Day surgery regional anesthesia in children: safety and improving outcomes, do they make a difference?

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Purpose of review
The objective of this review is to provide an overview of recent developments in pediatric regional anesthesia and elucidate outcomes as it relates to patient safety and overall satisfaction.

Recent findings
Since the inception of the Pediatric Regional Anesthesia Network database, the acquisition of data has enabled the pediatric anesthesiologist to extrapolate results and translate them into useful outcomes. Despite the growing trend to provide regional anesthesia in the pediatric population, there continues to be a paucity of available research studies to evaluate outcomes of various regional nerve blocks. This review serves as a conduit to explore the most recent data available, in each regional anesthetic technique, as it relates to outcomes such as analgesia, patient safety and satisfaction.

Summary
Despite the limited number of randomized controlled trials evaluating the safety of individual regional anesthetic techniques, the growing body of data, such as presented in the Pediatric Regional Anesthesia Network database, suggests a high degree of safety in performing various regional anesthetic modalities. Modern medicine should continue to embrace the use of regional anesthesia, particularly in the ambulatory setting, to reduce perioperative pain and improve patient outcomes.

Keywords
patient safety, pediatric regional anesthesia, peripheral nerve blocks, Pediatric Regional Anesthesia Network database

INTRODUCTION

Few studies have evaluated the characterization and presence of postoperative pain in children in the ambulatory setting. History has demonstrated that in the pediatric population, hospitalized patients exhibit a relatively high prevalence of moderate-to-severe pain in the postoperative period [1–2]. Despite the increased application of regional anesthesia, research remains limited regarding the comparative efficacy of various techniques in reducing postoperative pain in pediatric surgical procedures [3]. The use of ultrasound guidance and its increasing availability continues to allow greater access to regional techniques in the pediatric population. Ultrasound has revolutionized our ability to safely administer nerve blocks particularly in a population in which targeted neural structures are often very close to other critical anatomical structures [4]. To that end, at least in the adult population, an ultrasound-guided technique has demonstrated a higher success rate when compared with a nerve stimulator-guided technique [4].

In an effort to extend beyond the barriers of limited comparable research in pediatric regional anesthesia, the Pediatric Regional Anesthesia Network (PRAN) was established in 2006. The aim of PRAN is to facilitate data collection on regional anesthesia techniques from multiple, large-scale institutions providing primarily pediatric anesthetic care. The PRAN database provides details regarding

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KEY POINTS

- The PRAN database continues to elucidate a high degree of safety in supporting the utilization of regional anesthetic techniques in the pediatric ambulatory setting.
- Current data are suggestive that the use of peripheral nerve blocks is safe in children, few comparative studies exist in order to compare outcomes.
- Current data provide strong support that truncal blocks such as the ilioinguinal/hypogastric, rectus sheath, TAP and paravertebral are safe and effective techniques when compared with other modalities of pain control.
- The use of PNCs in the ambulatory setting allows the benefit of extended analgesia that would minimize the risk of hospitalization secondary to poor pain control.
- The use of neuraxial techniques remains safe and efficacious in providing analgesia; however, the application of a newer modality (ultrasound guidance) should enhance utility and improve future outcomes.

practice patterns, adverse events and complications as it relates to regional anesthetic techniques in the pediatric population [5▪▪]. In effect, the PRAN database serves as an up-to-date conduit of information in the exploration of safety outcomes as it relates to regional anesthesia techniques in all clinical settings. To date, the PRAN database identifies over 100 000 nerve blocks performed on pediatric patients, with American Society of Anesthesiologists Physical Status classification 1 and 2 patients constituting over 80% of the total blocks in the PRAN network [5▪▪]. As the PRAN database continues to increase, emerging studies should elucidate the impact that regional anesthesia has on the pediatric population.

UPPER EXTREMITY

Upper extremity nerve blocks, as encompassed by the PRAN database, include interscalene/parascalene, supraclavicular, infraclavicular, axillary, musculocutaneous, elbow and wrist. Few studies have evaluated outcomes of upper extremity peripheral nerve blocks in the pediatric population. The most recent published PRAN database analysis substantiates this paucity of literature by reporting only 455 upper extremity nerve blocks performed, the lowest number of blocks of all the respective single-shot injection groups [5▪▪]. With respect to all upper extremity nerve blocks, failed block and inadequate intraoperative analgesia were reported as the most common complications, with an overall complication rate of 2% [5▪▪].

Since 2008, practice guidelines published by American Society of Regional Anesthesia and Pain Medicine supported the safety and efficacy of placing peripheral nerve blocks under general anesthesia in the pediatric population [6▪,7▪]. The notable exception to this practice guideline was the interscalene brachial plexus block. However, Taenzer *et al.* [7▪] evaluated data from the PRAN network in 2014 comparing the incidence of adverse events and complications related to interscalene blocks in patients under general anesthesia. This investigation found that the overall risk of neurologic or cardiovascular complications in interscalene blocks performed under general anesthesia was not statistically different from those performed awake. The rate of adverse events in the use of interscalene blocks were reported as zero percent when 98% of these blocks in anesthetized patients were performed under ultrasound guidance [5▪▪]. The prior notion that interscalene nerve blocks cannot be performed safely in an anesthetized pediatric patient is not supported by current evidence.

LOWER EXTREMITY

Studies comparing the efficacy of lower extremity peripheral nerve blocks remain relatively scant (less than six exist). These historical studies have suggested that the use of lower extremity peripheral nerve blocks results in lower pain scores and less postoperative opioid consumption. At present, no comparative study exists evaluating the efficacy of lower extremity peripheral nerve blocks in the pediatric population. In an article published by Kuo *et al.* [8], examining data from 1996 to 2006 prior to the establishment of the PRAN database, Kuo demonstrated that there was a marked increase in the number of peripheral nerve blocks performed in the ambulatory orthopedic population. Lower extremity nerve blocks tripled during this period (2.2–9.2%), whereas neuraxial techniques declined (1.1–0.4%). These data were obtained from results taken from the Centers for Disease Control and Prevention's National Health Survey and may in fact represent an evolving trend in the future utility of pediatric lower extremity regional anesthesia.

The current PRAN database identifies lower extremity nerve blocks as lumbar plexus/psoas compartment blocks, fascia iliaca, femoral, sciatic, popliteal fossa, saphenous and other/unspecified. Historical analysis of the PRAN data, as presented by Polaner *et al.* [5▪▪], demonstrated a 1% complication rate in the lower extremity group. The highest complication rate occurs in the lumbar plexus/psoas compartment block with a complication rate of 8%. The highest complications were described as

failed block, inadequate analgesia or abandoned block. Given the relatively high number of lower extremity blocks performed and the likely continued increased use in outpatient ambulatory orthopedic procedures, studies characterizing the outcomes of lower extremity peripheral nerve blocks will be necessary.

TRUNCAL

Truncal nerve blocks are performed in various surgical procedures, but their utility may diminish in the ambulatory setting for peripheral nerve blocks such as the paravertebral block. However, a recent meta-analysis by Hamill *et al.* [9▪▪] indicated that the use of a rectus sheath block and transversus abdominis plane (TAP) block reduced both pain and opiate use in children. Therefore, it is prudent to evaluate truncal blocks and their potential use in the pediatric ambulatory surgical setting especially as the utility of neuraxial techniques decreases with increasing age and body size.

For the purposes of the PRAN database, truncal nerve blocks are identified as TAP block, rectus sheath blocks, ilioinguinal/iliohypogastric nerve blocks and paravertebral. The PRAN database indicates an overall complication rate for truncal nerve blocks of 0.3%. Failed block/inadequate analgesia, abandoned block and vascular puncture were identified as the most common complications.

In recent years, the TAP block has increased in popularity in order to provide analgesia after pediatric surgeries involving the abdominal wall (e.g. laparoscopic surgery). The variability in success of the TAP block has been associated with a number of factors including anatomic site of injection (posterior placement demonstrating longer duration of analgesic action) and volume or dose of local anesthetic used (higher doses appear to prolong analgesic duration and decrease need for additional analgesics in first 24 h postop) [10–16]. The most recent data indicate an overall complication rate of 0.3% with failed block or inadequate analgesia as the most common complication. Regardless of its low complication rate, the utility of the TAP block in the pediatric outpatient setting may be deemed to be limited given that those surgical procedures in which it may demonstrate the most benefit (cholecystectomy and appendectomy) are likely to be not well suited for the ambulatory surgical setting [13].

The use of the rectus sheath block has demonstrated effective analgesia for midline abdominal procedures such as umbilical hernia repair [9▪▪,17]. Of the reported rectus sheath blocks in the PRAN database, a complication rate of 0% is identified. Hamill *et al.* [9▪▪], in a recent systematic review, demonstrated that the use of the rectus sheath block and transversus abdominis plane block lowered morphine requirements 6–8 h postoperatively, decreased immediate pain scores and delayed time to rescue analgesia. Given the relative efficacy of the rectus sheath block combined with its low complication rate, this block may prove particularly useful in ambulatory surgery in improving analgesic outcomes and patient satisfaction.

Ilioinguinal/iliohypogastric nerve blocks have been shown to be efficacious in anesthesia for ipsilateral groin surgery. The use of an ultrasound-guided technique compared with the use of anatomic landmarks for the placement of the ilioinguinal/iliohypogastric block results in less postoperative rescue analgesia administered and perceived block success [18–21]. The repeated success of the ilioinguinal/iliohypogastric nerve block in relation to postoperative pain outcomes allows for greater utility in groin surgeries when neuraxial techniques are less desirable or contraindicated. The PRAN database shows an overall complication rate of 0.4%. The most commonly identified complications for the ilioinguinal/iliohypogastric block are abandoned block and failed block or inadequate analgesia and vascular puncture [5▪▪].

Other truncal blocks that are increasing in popularity, but whose utility may prove limited in the ambulatory setting, is the paravertebral nerve block. The use of the paravertebral block improved outcomes (reduced pain scores) in inguinal hernia surgery when compared with control groups, caudal, or ilioinguinal nerve blocks [22–24]. In her review article on the paravertebral block, Wardhan [25▪] highlights the increasing utilization of and improved outcomes from the use of the paravertebral block when compared with other methods (control group and thoracic epidurals) for breast surgery, thoracic surgery and pectus excavatum repair. These surgical cases are unlikely to be performed in the ambulatory setting. Paravertebral blocks have, historically, carried a higher complication rate when compared with other truncal blocks [26]. The PRAN data presented by Polaner *et al.* [5▪▪] in 2012 demonstrated a 7% complication rate, but total case volume for paravertebral blocks was low. The majority of those complications were because of failed/inadequate analgesic block or adverse drug reaction. Current analysis of the most recent PRAN database is needed in order to compare the complication rate as the number of paravertebral blocks has likely dramatically increased. As the focus continues to redirect efforts to utilize better analgesic efforts than our past, the popularity and utility of blocks such as the paravertebral will likely continue to increase.

PERIPHERAL NERVE CATHETERS

Peripheral nerve catheters (PNCs) have the unique capacity to provide prolonged analgesia than what is provided by a single-shot peripheral nerve block. This has the potential to allow children who have painful procedures to have same day surgery, or avoid prolonged hospitalization because of uncontrolled pain. However, there are a limited number of reports with regard to safety in the use of PNCs in children. Walker *et al.* [27▪▪] recently published a report from the PRAN on 2074 PNCs used in pediatrics. They found an overall incidence of complications of 12.1%, mostly attributed to catheter dislodgement and block abandonment/failure [27▪▪]. More importantly, serious complications were determined to be 0.04%, with no events of long-term neurologic problems and no local anesthetic systemic toxicity. Gurnaney *et al.* [28] also reported comparable complication rates (overall and serious) in a report of 1492 PNCs. Ecoffey *et al.* [29] looked at 1164 PNCs and reported two cases of catheter complications, with neither having long-term sequelae. Although there have been cases of transient neurologic morbidity in the adult literature, there has not been any reports of permanent neurologic injury from PNCs in pediatrics. Practitioners sometimes hesitate to use PNCs to provide analgesia to an operative extremity because of the risk of masking clinical signs of acute compartment syndrome. In a recent practice advisory from ESRA/ASRA, this was addressed to determine that current literature does not support that regional anesthesia increases the risk of acute compartment syndrome in children [30▪]. It was noted that for continuous infusions, concentration of local anesthetics should be limited to 0.1%. Current available evidence encourages clinicians to use PNCs without fear of serious complications, but also warns that significant management hurdles still exist in providing a streamlined, efficient experience for the patient.

The overall experience of several surgical procedures in the ambulatory day setting has been improved for children with the routine use of regional anesthetics and PNCs. Children born with limb abnormalities or femur angulation deformities often need soft tissue and bone repair. The utilization of a single-shot regional nerve block has allowed better perioperative pain control and improved overall experience. The implementation of the PNC has augmented this positive experience at home with minimal use of oral pain medications and associated side-effects. This is similar for patients undergoing varus and valgus deformity repairs. PNCs have also made it possible for children to undergo anterior cruciate ligament and medial patellofemoral ligament injury repair in the outpatient surgery setting. Prior to the implementation of peripheral regional anesthesia for pain control supplementation, pediatric patients were risked by (or disadvantaged by) getting admitted to the hospital just to avail themselves of parenteral analgesia.

Although more rigorous clinical studies need to be undertaken, clinicians should utilize PNCs in the appropriate setting for extended analgesia in a safe and efficacious manner. Clinicians should be prepared to overcome the current hurdles of using PNCs, particularly regarding issues of catheter disconnect or block failure. In addition, a low concentration of local anesthetic should be used when possible (0.1% ropivicaine or bupivicaine) to provide sensory analgesia without motor block, with the theoretical benefit of minimizing fall risk. This will also decrease the total dose of local anesthetic a patient receives, reducing the risk of local anesthetic toxicity. Within such parameters, PNCs can effectively be used to optimize patient's perioperative experience.

NEURAXIAL REGIONAL ANESTHESIA

Neuraxial blockade in the form of single-shot caudal blocks is common in providing analgesia for urogenital and lower extremity orthopedic procedures. Caudal blockade allows the clinician to provide a regional anesthetic with a high success rate combined with a low morbidity. A review of the available PRAN data showed an overall complication rate of 1.9%, which included a block failure rate of 1% [31▪▪]. Newer modalities including imaging with ultrasonography are available to aid guidance, but most clinicians utilize a landmark-based approach with a loss of resistance technique, allowing expeditious completion of the block.

CONCLUSION

A variety of regional anesthetic techniques are available to the clinician for providing surgical anesthesia and postoperative analgesia to children undergoing ambulatory surgery. Although prospective randomized trials evaluating various regional anesthetics are limited, available data from the PRAN network suggest that current practices are safe and effective in children. Comparative studies continue to support the use of regional anesthetic techniques over historical control groups when outcomes such as improved analgesia, safety and perceived satisfaction are examined. The implementation of new modalities, such as the PNC, in pediatrics allows extended outpatient analgesia,

hence avoiding the need for hospitalization. Concerns on safety in performing regional anesthesia in children should not limit the clinician. The use of these techniques enables a perioperative experience that is pain free and with minimal undesirable side-effects from the decreased use of oral opioids. As regional anesthesia has revolutionized the way in which we deliver perioperative care, the use of these techniques and achievement of positive outcomes will be instrumental in the delivery of care in the ambulatory setting.

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Conflicts of interest

There are no conflicts of interest.

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