Pediatric Pain: New Approaches for Our Most Vulnerable Patients

Overview of Regional Techniques in Pediatric Pain Management

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In recent years, advances in regional anesthesia techniques have revolutionized perioperative multimodal analgesia (*Anesthesiology* 2018;129:721-32). Although, the utilization of regional anesthesia in the adult patient population is widespread, clinical practice of pediatric regional anesthesia (PRA) is still suboptimal. With increasing health care costs and the current opioid epidemic, PRA has an exceptional role in impacting quality and safety outcomes in this population (*Br J Anaesth* 2014;113:375-90).

Is regional anesthesia in children safe?

According to the Pediatric Regional Anesthesia Network (PRAN) database, complications associated with PRA are very rare (*Anesthesiology* 2018;129:721-32). In a prospective cohort of more than 100,000 regional blocks in children, the rate of transient neurologic deficit was low (2.4 per 10,000), and no cases of permanent neurologic deficits were found. Incidence of local anesthesia systemic toxicity (LAST) was also low at 0.76 per 10,000 blocks (*Anesthesiology* 2018;129:721-32; *Curr Pain Headache Rep* 2017;21:11). Comparable safety results were also noted from the French-Language Society of Pediatric Anesthesiologists' (ADARPEF) large prospective trials (*Paediatr Anaesth* 2010;20:1061-9). No cases of cutaneous infections were noted with a single-shot injection, but the incidence rate was 53 per 10,000 with peripheral nerve catheters (PNC) and an even

higher rate was present with neuraxial catheters (*Anesthesiology* 2018;129:721-32; *Curr Pain Headache Rep* 2017;21:11). Despite the demonstrated overall safety of regional anesthesia in children, utilization was not as prevalent until the last two decades (Smith's Anesthesia for Infants and Children. 8th ed, 2011). "Reluctance to regional" in children was mainly contributed to the false assumption of higher complication rates in anesthetized patients. It is now well established that an anesthetized child aids the precision of block placement and decreases the likelihood of injury caused by unexpected movements (*Curr Pain Headache Rep* 2017;21:11; *Best Pract Res Clin Anaesthesiol* 2019;33:447-63). Therefore, contrary to common belief, regional anesthesia in children is safe in the hands of an experienced practitioner and use of the correct equipment.

Children are not small adults, and knowing the difference is the key:

- Several anatomical differences, especially in neuraxial anatomy, are present between children and adults. Lower levels of conus medullaris (L3) and dural sac (S2-S4) makes younger individuals susceptible to inadvertent damage during neuraxial block placement. Epidural space content in children has a higher amount of fat lobules, facilitating faster spread of anesthetic agents. Epidural space is also accessible easily via sacral hiatus/caudal space until 7 to 8 years of age. The higher turnover rate of CSF and higher volume on per weight basis result in increased requirement of local anesthetic (LA) volume and shorter duration of spinal blocks (A Practice of Anesthesia for Infants and Children. 5th ed, 2013).
- Children lack prominent hemodynamic responses to test dose epinephrine due to immature cardiac fibers, higher basal heart rate, and presence of I.V. and/or inhalational agents. Therefore, a negative test dose may not be a reliable indicator of ruling out an intravascular injection in neonates and young children (*Reg Anesth Pain Med* 2015;40:526-32).
- Neonates and infants have a higher predilection of developing local anesthetic systemic toxicity (LAST) (*Best Pract Res Clin Anaesthesiol* 2019;33:447-63; A Practice of Anesthesia for Infants and Children. 5th ed, 2013). Lower levels of a-1 glycoprotein (AGP) and P-450 enzymes at birth leads to a higher free-fraction of LA, whereas increased levels of AGP (also an acute phase protein) during the perioperative period decreases the rate of clearance (A Practice of Anesthesia for Infants and Children. 5th ed, 2013; *Paediatr Anaesth* 2012;22:39-43; *Paediatr Anaesth* 2012;22:31-8). Hence, adherence to maximum recommended doses of LA should be practiced at all times to minimize the incidence of LAST (Table 1) (*Reg Anesth Pain Med* 2018;43:211-6).
- The misconception regarding presence of a regional block masking the onset of ischemia pain and acute compartment syndrome (ACS) has been a major barrier in utilization of PRA. In fact, clinical evidence suggests that the delay in detection of ACS and ischemic pain is mostly secondary to the communication difficulties in younger children. Therefore, it is recommended to use diluted and lower volumes of LA in cases where risk of developing ACS is higher (*Reg Anesth Pain Med* 2018;43:211-6).

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Common pediatric regional blocks

Due to the limitations of this overview article, descriptions of common pediatric regional blocks are listed in Table 2.

Head and neck blocks

Head and neck blocks have provided a new facet to multimodal analgesia for ambulatory ENT and ophthalmologic surgeries in pediatric patients. They are relatively low

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Table 1: ASRA/ESRA Recommendations for a Single-Injection LA Dose for Neuraxial Nerve Block and PNB in Children

Nerve Block	Drug and Concentration	Dose (ml/kg)
Spinal anesthesia	Tetracaine 0.5%	0.5-1
	(Child <5 kg) hyper-isobaric bupivacaine 0.5%	1
	(Child 5-15 kg) hyper-isobaric bupivacaine 0.5%	0.4
	(Child >15 kg) hyper-isobaric bupivacaine 0.5%	0.3
Caudal	Ropivacaine 0.2% or levobupivacaine 0.25%	0.5-1.2
Upper limb	Bupivacaine, levobupivacaine 0.25%, or ropivacaine 0.2%	0.5-1.5
Lower limb	Bupivacaine, levobupivacaine 0.25%, or ropivacaine 0.2%	0.5-1.5
Fascial plane blocks	Bupivacaine 0.25% or ropivacaine 0.2%	0.2-0.75

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risk and easy to place. Despite no observed complications and/or adverse events in over 500 head and neck blocks reviewed, these remain one of the most underutilized blocks in the pediatric population (*Paediatr Anaesth* 2012;22:81-7; *Anesth Analg* 2012;115:1353-64).

Upper-extremity blocks
The upper-extremity (UE) blocks are the least-performed single-shot nerve blocks in children per the PRAN database, with an overall complication rate of 2% (*Anesth Analg* 2012;115:1353-64). These mainly include interscalene, supraclavicular, infraclavicular, axillary, and musculocutaneous nerve blocks. Interscalene block remains one the most controversial UE blocks in pediatrics after a practice advisory from the European Society of Regional Anesthesia & Pain Therapy (ESRA) and American Society of Regional Anesthesia and Pain Medicine (ASRA) recommended avoiding this block in children under sedation due to potential neurologic complications (*Curr Opin Anaesthesiol* 2019;32:649-52). Later, this recommendation was changed when Taenzer et al. showed no significant difference in complications for interscalene blocks with or without sedation and/or general anesthesia (*Reg Anesth Pain Med* 2015;40:526-32; *Reg Anesth Pain Med* 2014;39:502-5).

Lower-extremity blocks
Better visualization of anatomical structures and lack of respiratory complications make lower extremity (LE) blocks more prevalent in children (*Curr Pain Headache Rep* 2017;21:11). Commonly performed LE blocks include lumbar plexus, fascia iliaca, femoral, lateral femoral cutaneous, sciatic (subgluteal, popliteal fossa), adductor canal, and ankle blocks. Though earlier studies comparing the safety and efficacy of LE blocks were insufficient, PRAN review of over 2,300 blocks indicate overall safety with a complication rate of only 1% (*Anesth Analg* 2012;115:1353-64).

Truncal blocks
Truncal blocks are becoming an integral part of multimodal analgesic regimes for abdominal surgeries (*Best Pract Res Clin Anaesthesiol* 2019;33:447-63). Transversus abdominis plane, ilioinguinal/iliohypogastric, and rectus sheath blocks are the most commonly performed truncal blocks, with an overall complication rate of 0.3% (*Anesth Analg* 2012;115:1353-64). On the other hand, utilization of paravertebral blocks is declining due to the higher complication rate (7%) (*Anesth Analg* 2012;115:1353-64) and availability of novel blocks like erector spinae plane blocks (*Paediatr Anaesth* 2020;30:96-107).

Table 2: Common Pediatric Regional Blocks, Indications, and Suggested Volume of Local Anesthetics
(Adapted from nysora.com)

Blocks	Indications	Local Anesthetic Volume (ml/kg)
Greater auricular	Otoplasty Mastoidectomy	1.0-3.0
Infraorbital	Cleft lip repair Endoscopic sinus surgery	Infants: 0.5-1.0 Children: 1.0-2.0
Supraorbital and supratrochlear	Frontal scalp incisions; e.g., simple minor plastic surgery, frontal craniotomy	1.0-2.0
Superficial cervical plexus	Otoplasty Tympanomastoid surgery Cochlear implant	1.0-3.0
Greater occipital	Posterior fossa surgery Occipital neuralgia, migraine headaches	1.0-2.0
Nerve of Arnold	Myringotomy	0.5-1.0
Interscalene	Shoulder surgery	0.3-0.5
Supraclavicular	Upper arm surgery	0.3-0.5
Infraclavicular	Upper arm surgery	0.3-0.5
Axillary	Elbow and forearm surgery	0.3-0.5
Median, ulna, and radial	Syndactyly surgery	0.1-0.3
Transverse abdominis plane (TAP): unilateral and bilateral	Open appendectomy Inguinal hernia Colostomy formation Subumbilical midline laparotomy	0.3-0.5 per side
Subcostal TAP	Cholecystectomy Percutaneous endoscopic gastrostomy	0.3-0.5 per side
Rectus sheath	Umbilical herniotomy Pyloromyotomy	0.2-0.3 per side
Ilioinguinal	Inguinal herniotomy	0.2-0.3
Penile	Circumcision Distal hypospadias	0.1 per side
Unilateral paravertebral Bilateral paravertebral	Thoracotomy; e.g., tracheoesophageal fistula Renal surgery Sternotomy Pectus surgery	0.3-0.5 per side
Intercostal	Chest drain insertion Thoracoscopy	0.5
Lumbar plexus	Hip surgery	0.5
Femoral	Femoral fracture Slipped upper femoral epiphysis (combined with LFC)	0.2-0.4
Fascia iliaca	Femoral fracture Slipped upper femoral epiphysis	0.5
Lateral femoral cutaneous (LFC)	Thigh muscle biopsy	0.1
Proximal sciatic	Cruciate ligament repair	0.3-0.5
Popliteal	Tendon transfers/lengthening	0.3-0.5
Ankle	Syndactyly surgery	0.1-0.2
Digital nerve	Distal finger/toe surgery	0.05-0.1

Neuraxial blocks
A single-shot caudal epidural injection is the most common block performed in the pediatric population for sub-umbilical procedures (*Anesth Analg* 2015;120:151-6). Even though ultrasound-guided caudal blocks are gaining popularity, landmark-based caudal injections are performed more frequently (*Anesth Analg* 2012;115:1353-64). Data analysis of more than 6,000 single-shot caudal blocks have shown an overall complication rate of

1.9%, given the recommended dose of LA is used (*Anesth Analg* 2012;115:1353-64; *Anesth Analg* 2015;120:151-6). Although safety of single-shot spinal blockade became more prominent after the publication of the GAS study (*Lancet* 2016;387:239-50), clinical implementation is not common. In premature neonates and infants with risk of postoperative apnea, it is a safe and cost-effective alternative to general anesthesia, but limitations like lack of trained personnel and shorter duration of block with almost 10% failure rate are barriers for this technique (*Lancet* 2016;387:239-50; *Anesthesiology* 2015;123:38-54).

Epidural catheters can be placed in the thoracic, lumbar, and caudal regions for a controlled, longer duration of blockade. They can be placed in respective anatomical regions or advanced to the desired level using a caudal approach. According to Polaner et al., a prospective analysis of >2,900 epidural catheters demonstrated an overall complication rate of 0.7%, with a cumulative failure rate of 2%. Thoracic epidurals were associated with more catheter-related adverse events (8%) than lumbar (5%) and caudal (2%) catheters. Accidental dural puncture was present in 0.9% with a much higher incidence in lumbar followed by thoracic and caudal epidural catheters. Transient neurological complications were only found in cases with lumbar and thoracic epidural catheters (0.2%), whereas cutaneous infections were more prevalent in thoracic (0.17%) compared to caudal (0.15%) and lumbar (0.6%) epidural catheters. Although the complication rate of continuous neuraxial catheters is slightly higher than a single-shot, benefits like longer duration of block, decrease opioid requirements, and patient satisfaction should be considered to outweigh the risks (*Anesth Analg* 2012;115:1353-64).

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Peripheral nerve catheters

Though the safety of peripheral nerve catheters (PNCs) has been established in adult literature, studies are limited in children. Delayed diagnosis of ACS was considered as one of the contraindications of PNC in children, but recent practice advisories from ESRA/ASRA do not support the above, given that PNC is used in an appropriate clinical setting (*Reg Anesth Pain Med* 2018;43:211-6). Lower-extremity nerve catheters are the most commonly placed PNC in children, with an overall complication rate of 12.1%. Most of these included catheter-related complications like dislodgement, kinking or failure of block, whereas, only 0.04% resulted in serious outcomes. This was not applicable to children younger than 3 years of age due to lower representation in the cohort. Also, use of lower concertation of LA (0.1%) was recommended when indicated to prevent motor blockage and risk of falls (*Anesth Analg* 2012;115:1353-64; *Curr Opin Anaesthesiol* 2016;29:691-5).

Adjuncts for pediatric regional blocks

Clonidine is the most studied regional anesthesia adjunct in children, showing an increase in analgesia duration when used for neuraxial blockade (*Pain Manag* 2012;2:479-86). Dexmedetomidine appears to be similar in prolonging the blockade duration (*Paediatr Anaesth* 2014;24:1224-30). Although ketamine seems more potent than clonidine when used in neuraxial blocks, concerns regarding neurotoxicity in animal models has resulted in restricted use (*Br J Anaesth* 2011;107:601-11). Preservative-free morphine up to 50 mcg/kg can also be used safely in caudal blocks (*Anesthesiology* 1989;71:48-52).

While clonidine, dexmedetomidine, and dexamethasone have all been used as adjuncts in peripheral nerve blocks in children, use of dexmedetomidine is supported by the recent ASRA/ESRA guidelines (*Reg Anesth Pain Med* 2018;43:211-6).

Due to the paucity of data from prospective trials and lack of specialized training, many care providers shy away from PRA in perioperative settings. Databases like PRAN and ADARPEF continue to support the use of ultrasound-guided regional anesthesia in children with proven safety, improved clinical outcomes, and overall satisfaction by families. With the momentum in advocacy for multimodal analgesia, further prospective studies are warranted to enable practitioners to deliver cost-effective and quality perioperative care. ■

ASA News

Announcement of Candidates for Elected Office

In accordance with section 2.6 of the Administrative Procedures, ASA is pleased to announce that notices of intent to run for elected offices are being accepted through **Thursday, July 1, 2021**. Any prospective candidate for ASA office may send a Notice of Intent to run for a specified office. Position descriptions for each office are available from the Executive Office and Governance Department of the Executive Division. Prospective office-seekers are encouraged to obtain the relevant position description(s), as each contains not only the duties of each office but the inherent time commitment involved.

Notices of Intent are requested to be submitted to Governance staff at *governance@asahq.org. Each notice submitted should be accompanied by a Web-ready photograph, an abbreviated (one-page) curriculum vitae (CV) and a Statement of Candidacy.* Governance staff will compile a list of candidates submitted. This list will be published in the September *ASA Monitor* and posted, along with the photo, CV and statement, to the Candidates' Forum page of the ASA website.

An announcement of candidacy does not constitute a formal nomination to an office, nor is it a prerequisite for being nominated. Nominations are formally made at the first session of the House of Delegates for all candidates as prescribed by the ASA Bylaws.

ASA seeking nominations for Excellence in Education Award

The ASA Excellence in Education Award recognizes ASA members who have made outstanding contributions through demonstrated excellence in teaching, development of new teaching methods, and/or implementation of innovative educational programs in anesthesiology. The nominee for this award must be an active ASA member in good standing who teaches students, residents, fellows, or faculty in an Accreditation Council for Graduate Medical Education-accredited (or international equivalent) anesthesiology or subspecialty training program and spends at least 50% of his or her time on clinical activities. Physicians from academic or community practices who have training programs are eligible. Nominees should have a minimum of five years of experience in resident and/or continuing medical education.

Those who wish to submit nominations should include the following:

1. A one-page cover letter summarizing why he or she believes the nominee should receive this recognition
2. A copy of the nominee's current resume or curriculum vitae
3. A letter of support from the nominee's department chair
4. Any additional supporting materials that are essential to impact the final decision of the Committee on Professional Education Oversight in selecting the reward recipient

All nominations and supporting materials should be submitted to **j.jacobson@asahq.org** by May 17, 2021. The award recipient will be announced in June 2021 and will receive a plaque, an honorarium, reimbursement for hotel and travel, and per diem to accept the award at the ANESTHESIOLOGY® annual meeting. ■