Implementation of Ultrasonography in Pediatric Regional Anesthesia

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Barriers to implementation of ultrasonography (US): has steep learning curve (recognition of sonoanatomy takes time and practice to develop); lack of appropriate follow-up of patients; lack of education of surgical colleagues about placement, duration, and safety of blocks; potential costs of equipment and training

History of US-guided blocks: 1978 — first brachial plexus block performed by La Grange, with localization of subclavian artery by Doppler US and periarterial injection of local anesthetic; 1994 — use of direct US for placement of suprachlavicular block; current trend — use of central neuraxial blockade decreasing

Advantages of US for placement of blocks: only modality available for real-time view of anatomy; allows real-time visualization of needle advancement; provides direct view of injection of local anesthetic around target; “perceived” advantages — decreased morbidity and mortality; improved postoperative satisfaction; faster postprocedure discharge; fewer side effects; sparse pediatric data available; performance time — time from placement of US probe to needle withdrawal after injection of local anesthetic; not addressed in pediatric studies; shown to be shortened in adult studies; onset time — time from injection of local anesthetic to full sensory block; 2004 study shows faster onset with prolonged duration in children when US used; because pediatric patients generally anesthetized during placement, onset time possibly irrelevant; reliability and predictability — improved success rates seen with US-guided vs classic fascial “pop” technique for ilioinguinal-iliohypogastric block; success rates similar among all peripheral blocks

Safety: studies ongoing; available data show 0.12% complication rate, with complications 6 times more likely with central vs peripheral blocks; Rubin meta-analysis (2009) reported improved success and safety for truncal blocks; adult studies show decreased vascular puncture rate; required local anesthetic volume shown to be reduced; US-guided infraclavicular blocks (2006) had 99% success rate, with <1% arterial puncture and no toxicity or peripheral nerve injury; suprachlavicular nerve block — gaining favor; classically, pneumothorax considered major and frequent complication, but now anecdotal and reportable occurrence; Pediatric Regional Anesthesia Network — formed in 2007 for multicenter prospective collection of data; goal to capture all blocks and complications; as of August 2011, databank includes 28,000 anesthetics

Costs of US-guided regional anesthetic: $3.00 per patient if 1000 cases performed annually (average volume for practices providing 20,000-30,000 anesthetics annually)

Strategy for implementation: structured exposure required for learning techniques; development of skills and familiarization with equipment duty of providers; resources available through colleagues, American Society of Regional Anesthesia (ASRA), workshops, and commercial courses; education required for patients and families; development of pain service for patient follow-up helpful; improve communication with surgeons and patients about safety profiles

Local Anesthetic Systemic Toxicity

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Signs of local anesthetic systemic toxicity (LAST): first reported in 1880s with cocaine; classical presentation consists of progressive central nervous system (CNS) symptoms, which lead to coma, seizures, hemodynamic instability, and (ultimately) complete cardiovascular collapse; in study of 93 patients, >40% had atypical presentation, including cardiac toxicity without evidence of CNS toxicity, simultaneous cardiovascular and CNS toxicity, or delayed symptoms of cardiovascular toxicity

Treatment priorities: airway management and ventilation — early (1924) recommendations to establish primacy of clear airway for optimization of oxygenation and ventilation; 1960 study shows no irreversible cardiovascular collapse occurs if hypoxia and acidosis prevented; prevention of hypoxia and acidosis potentially halts progression of CNS and cardiovascular toxicity; reestablishment of coronary perfusion prevents acidosis, improves contractility, and washes out local anesthetic agent bound to cardiac tissue; third priority — minimization of systemic effects of local anesthetics

Immediate treatment of LAST: stop injection of local anesthetic; call for help; maintain airway (low threshold for

Educational Objectives

The goal of this program is to improve pediatric pain management through use of ultrasonographically (US) guided regional techniques, prompt diagnosis and treatment of local anesthetic systemic toxicity (LAST), and use of intravenous (IV) nonopioid analgesic adjuncts. After hearing and assimilating this program, the clinician will be better able to:

1. Implement US-guided regional techniques to improve pediatric patient safety and satisfaction.
2. Recognize the signs and symptoms of LAST.
3. Develop departmental treatment protocols for LAST that incorporate use of 20% lipid emulsion.
4. Cite evidence supporting the benefits of IV NSAIDs as nonopioid analgesic adjuncts in pediatric patients.
5. Use appropriate doses of nonopioid analgesic adjuncts to reduce the need for postoperative opioids.

Faculty Disclosure

In adherence to ACCME Standards of Commercial Support, Audio-Digest requires all faculty and members of the planning committee to disclose relevant financial relationships within the past 12 months that might create any personal conflicts of interest. Any identified conflicts were resolved to ensure that this educational activity promotes quality in health care and not a proprietary business or commercial interest. For this program, the faculty and planning committee reported nothing to disclose. In their lectures, Drs. Hoang and Garcia present information that is related to the off-label or investigational use of a therapy, product, or device.
intubation indicated); give mild hyperventilation with fraction of inspired oxygen (FIO₂) 1.0; control seizures with benzodiazepines (eg, midazolam, lorazepam) to minimize cardiac depression; low-dose propofol, 1 mg/kg intravenously (IV) or sodium thiopental, 1 to 2 mg/kg IV may be administered but may increase hypotension and cardiac depression (benzodiazepines drug of first choice); persistent tonic clonic activity may require neuromuscular blockade, but benzodiazepine still needed for central seizure; cardiac arrest — start cardiopulmonary resuscitation (CPR) with Pediatric Advanced Life Support (PALS) protocol; oxygenation and ventilation primary focus in LAST; prolonged resuscitation often necessary; activate cardiopulmonary bypass or extracorporeal membrane oxygenation (ECMO) team; if available; consider IV administration of 20% fat emulsion (Intralipid; off-label use).

**History of lipid rescue:** study (1960s) found decreased duration of action of sodium thiopental when combined with oil; Weinberg (1998) successfully treated cardiac toxicity in rats with lipids; several case reports (4 pediatric cases) support 20% fat emulsion rescue from bupivacaine-induced cardiac arrest in humans; evidence also supports use for CNS toxicity due to lipophilic drugs

**Proposed mechanisms of action of lipid emulsion:** 1) lipid sink — lipids pull lipophilic drugs from aqueous plasma phase, thereby decreasing availability of free drug for binding with cardiac tissue; 2) lipid substrate — binds bupivacaine; lipids inhibit bupivacaine from blocking acylcarnitine translocase, thereby restoring myocardial energy

**Protocol for use of 20% fat emulsion:** speaker uses protocol blended from those of American Society of Regional Anesthe sia and Pain Management and Association of Anesthetists of Great Britain and Ireland: administer 1.5 ml/kg IV bolus over 1 min; continue PALS with chest compressions to circulate fat emulsion; repeat bolus 1 to 2 times at 5-min intervals until circu lation restored; begin 0.25 ml/kg per min IV infusion after first bolus (double rate if hypotension persists for ≥15 min); maintain infusion 10 min beyond establishment of circulatory stability; dose limit for acute administration 10 to 12 ml/kg over first 30 min

**Recommended modifications to PALS for treatment of LAST:** when LAST suspected, balance PALS and chest compressions with mild hyperventilation; epinephrine — for cardiac arrest, lower standard dose (10 µg/kg IV) to <1 µg/kg IV; vasopressin — not in PALS protocol but often alternative to epinephrine; not recommended for treatment of LAST; ventricular arrhythmias — use amiodarone and avoid local anesthetics (eg, procainamide).

**Preventive measures:** perioperative local anesthetic and 20% fat emulsion calculator available to calculate maximum weight-based local anesthetic doses and 20% fat emulsion bolus and infusion doses; 20% fat emulsion rescue kit — consists of 20% fat emulsion, IV infusion tubing, needles and syringes, and copy of institution protocol; speaker suggests website http://lipidrescue.org/

**Intravenous Nonopioid Analgesic Adjuncts**

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**Pediatric pain management:** historically lags behind adult pain management due to lack of research and fear of opioid-related side effects and addiction; majority of hospitalized children experience moderate to severe pain during admission, but few receive regularly scheduled analgesia; unrelieved pain results in negative clinical and psychologic outcomes, which include increased length of stay, readmission, and patient and family dissatisfaction; combinations of opiates with drugs and techniques that target alternate receptors provide equivalent or superior analgesia, decrease opiate requirements, and minimize opiate-related side effects

**Nonsteroidal anti-inflammatory drugs (NSAIDS):** decrease use of opiates by ≤50%; mechanism of action — inhibit cyclooxygenase (COX), which decreases prostaglandin and inflammatory cascade; COX-1 inhibition associated with altered platelet function, gastrointestinal (GI) mucosal injury, and decreased renal perfusion; COX-2 inhibition associated with increased morbidity and mortality in adults (although risks not evident in children); direct spinal action blocks hyperalgesic response

Parenteral formulations: ketorolac (Toradol) — approved by Food and Drug Administration (FDA) in 1989; inhibition of COX-1 greater than that of COX-2; side effects include decreased bone repair, renal failure, and increased bleeding; ibuprofen (Caldolor) — approved by FDA in 2009; COX-1 and COX-2 effects balanced, with decreased platelet inhibition

Dosage recommendations: ketorolac — for moderate to severe pain in children ≥2 yr of age; loading dose 1 mg/kg, then 0.5 mg/kg (maximum dose 30 mg) every 6 hr; do not exceed 5 consecutive doses or 20 doses in 30 days; ibuprofen — for mild to moderate pain, or as adjunct to opioid therapy for moderate to severe pain and reduction of fever; approved for patients ≥17 yr of age; manufacturer seeking pediatric approval for dose of 10 mg/kg infused over 15 min; side effects include pruritus, nausea, vomiting, headache, and flatulence; black box warnings — issued for both agents; ibuprofen does not carry warnings about avoidance in patients with renal impairment (but hydration before administration recommended) or risk for bleeding.

**IV acetaminophen: mechanism of action** — inhibits synthesis of prostaglandins in CNS; blocks pain impulses peripherally; inhibits hypothalamic thermoregulatory center (antipyretic effect); oral, rectal, and IV formulations available; indications — include treatment of mild to moderate pain (as adjunct to opioids), and reduction of fever; decreases opiate consumption 20% to 30%; contraindicated for patients with known hypersensitivity or hepatic impairment; administration — single-use vial contains 1000 mg acetaminophen in 100 mL solution; administer over 15 min within 6 hr of opening vial; incompatible with diazepam and chlorpromazine

Dosage recommendations: children <2 yr of age; Moffett (2006) concluded ketorolac has no adverse hematologic or renal effects and safe for use in neonates; nonunion of bone — no increase in incidence seen in adolescent studies; benefits of NSAIDs outweigh risks for most pediatric orthopedic surgeries; safety after tonsillectomy — NSAIDS generally avoided in procedures with high risk for bleeding; data mixed; general recommendation advises avoidance of ketorolac (no data yet about ibuprofen)

**COX-1 and COX-2 effects balanced, with decreased platelet inhibition**
o2-Agonists
Clonidine: semi-selective α2-agonist; decreases sympathetic nervous system activity; synergy with opioids causes sedation, hypopnea, and hypoxemia; used perioperatively for treatment of hypertension, anxiety, analgesia, reduction of postoperative shivering, nausea, and vomiting, and reduction of emergence agitation; side effects include sedation, hypotension, bradycardia, and dry mouth; available in oral, IV, and transdermal formulations; often used as component of peripheral neuraxial blockade
Dexmedetomidine: approved for adults by FDA in 1999; frequently used in children; affinity for α2-receptors 8 times greater than that with clonidine; uses include sedation, analgesia, emergence agitation, and postoperative shivering; side effect profile similar to that of clonidine; dosing for sedation — loading dose 1 μg/kg infused over 10 min, then continuous infusion 0.6 μg/kg per hour (range 0.2-1 μg/kg per hour); has gradual onset, with full sedation occurring in 20 to 30 min; data support adjunctive use with opiates to decrease postoperative pain with no increase in time to discharge

Conclusions: increased numbers of nonopiod adjuncts available; associated with improved analgesia, decreased consumption of opioids, and decreased side effects when given in conjunction with opioids

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Suggested Reading

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Take pretest 10 minutes
Listen to audio program 60 minutes
Review written summary and suggested readings 35 minutes
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ULTRASONOGRAPHY/LOCAL ANESTHESIA/NONOPIOID ANALGESICS

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To submit a test form by mail or fax, complete Pretest section before listening and Posttest section after listening.

1. Choose the correct statement about ultrasonographically (US) guided regional techniques in pediatric patients.
   (A) Decrease need for sedation when placing the block
   (B) Allow real-time visualization of needle advancement
   (C) Require no special skills or education
   (D) Improve patient satisfaction at the cost of longer discharge times

2. Strategies for implementing US-guided regional techniques include all the following, except:
   (A) Becoming familiarized with required equipment
   (B) Attending courses and workshops
   (C) Improving communication with surgeons about techniques and safety profiles
   (D) Scheduling additional time into the surgical schedule for block placement

3. Which of the following is not a sign of local anesthetic systemic toxicity (LAST)?
   (A) Bronchospasm
   (B) Seizure
   (C) Cardiac arrhythmia
   (D) Cardiovascular collapse

4. Which of the following are recommended for immediate treatment of LAST?
   (A) Avoid intubation
   (B) Ventilate with room air
   (C) Control seizures with benzodiazepines
   (D) Quickly administer high-dose propofol

5. Epinephrine doses should be decreased to <1 μg/kg when implementing Pediatric Advanced Life Support for the resuscitation of LAST.
   (A) True
   (B) False

6. Cyclooxygenase (COX)-2 inhibition is associated with increased morbidity and mortality in _______, but not in _______.
   (A) Children; adults
   (B) Adults; children

7. Which of the following statements about intravenous (IV) nonsteroidal anti-inflammatory drugs is correct?
   (A) Frequently cause exacerbation of asthma in children
   (B) Ketorolac is safe to use in children <2 yr of age
   (C) Associated with serious risk for nonunion of bone in adolescents
   (D) Ketorolac should be routinely administered for pediatric tonsillectomies

8. IV acetaminophen is safe to use in patients with hepatic impairment.
   (A) True
   (B) False

9. Which of the following statements about clonidine is true?
   (A) Sedation is rare
   (B) Low-dose atropine should be administered to counteract increased salivation
   (C) May be used to treat emergence agitation
   (D) Neurotoxic (should not be used in neuraxial blocks)

10. Dexmedetomidine has a _______ affinity for α₂-receptors than clonidine and has a _______ onset after the loading dose.
    (A) Greater; rapid
    (B) Greater; gradual
    (C) Lower; rapid
    (D) Lower; gradual

Answers to Audio-Digest Anesthesiology Volume 55, Issue 03: 1-C, 2-A, 3-D, 4-A, 5-B, 6-A, 7-A, 8-D, 9-B, 10-B