rectus sheath blocks have also been used for women undergoing open and laparoscopic gynecological procedures [20–22] and to augment postoperative analgesia in patients after midline laparotomy [23,24]. Ferguson et al. in 1996, then Courreges et al. in 1997 [25,26], described the use of the rectus sheath block for providing analgesia for children undergoing umbilical hernia repair. This block has been used not only for umbilical hernia repairs, but also for pyloromyotomies and procedures with midline laparoscopic incisions [27].

ANATOMY AND TECHNIQUES

The umbilical area is innervated by the right and left thoracoabdominal intercostal nerves, derived from the anterior rami of spinal roots T8–T12. The nerves pass from behind the costal cartilage and travel in the plane between the transversus abdominis muscle and internal oblique muscle. The rectus sheath has an anterior and a posterior wall, with the tendons of the internal and external oblique muscles forming the anterior wall and the tendon of the transversus muscle forming the posterior wall. The nerves run between the sheath and the posterior wall of the rectus abdominis muscle, innervating the muscle and ending as the anterior cutaneous branch supplying the cutaneous area of the umbilicus. Anatomical variations have been identified, with the nerves either coursing beneath or on top of the rectus abdominis muscle before ending at the umbilicus (Fig. 3) [28].
Traditionally, the rectus sheath block has been performed using landmarks, in which a 23-gauge needle is placed above or below the umbilicus about 0.5 cm medial to linea semilunaris. The anterior rectus sheath is identified by moving the needle back and forth until a scratching sensation or click is felt [25,26]. Because of the inaccuracy of this technique, most rectus sheath blocks are performed today using ultrasonography. Willschke et al. [29] demonstrated, using ultrasonography, that there was a poor correlation between the depth of the rectus sheath and the height, weight and body surface area of children and effectively argues the point that the use of ultrasonography is a more reliable and superior technique. A high frequency probe is placed perpendicular to the umbilicus and the linea alba is identified in the midline with the rectus muscles laterally. The needle is then inserted using the in-plane technique and local anesthetic is injected in a potential space between the rectus abdominis muscle and posterior sheath just superior to the peritoneum [30**,31].

**INDICATIONS**

Rectus sheath block has been used to provide intraoperative and postoperative analgesia in children undergoing procedures involving the midline abdominal wall and umbilical areas as well as procedures with a single incision through the umbilicus such as laparoscopic appendectomies [28**,29,30**, 31,32]. Rectus sheath blocks have also been used successfully in pediatric patients with chronic abdominal pain caused by abdominal cutaneous nerve entrapment, iatrogenic peripheral nerve injury, myofascial pain syndrome or of unknown cause [33].

**COMPLICATIONS**

The rectus sheath block has been associated with bowel perforation and damage to abdominal organs because of the close proximity of the needle to the peritoneum. There have also been reports of intravascular injection involving the inferior epigastric artery and retroperitoneal hematoma [34]. These complications have significantly been reduced with the use of ultrasonography [35]. Polaner et al. conducted a multicenter study, which reviewed pediatric regional blocks and their associated complications. Based on his database, 294 rectus sheath blocks were performed in which 256 (87%) of these blocks were performed with the use of ultrasound and no adverse events or complications were noted [36**].

**ilioinguinal and iliohypogastric nerve blocks**

The ilioinguinal/iliohypogastric block is a commonly used peripheral nerve block technique used for children undergoing groin or urologic surgeries. It has been shown to be equivalent or better than caudal block and is associated with minimal side-effects and complications.

**ANATOMY AND TECHNIQUES**

The ilioinguinal and iliohypogastric nerves (T12–L1) travel below the internal oblique within its aponeurosis 1–3 cm medial to the anterior superior iliac spine (ASIS). This block can be performed with the use of landmarks or ultrasonography. The landmark technique involves identifying the ASIS and a mark is made 2 cm medial and 2 cm superior to the initial mark and the needle is inserted perpendicular to skin; two pops are appreciated after the needle passes first through the external oblique muscle and then the internal oblique muscle; local anesthetic is then injected [37]. Another landmark technique involves placing the needle one-third of the way between the ASIS and the umbilicus and injecting local anesthetic after feeling a pop or click when the needle passes through the internal oblique and is the space between the internal oblique and transversus abdominis muscle [38**]. This block is more commonly performed with the use of a high-frequency linear probe placed at ASIS facing the umbilicus; the layers of the abdominal muscles are identified and the nerves are located between the internal oblique and transversus abdominis muscle; local anesthetic is injected in this potential space (Fig. 4). The use of ultrasound is associated with a higher success rate compared with landmark technique as demonstrated by Weintraud et al. [39].
INDICATIONS

Ilioinguinal/iliohypogastric nerve blocks are commonly used to provide analgesia for surgery involving the inguinal region and groin area such as inguinal hernia repair, orchiopexy and hydrocelectomy. Abualhassan et al. performed a randomized prospective study in which 50 children ages 1–6 years scheduled for unilateral groin surgery were randomized into either use of a caudal or an ultrasound-guided ilioinguinal/iliohypogastric nerve block. Those in the ilioinguinal/iliohypogastric nerve block group were noted to have a longer time to first rescue analgesia 253/102.6 min compared with 219.6/48.4 min in the caudal group and more children in the caudal group required rescue medications in a day-stay unit or at home compared with the ilioinguinal/iliohypogastric nerve group [40]. He also noted that the use of ultrasound allowed for lower doses of local anesthetic solution compared with caudal block and significant reduction in complications. Willschke et al. clearly demonstrated in a prospective study that ultrasound-guided technique was superior to landmark technique in accuracy and had a higher success rate [41]. These findings were confirmed by Bhatpara et al. who showed that IL/IH nerve blocks provide longer postoperative analgesia and better safety margin, as lower doses of local anesthetic can be used compared with caudal block in children undergoing herniotomy [42].

PARAVERTEBRAL NERVE BLOCKS

PVBs were first described in 1905 by Hugo Sellheim but were not utilized extensively until the last 15 years when the block was felt to be a viable alternative to epidural or caudal blockade in certain patient populations. PVBs have been shown to not only be safer but also to provide similar analgesic benefits for managing postoperative pain as well as delaying the recurrence of tumors and metastases when compared to epidurals [47]. This technique was first utilized in children undergoing surgery by Lonnqvist in 1992 and has been subsequently used to provide postoperative pain control in children undergoing thoracic, abdominal or urogenital procedures with postoperative pain control equivalent to or superior to neuraxial blockade with fewer side-effects [48].

ANATOMY AND TECHNIQUES

The paravertebral space is a potential space that exists lateral to the spinous process, which contains the intercostal and sympathetic nerves and is bordered anteriorly by the parietal pleura, medially by the posterolateral aspect of the vertebra and the intervertebral foramen, laterally by the parietal pleura and posteriorly by the costotransverse ligament. The paravertebral space has been estimated to be 1 cm caudal to the transverse process and 2.5 cm lateral to the spinous process in most adults and is affected by multiple factors [49]. Naja et al. [50] measured the paravertebral space using nerve stimulation technique and showed that the distance from skin to the paravertebral space was influenced by BMI, which significantly affected the paravertebral space depth at upper (T1–3) and lower (T9–12) thoracic levels but had no effect at the mid (T4–8) thoracic level. Chelly et al. [51] further showed that the depth of the paravertebral space is also influenced by factors other than weight (BMI) such as age, height and thoracic level.

In children, identifying the correct location and depth of the paravertebral space is of utmost importance in decreasing complications such as pneumothorax or pleural puncture, which are rare but complications especially when ultrasound is utilized. Most complications include bowel puncture or intravascular injection [43]. Other complications such as pelvic hematoma [44], femoral nerve palsy [45] and quadriceps muscle paresis [46] have occurred during ilioinguinal/iliohypogastric block placement when utilizing the conventional landmark technique.
Beyond the caudal: truncal blocks an alternative option for analgesia in pediatric surgical patients

Oliver and Oliver

The paravertebral nerve block can be performed using landmark, loss of resistance, neurostimulation or ultrasound guidance. The classic or landmark technique involves identifying the spinous process and marking the skin laterally at the level of the transverse process and using a Tuohy needle to contact the posterior surface of the transverse process [54]. Once the transverse process is contacted, the distance from the skin to transverse process is measured and the needle is withdrawn to skin and angled at 15 to 60 degrees and advanced 1 cm caudally beyond the transverse process and local anesthetics can be injected slowly following a negative drop technique. Chelly [55] describes the drop technique in which a drop of fluid is injected on the top of the needle to check for respiratory variations before catheter placement. Loss of resistance technique is similar to the classic technique but employs the use of a loss of resistance syringe or pressure transducer that is filled with saline and connected to the Tuohy needle and advanced until there is a notable loss of resistance. The neurostimulation technique employs the use of an insulated Tuohy needle, which is connected to a nerve stimulator, and a motor response in the intercostal or abdominal muscles is elicited [56]. The ultrasound can also be utilized to visualize the paravertebral space using a high-frequency linear 10–15 MHz probe placed perpendicular (lateral or intercostal approach) or parallel (sagittal approach) to the spinous process and has become the standard technique utilized in children undergoing surgery under general anesthesia [57]. In larger children and adolescents, the use of a low-frequency curvilinear 2–5 MHz probe may offer better visualization of the paravertebral space in comparison with the high-frequency linear probe (Fig. 5).

**INDICATIONS**

The PVB is a versatile technique, as it can be performed at every spinal level and has been increasingly used as an alternative to neuroaxial blockade for a variety of reasons. Koyyalamudi et al. [58] used a continuous cervical (C5) PVB with a continuous thoracic (T5) PVB to provide postoperative analgesia for a 10-year-old child undergoing a forequarter amputation for an osteosarcoma of the left humerus, where a brachial plexus block would have provided ineffective postoperative analgesia. Visoiu and Yhang [59] used ultrasound-guided bilateral thoracic paravertebral catheters to treat postoperative pain following bowel resection in an opioid tolerant and mildly coagulopathic pediatric patient, in which epidural placement was contraindicated. Berta et al. showed that a single-injection PVB at T10–12 level was as efficacious in controlling postoperative pain when compared with continuous paravertebral catheters for children undergoing major renal surgery [60].

PVBs have also been used in outpatient ambulatory settings, in which faster postoperative recovery and same-day discharges are essential. In this specific patient population, the single shot caudal has been the gold standard but has been associated with short duration of analgesia, requiring the use of supplemental analgesia in the immediate postsurgical period as well as unwanted side-effects such as urinary retention and motor weakness, which can delay patient discharge. PVBs have been associated with prolonged analgesia that exceeds the expected duration of the local anesthetics administered when compared with caudals or epidurals. Tug et al. showed in a small prospective study involving...
70 children from ages 3–7 that a single L2 paravertebral injection provides analgesia that is superior to caudal placement in children undergoing inguinal surgery. Patients in the paravertebral group had decreased need for supplemental analgesics (11.4 vs. 34.3%) because of increased duration of analgesia with a mean duration of 1300 min (range: 120–1440 min), lower block failure rates (5.7 vs. 11.4%) and higher parental satisfaction scores (74.3 vs. 40%) [61].

COMPLICATIONS

PVBs are rarely associated with complications, which include pneumothorax and pleural puncture, bleeding, epidural or intrathecal spread, infection, nerve injury, hypotension and spinal headache [62**]. Naja et al. conducted a prospective trial with 662 patients including 42 children in which PVBs were placed using neurostimulation technique. He reported a 6.1% failure rate in the adults with complications such as hypotension, inadvertent vascular puncture, epidural and intrathecal spread, pleural puncture, hematoma and pneumothorax in the adults with no failures or complications noted in the children [63]. Berta et al. also reported a complication rate of 8.3% involving two inadvertent intravascular injections in a small study group of 24 patients [60].

SUMMARY

The use of regional anesthesia techniques in children has increased, largely in part because of the advent of ultrasonography, which has improved the efficacy and the safety profile of these blocks. Also peripheral nerve blocks provide excellent intraoperative and postoperative pain control, by reducing the use of opioids and its associated adverse effects. Truncal blocks offer an excellent alternative to neuraxial blockade in patients with contraindications as well as in outpatient ambulatory procedures, in which the adverse effects of neuraxial blockade such as motor weakness, difficulty ambulating and urinary retention may delay same day discharge. The use of peripheral nerve blocks in children will continue to increase and it is imperative for pediatric anesthesiologists to embrace and master these techniques, as they offer immense benefits to improving the perioperative pain management of their patients.

Acknowledgements

None.

Conflicts of interest

There are no conflicts of interest.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

- of special interest
- of outstanding interest


This article provides a review of the literature regarding the benefits of regional anesthesia over other forms of analgesia in children.


This report reviews the complications and risks in pediatric regional anesthesia and discusses the use of ultrasonography in terms of improving the safety profiles of regional techniques.


This article is a review of the available literature regarding core and trunk blocks in infants and children and specifically focuses on the TAP, ilioinguinal/iliohypogastric nerve, rectus sheath, lumbar plexus, and paravertebral and intercostal nerve blockade. This article includes the common indications, complications, anatomy and techniques for the above-stated blocks.


This article reports the use of unilateral TAP catheters for analgesia in six low weight children, following single-sided open lower abdominal surgery when epidural analgesia was undesirable. This article also highlights the use of TAP catheters, though technically challenging, as a feasible option for analgesia for surgeries involving the lower ‘abdominal wall’ in very small patients.


This study compared the efficacy of ultrasound-guided TAP block with wound infiltration and was able to demonstrate that ultrasound-guided TAP patients had longer postoperative analgesia and reduced analgesic use in comparison with the wound infiltration group in children undergoing unilateral inguinal hernia repair.


Beyond the caudal: truncal blocks an alternative option for analgesia in pediatric surgical patients

Oliver and Oliver


29. This review focuses on commonly used trunk blocks and highlights the indications, anatomy and techniques: both landmark and ultrasound-guided and complications of each block.


32. This article is a review of the available literature regarding core and trunk blocks in infants and children and specifically focuses on the TAP, ilioinguinal/iliohypogastric nerve, rectus sheath, lumbar plexus, and paravertebral and intercostal nerve blocks. This article also includes the common indications, complications, anatomy and techniques for the above-stated blocks.


39. The Pediatric Regional Anesthesia Network is a multicenter study, which obtained data on practice patterns and complications involving the use of regional anesthesia in infants and children. This article highlights a low rate of complications in the United States, which is comparable with the data from large multicenter European studies.


42. This article is a review of the available literature regarding core and trunk blocks in infants and children and specifically focuses on the TAP, ilioinguinal/iliohypogastric nerve, rectus sheath, lumbar plexus, and paravertebral and intercostal nerve blockade. This article also includes the common indications, complications, anatomy and techniques for the above-stated blocks.


45. This study was designed primarily to determine whether ultrasound-guided ilioinguinal/iliohypogastric nerve blocks could provide comparable postoperative analgesia to blind technique caudal block in children undergoing unilateral lower limb surgery, with secondary endpoints such as analgesic consumption, parental satisfaction, and postoperative complications. They were able to show that ultrasound-guided IL/II nerve blocks provide ideal postoperative analgesia for unilateral lower limb surgery in children and are as effective as caudal block, with a lower volume of local anesthetics used.


53. This article provides a comprehensive review of paravertebral nerve blocks: the anatomy, techniques, indications and complications associated with these blocks.


55. This article is a review of the available literature regarding core and trunk blocks in infants and children and specifically focuses on the TAP, ilioinguinal/iliohypogastric nerve, rectus sheath, lumbar plexus, and paravertebral and intercostal nerve blockade. This article also includes the common indications, complications, anatomy and techniques for the above-stated blocks.


57. This article provides a comprehensive review of paravertebral nerve blocks: the anatomy, techniques, indications and complications associated with these blocks.


59. This article compared the effectiveness of a single injection PVB to epidural blockade in patients undergoing major renal surgery and was able to show that the single-injection PVB resulted in similar analgesia but with greater hemodynamic stability than the epidural blockade and may be recommended for patients with coexisting circulatory dysfunction.


61. This article provides a comprehensive review of paravertebral nerve blocks: the anatomy, techniques, indications and complications associated with these blocks.


67. This article provides a comprehensive review of paravertebral nerve blocks: the anatomy, techniques, indications and complications associated with these blocks.

68. This article is a review of the available literature regarding core and trunk blocks in infants and children and specifically focuses on the TAP, ilioinguinal/iliohypogastric nerve, rectus sheath, lumbar plexus, and paravertebral and intercostal nerve blockade. This article also includes the common indications, complications, anatomy and techniques for the above-stated blocks.