Neuraxial Blockade

PEDIATRIC PAIN MANAGEMENT

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Contents

▪ Route
  › Caudal, Epidural, Intrathecal
▪ Dosing
▪ Local Anesthetics
▪ Adjunctive Medications
  › Clonidine
  › Opioids
  › Ketamine
▪ Potential Complications
  › Local Anesthetic Systemic Toxicity (L.A.S.T.)
▪ Placement Guidelines
  › Contraindications
  › Anticoagulation
Route
Caudal Epidural Analgesia
Route

Caudal Epidural Analgesia

- Sacrum flatter and more narrow than adults
- Sacral vertebral fusion incomplete until 8 years of age
  › May continue to 21 years
- Sacral hiatus more cephalad in young children
- Dural sac may extend to S4 in infants
  › S2 in older pediatric population and adults
- Complications (2%)
  › Failure of block (1%) > aspirated blood > positive test dose/intravascular > intrathecal injection > cardiac arrest
Route

Thoracic & Lumbar Epidural

- Differing rate of vertebral column and spinal cord growth
  - Conus medullaris located at L3 in infants (L1 beginning ~ 12 mos. old)
- Pediatric epidural space typically at depth approximately 0.1cm/kg
- Structures encountered with various approaches
  - Paramedian: subcutaneous - erector spinae - ligamentum flavum
  - Midline: subcutaneous - supraspinous ligament - interspinous ligament - ligamentum flavum
- Progression of loss with dosing:
  - Pain > temperature > touch > proprioception > skeletal muscle tone
Route

Intrathecal “Spinal”

- Neonatal spinal cord non-myelinated
  - Lower concentration of local anesthetic may be used
- Proportionally more CSF in infants (4mL/kg) than adults (2mL/kg)
- Pediatric cardiac output relatively greater than adults
  - Increased rate of systemic absorption of local anesthetics
  - Toxic plasma levels; shorter block duration
- High concern in volume compromised patients
Route

Confirmatory Techniques

- Test dosing
  - >25% increase in T wave after injection of epinephrine 0.5mcg/kg
  - Spontaneous ventilation if possible
    - Depression: LAST
    - Tachypnea: pain on injection
    - Tachypnea followed by bradypnea: spinal

- Imaging:
  - Ultrasound
  - Radiography
  - Electrical stimulation (safety not verified)
Imaging

Notes on Radiation Guidelines

- Skin entrance doses as high as 6-10 Gy in interventional procedures
  - 2Gy - erythema and epilation
  - 6Gy - permanent epilation
  - 10Gy - dry desquamation, dermal atrophy, telangiectasia
  - 15Gy - moist desquamation and necrosis of other organs

- kVp vs mA
  - 15% increase in kVp is equivalent to doubling the mA
  - Goal: increase kVp as needed, minimize mA

- Annual dose limit of radiation in physicians:
  - Effective whole-body dose: 5REM
  - Thyroid, extremity, gonads: 50REM
  - Lens of eye: 15REM
  - Fetal: 0.5REM/gestational period
  - General public: 0.1REM/year

- NOTE: 1Gy = 100rad = 100rem = 1Sv
Dosing

Epidural Dosing

- Loading Bolus
  - Caudal
    - Volume-Based
      - 0.5mL/kg for sacral dermatomal coverage
      - 1.25mL/kg for high lumbar spread
      - 1.5mL/kg for low thoracic levels
  - Epidural
    - 0.05mL/kg/dermatome spread from catheter/needle tip

- Continuous Infusion
  - Bupivacaine maximum 0.5mg/kg/hr
  - Ropivacaine maximum 0.6mg/kg/hr
## Local Anesthetics

Amide LAs with “i” preceding “-caine”

<table>
<thead>
<tr>
<th>Local Anesthetic</th>
<th>Epidural Onset (min)</th>
<th>Duration Alone (min)</th>
<th>Duration w/Epi (min)</th>
<th>Potency</th>
<th>Toxicity</th>
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<tbody>
<tr>
<td><strong>Ester</strong></td>
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<tr>
<td>Chloroprocaine</td>
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<td>30-45</td>
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<tr>
<td>Lidocaine</td>
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<td>30-120</td>
<td>120-360</td>
<td>Moderate</td>
<td>Moderate</td>
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<tr>
<td>Mepivacaine</td>
<td>15</td>
<td>60-140</td>
<td>140-200</td>
<td>Moderate</td>
<td>Moderate</td>
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<tr>
<td>Bupivacaine</td>
<td>10-20</td>
<td>120-240</td>
<td>180-240</td>
<td>High</td>
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<tr>
<td>Ropivacaine</td>
<td>15</td>
<td>120-360</td>
<td>-</td>
<td>Moderate</td>
<td>Low</td>
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</table>
Adjunctive Medications

Clonidine

- **Mechanism**
  - Stimulation of $\alpha$-2
    - Diminishes pain transmission via descending inhibition
    - Increases acetylcholine levels in CSF $\rightarrow$ cholinergic action at dorsal horn
    - Intrinsic inhibitory action of A$\delta$ and c fibers
    - Additive with neuraxial opioids
      - Dose reduced by 60% when used in conjunction with clonidine

- **Dose**
  - 0.5-2 mcg/kg epidural
  - 0.01-0.1 mcg/kg intrathecal
Adjunctive Medications

Opioids

- Morphine: Bimodal respiratory depression
  - Initial secondary to systemic absorption (30-90 min)
  - Later from rostral spread via CSF to brainstem (6-18 hours)
- Opioid dosing: “Rule of 10s”
  - Epidural dose 1/10 systemic dose
  - Intrathecal dose 1/10 epidural dose

Pruritus

- Transmission similar to pain: via small, unmyelinated c-fibers
  - Prostaglandin release enhances c-fiber transmission
  - 5-HT3 and μ (κ is inhibitory) at dorsal horn and trigeminal nucleus
  - Itch selective secondary neurons at lamina I of spinal cord
    - Inhibition by wide dynamic range (WDR) neurons
    - Opioids weaken WDR response
  - Nalbuphine, naloxone infusion, etc.
Adjunctive Medications

Ketamine

- Potentiates analgesic effects of neuraxial local anesthetics and opioids
- Shortens time to onset of epidural local anesthetics
- Animal studies of spinal cord damage with intrathecal administration
  - Attributed to preservatives rather than medication [Malinovsky]
- Epidural, preservative-free ketamine without notable side effects [Acosta]
  - Low concentration ketamine (0.2%) administered
- No definitive studies in pediatrics
Potential Complications

Thoracic & Lumbar Epidural
- Direct needle trauma
- Hematoma
  › Appropriate anticoagulation guidelines
- Infection
- Subdural placement
  › Gradual, delayed onset
  › Extensive sensory & minimal motor block
  › Hypotension (less than total spinal)
  › Intracranial spread resulting in dyspnea, loss of consciousness
- Total spinal anesthesia - suspected in hypotension
  › Cardiovascular instability uncommon in typical pediatric neuraxial
  › Supportive treatment; CSF lavage with crystalloid possible
- Systemic toxicity
- Postdural puncture headache
Potential Complications

Local Anesthetic Systemic Toxicity (LAST)

- Absorption: intrapleural > intercostal > caudal > epidural > brachial plexus > femoral/sciatic > subcutaneous > intra-articular > spinal
- Signs & Symptoms
  - Lidocaine: neurologic precede cardiovascular
  - Bupivacaine: cardiovascular occur first
  - Neurological:
    - Tongue/perioral numbness, paresthesias, restlessness, tinnitus, muscular fasciculations & tremors, tonic-clonic seizures, global CNS depression, decreased LOC, apnea
  - Cardiovascular
    - Early: hypertension & tachycardia
    - Late
      - Peripheral vasodilation, profound hypotension
      - Sinus bradycardia, AV block
      - Ventricular dysrhythmias
      - Cardiac arrest
Potential Complications

Local Anesthetic Systemic Toxicity (LAST)

- Treatment
  - Intralipid  20% 1.5mL/kg over 1 minute
    - 15 mL/kg/hr infusion
  - Avoid
    - Beta blockers, calcium channel blockers, local anesthetics
    - Vasopressin, individual epinephrine doses >1mcg/kg
      - Increased afterload; impaired pulmonary gas exchange

<table>
<thead>
<tr>
<th>Local Anesthetic</th>
<th>Toxic dose (mg/kg)</th>
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<tbody>
<tr>
<td>Bupivacaine</td>
<td>3.0</td>
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<tr>
<td>Ropivacaine</td>
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<td>Lidocaine (w/wo epinephrine)</td>
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<td>Mepivacaine (w/wo epinephrine)</td>
<td>4.5/7</td>
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<tr>
<td>Chloroprocaine</td>
<td>12</td>
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Contraindications

Epidural Analgesia Contraindications

- **Absolute**
  - Patient refusal, inability to cooperate
  - Severe coagulopathy
  - Allergy to local anesthetic
  - Infection at site of puncture
  - Uncorrected hypovolemia (intrathecal)

- **Relative**
  - Low platelets but no bleeding diathesis
  - Infection remote from site of lumbar puncture
  - Pre-existing neurological deficit in region to be blocked
  - Progressive neurological disease
  - Raised intracranial pressure
  - Hypovolemia
  - Fixed cardiac output states
Placement Guidelines

Anticoagulation

- American Society of Regional Anesthesia and Pain Medicine (ASRA)
  - Guidelines for anticoagulation - frequently updated
- NOTE: Peripheral blocks
  - Superficial blocks may be safely performed by ultrasound in residual anticoagulation
  - Deep blocks: guidelines for neuraxial apply

### TABLE 22. Stratification of Risk According to Procedures

<table>
<thead>
<tr>
<th>Low Risk</th>
<th>Intermediate Risk</th>
<th>High Risk</th>
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<tr>
<td>Regional Guidelines</td>
<td>Regional Guidelines</td>
<td>Regional Guidelines</td>
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<tr>
<td>Superficial and compressible</td>
<td>Other procedures based on</td>
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<td>plexus/peripheral nerve blocks</td>
<td>based on compressibility, patient body</td>
<td>Deep and noncompressible</td>
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<td>habitus, comorbidities, and the degree</td>
<td>plexus/peripheral nerve blocks</td>
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<td>and duration of anticoagulation</td>
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<tr>
<td>Pain Guidelines</td>
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<td>Peripheral nerve blocks</td>
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<td>lateral branch blocks</td>
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Narouze et al, with permission.
Questions ????
Bibliography


