Pediatric Regional Anesthesia
Learning Objectives

- Understand the use of local anesthetics in regional anesthesia in pediatrics
- Manage the toxicity of local anesthetics
- Understand the techniques for completing regional anesthesia
- Understand the use of ultrasound guidance for completing peripheral nerve block in pediatrics
Common Local Anesthetics

- Bupivacaine
- Ropivacaine (0.1% and 0.2% solutions)
- Lidocaine
- Tetracaine (bolus)
- Mepivacaine (bolus)
Common Local Anesthetics: Dosing

- **Bupivacaine: Bolus**
  - Infants: 2 mg/kg
  - Toddlers: 3 mg/kg
  - Adolescents: 3 mg/kg

- **Bupivacaine: Continuous**
  - Infants: 0.2 mg/kg/hr
  - Toddlers: 0.3 mg/kg/hr
  - Adolescents: 0.4 mg/kg/hr
Local Anesthetic Toxicity: Symptoms

- Peri-oral sensations
- Metallic taste
- Tinnitus
- Altered mental status
- CNS symptoms
- Cardiovascular instability
Local Anesthetic Toxicity: Avoidance & Treatment

- Avoid large bolus doses for peripheral and neuraxial blocks
- Use low concentration local anesthetic solutions
- Use incremental dosing
- Availability of lipid emulsion
- Supportive therapy available where regional anesthesia is completed
• Recommended treatment of bupivacaine associated cardiac arrest:
  Lipid emulsion (20%) formulation 1-3 ml/kg bolus dose
  0.25 ml/kg/min infusion dose for 10 min
  Bolus may be repeated every 5 – 10 min
  If effective, infusion should be continued for 30 min
  Total 8 ml/kg dose

Regional Anesthesia: Awake, sedated, or anesthetized?

- “heavy sedation or general anesthesia prior to performing regional blocks is the standard practice of most pediatric anesthesiologists”
- “recommendation that anesthesia or heavy sedation should not be considered an absolute contraindication to regional anesthesia in children” (class 2)

Nerve Localization

- Ultrasound guidance
- Nerve Stimulation
- Anatomic landmarks
- Combinations...
Nerve Localization: PNB’s

- “no evidence to support that ultrasound-guided block placement is faster than when using conventional localization techniques”
- “Ultrasound guidance improves the intraoperative block success for PNB’s of the trunk”
- “Ultrasound guidance prolongs analgesia for upper and lower extremity blocks”
- “Ultrasound guidance reduces the volume of local anesthetic required for successful perioperative analgesia in PNB’s”

“Ultrasound enables sufficient visibility of the dura mater and ligamentum flavum in neonates, infants, and children”

“Preprocedural ultrasound imaging offers a moderate prediction of the depth to LOR”

“Ultrasound offers visibility of a needle within the epidural space in neonates”

Neuraxial Anesthesia

- Spinal
- Epidural
  - Thoracic
  - Lumbar
  - Caudal
Spinal Anesthesia

- It is most commonly used as a sole anesthetic in former preterm infants to decrease the risk for postoperative apnea.
- In neonates the spinal cord terminates at the vertebral level as low as L3 while in adults the spinal cord terminates at L1

Spinal Anesthesia

- Minimal hemodynamic changes
- Dosing: ropivacaine 1 mg/kg
- Failure rates <5%

Complications of spinal blockade

- Post-dural puncture headache
- Backache
- Total spinal anaesthetic
- Infection at the site of injection
- Epidural bleeding
- Failed spinal anaesthesia
- Dry tap
Caudal Anesthesia

- Single-shot caudal epidural blockade can be completed for most urological, lower extremity and lower abdominal procedures.
- Placement of a caudal catheter can extend its use to upper abdominal and thoracic surgical procedures (especially in infants).

Caudal Anesthesia

- The duration and anatomic location of the surgical procedure as well as the need for prolonged postoperative analgesia may guide the decision to choose single shot versus catheter placement for caudal anesthesia.
Caudal Anesthesia

- performed in conjunction with general anesthesia and allows for a lighter plane of anesthesia
- caudal epidural space is reached through the sacroccocygeal membrane at the sacral hiatus
- common error for the novice is to aim too low on the sacrum and coccyx

Caudal Anesthesia

• Positive aspiration or difficulty on injection should alert the practitioner to incorrect needle positioning. The use of ECG to predict intravenous placement is routinely used.¹,²
• ultrasound-guidance allows for visualization of the caudal space to avoid inadvertent injection into the intrathecal space or subcutaneous tissue.³

Caudal Anesthesia
Caudal Anesthesia

- **Dosing**
  - Ropivacaine 2 mg/ml
  - Bupivacaine 1.25-2.5 mg/ml

- **Volume**
  - 1 ml/kg can be used to reliably achieve a T10 level
Caudal Anesthesia

- Additives
  - Epinephrine
  - Opioids
    - Morphine
    - Fentanyl
  - Clonidine
Complications of caudal anesthesia

- Inadvertent spinal anaesthesia
- Subcutaneous injection
- Intraosseous injection
- Intravascular injection
- Delayed micturition/urinary retention
- Local anaesthetic toxicity
- Backache
- Bleeding
- Infection at the site of injection
- Motor block
- Rectal injection
- Implantation dermoid
Complications of caudal anesthesia

• The potential devastating risk of neurological injury is rare but possible
• A large prospective study by Giaufre et al. reported no reported permanent neurologic injury in over 15,000 completed caudal blocks.

Lumbar and thoracic epidurals

- Lumbar and thoracic epidural anaesthesia is an effective method to provide analgesia for thoracic, abdominal and orthopaedic procedures.

  There is a shallow depth to the epidural space, that can be visualized under ultrasound-guidance. A useful guide is 1 mm/kg.

  The ligamentum flavum may be very soft and may not illicit the tactile feel when puncturing as in the adult patient.
Lumbar and thoracic epidurals

- Debate over for placing thoracic epidural catheters in anesthetized patients
- Concern for neurological injury during placement
- The ability for the patient to communicate an elicited paraesthesia can guide placement of an epidural catheter although this may indicate nerve root trauma rather than cord trauma.

Head and Neck Blocks

- Can be used for a variety of cases including:
  - Neurosurgical procedures
  - ENT procedures
  - Plastic surgery procedures
Occipital Nerve Block

- Posterior Fossa Craniotomies
- VP shunt revisions
- Technique:
  - Located just medial to occipital artery
  - 0.5-3 ml 0.25% bupivacaine
Auricular Nerve (Nerve of Arnold)

- Analgesia to the external ear (BTI)
- Technically easy to complete
- Minimal side effects
- Equivalent to intranasal fentanyl
- 0.2 ml 0.25% bupivacaine

Trigeminal Nerve

- Maxillary branch sensory nerve that supplies the maxillary sinus, nasal cavity, upper lip and palate.
- Can be used for:
  - Endoscopic Sinus Surgery
  - Rhinoplasty
  - Cleft Lip repair
• Cleft Lip Surgery
  Infraorbital branch provides sensation to the upper lip
  Equivalent sucking/feeding ability post-operatively
  Decreased analgesic requirements
  0.5 ml 0.25% bupivacaine

Case Reports

- 18 day old, 700 gram neonate undergoing Ommaya reservoir placement
- Occipital and Supraorbital nerve blocks completed
- Patient had effective intra-op and post-op analgesia as judged by vital signs

Case Reports

- 3 premature neonates (avg. weight 1850 grams) undergoing Ommaya or McComb reservoir placement
- All successfully completed with regional anesthesia (trigeminal nerve blockade) alone
- None required general anesthesia

Greater Palatine Nerve

- Provides analgesia to the hard palate
- 0.5-1 ml 0.25% bupivacaine
- Reduces need for post-operative opioid use
Greater Palatine Nerve
Superficial Cervical Plexus

- Greater auricular nerve provides sensory supply to the mastoid area
- Superficial block
- Decreased opioid use
- Decreased side effects

Upper Extremity Blocks: Brachial Plexus
Upper Extremity Blocks: Brachial Plexus

- Interscalene
- Supraclavicular
- Infraclavicular
- Axillary
Interscalene

- Ideal for shoulder, proximal arm procedures
- 0.2-0.4 ml/kg 0.25% bupivacaine
- Ideal for placing catheters
- Inform patients of side effects – Horner’s syndrome
Interscalene
Supraclavicular and Infraclavicular approaches

- Ideal for proximal arm and elbow procedures, fracture reductions
- Infraclavicular approach often used for catheter placement
- 0.2-0.4 ml/kg 0.25% bupivacaine
Infraclavicular
Axillary

- Most common approach to the brachial plexus in pediatrics
- Techniques:
  - US guided
  - Nerve Stimulation
  - Transarterial
- Musculocutaneous nerve must be blocked separately
- 0.2-0.4 ml/kg 0.25% bupivacaine
Axillary

Axilla - Median, Ulnar, Radial, and MC Nerve
Axillary
Ultrasound Guided Truncal Blocks

- Transversus Abdominis Plane Block (TAP)
- Rectus Sheath Block
- Ilioinguinal/Iliohypogastric Nerve Block
Ultrasound Guided TAP

• Anterior abdominal wall is innervated by T7 – T12 and L1

• Terminal branches traverse the lateral abdominal wall in the plane between the internal oblique and transversus abdominis muscles

• Landmark based technique with needle insertion at *Triangle of Petit*
  Latissmus Dorsi (posterior)
  External Oblique (anterior)
  Iliac Crest (inferior)

Transverse Abdominis Plane (TAP) Block

- Patient in supine position
- Aseptic technique
- Peds: 25-50mm 22G blunt tip needle
  0.125-0.25% Bupivacaine
  0.1-0.2 mL/kg per side
- Linear, high-frequency ultrasound transducer
- Mid-axillary line insertion

TAP Block

• Indications:
  Anterior abdominal wall incisions
  Does NOT provide surgical analgesia
  Reduces peri-operative narcotic usage

• Complications:
  Intravascular injection, peritoneal puncture, injury to bowel and/or liver
Rectus Sheath Block

- T9-T11 coverage
- **Indications**
  - Umbilical hernia repair
  - Epigastric hernia repair
  - Laparoscopic surgery (SILS)
  - Other small midline incisions
- 8-10 hours post operative analgesia


Ferguson S et al. The rectus sheath block in paediatric anaesthesia: new indications for an old technique. Paediatr Anaesth 1996; 463-6
Rectus Sheath Block

- Aseptic technique

- High frequency, linear probe placed lateral to the umbilicus

- 25-50mm 22G blunt tip needle
  0.25% Bupivacaine 0.1 mL/kg per side

Rectus Sheath Block

- The sheath appears hyperechoic with multiple linear layers
- Injection bilaterally at either point
- Complications
  - Intravascular injection
  - Intra-peritoneal injection

Ilioinguinal – Iliohypogastric Nerve Block

- T12/L1 coverage
- One of the most common peripheral nerve blocks in children
- Previous reliance on subjective detection (ie. “pops,” “clicks,” or “scratching sensations”)

- Indications
  - Inguinal hernia repair
  - Orchidopexy
  - Hydrocele repair

Ilioinguinal – Iliohypogastric Nerve Block

- Probe placed immediately medial to ASIS (short axis)
- Goal to capture ilioinguinal nerve between internal oblique and transversus abdominis muscles

- Aseptic preparation
- High frequency, linear probe
- In-plane technique
- Adult: 70mm 22G blunt tip needle
  0.2% Ropivacaine 15 mL
- Peds: 25-50mm 22G blunt tip needle
  0.25% Bupivacaine 0.1 mL/kg

Ilioinguinal – Iliohypogastric Nerve Block

• ASIS appears as hypoechoic along lateral edge
• Hyperechoic muscles layers denoted
• EOM often aponeurotic at this level
• Can be effective as a caudal block

Ultrasound Guided Lower Extremity Techniques

- Femoral Nerve Block
- Lateral Femoral Cutaneous Nerve Block
- Saphenous Nerve Block
- Sciatic Nerve Block
Femoral Nerve Block

- Indications: Ant thigh, flexor m. of hip, extensor m. of knee
- Branch of the lumbar plexus
  L2, L3, L4
- Deep to fascia iliaca
- Superficial to iliopsoas m.
- Below Inguinal ligament
- ‘N-A-V-EL’ or ‘N-A-V’
Sono-anatomy
## Complications

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| **Infection**     | - Just like with any other procedure, use a strict aseptic technique  
                    - Catheters at this location are difficult to keep sterile and should probably be removed after 48 hours |
| **Hematoma**      | - Avoid advancement of the needle when the patient reports pain; this may indicate insertion of the needle through the iliopsoas or pectineus muscles.  
                    - When the femoral artery or vein are punctured, the procedure should be stopped and a firm and constant pressure applied over the femoral artery for 2-3 minutes before proceeding with the blockade.  
                    - In a patient with difficult anatomy or severe peripheral vascular disease, use a single-shot smaller gauge needle to localize the femoral nerve before proceeding with a larger gauge needle for the continuous technique. |
| **Vascular Puncture** | - Never redirect the needle medially!  
                    - The needle is first inserted just lateral to the femoral artery and the consequent insertions and redirections should all be progressively more lateral |
| **Nerve Injury**  | - Use nerve stimulation and slow needle advancement  
                    - Distinct paresthesia is almost never elicited with femoral nerve block and should not be sought  
                    - Do not inject when the patient complains of pain or when high pressures on injection are met |
| **Other**         | - Instruct the patient on the inability to bear weight on the blocked extremity |
Lateral Femoral Cutaneous Block

- Arises from L2-L3
- Small subcutaneous nerve between fascia lata and iliaca
- Sensory innervation to the lateral thigh
- Psoas M. → ASIS → Inguinal Ligament → Sartorius M. → 2 Branches

Scanning Technique:

- Place probe medial to ASIS, inguinal ligament
- Scan medial and inferior
- Depth: 1-2cm

Inject 0.1-0.5mL/kg of 0.25% Bupiv or 0.2% Ropiv

Lateral Femoral Cutaneous Nerve Block

- Small linear hyperchoic structure, interfascial plane, above Sartorius M.

- If not visualized..
  Place needle at insertion of Sartorius M.
  Hydro-dissect the interfascial plane
  2 cm medial, 5 cm inferior to ASIS
  Scan from medial to lateral along fascia

- Indications:
  Sensory anesthesia of anterolateral thigh
  Muscle biopsy
Saphenous Nerve Block

- Largest cutaneous branch of Femoral N.
- Approaches: perifemoral, condylar, infrapatellar, medial malleolar
- Distal thigh, between Sartorius and Gracilis M.
- Traverses subcutaneous
- Below knee, tibial side, adjacent to saph v.
Saphenous Nerve Block

- Indications: foot/ankle/leg procedures involving medial dermatomes

Sciatic Nerve Block (SNB)

- Indication: Foot/Ankle Surgery
- Largest nerve in human body
- Anterior rami of L4-S3
- Sensory/Motor to post thigh and most of distal leg

Approaches:
- Gluteal/Labat
- Subgluteal
- Proximal Thigh
- Popliteal

Branches:
- Tibial
- Common Peroneal

1 = sciatic nerve
2 = piriformis muscle
3 = gluteus maximus muscle
4 = inner muscle layer (superior and inferior gemellus muscles, obturator internus muscle, quadratus femoris)
Regional Anesthesia: Summary

- Central neuraxial blockade remains an essential component of the goal to provide a pain-free perioperative experience for infants and children.
- Advances in ultrasound-guided techniques may prove to increase safety and efficacy in completing this goal.
- Improve time to discharge.
- Decrease unwanted side effects of opioid use.
- Can improve patient satisfaction.