A surgery center nightmare- total spinal after a caudal block for hypospadius repair

11 mo infant presents for hypospadius repair. Uneventful inhalational induction/LMA placement. IV antibiotics given while turning pt after atraumatic caudal block; patient noted to be apneic.

Objectives:
- To discuss:
  1. The differential diagnosis for apnea under anesthesia (including medication errors, total spinal, deep anesthesia, etc)
  2. Caudal block techniques, indications, risks, local anesthetic doses and adjuvants (intrathecal ketamine, narcotics, or clonidine) and their role in outpatients.
  3. Management of cardiovascular collapse from inadvertent intravascular injection of local anesthetic including intralipid infusion therapy.
  4. Diagnosis and management of inadvertent intrathecal injection of local anesthetic.
  5. The best approach with family after a complication

Case:
An otherwise healthy 11 mo 8kg infant presents for hypospadius repair. The friendly patient is taken to the operating room without premedication. ASA standard monitoring was placed with initial vital signs- BP 86/48 HR 99 O2 sat 99%. Uneventful inhalational induction with oxygen, nitrous oxide, and incremental increased sevoflurane. A 24 gauge PIV placed in left hand and #1.5 LMA placed without difficulty. The patient was turned to left lateral fetal position for caudal block. Caudal block performed without difficulty and 8 cc of 0.25% bupivacaine with epinephrine injected after negative aspiration for blood and CSF and no HR increase noted with 1 cc test dose. Vital signs at test dose BP 83/51, HR 94, RR 34, O2 sat 100% on N2O/O2 (FIO2 30%) and sevoflurane dial 2%. IV antibiotics given while turning pt supine after the caudal block is completed; the patient is noted to be apneic. Vital signs now BP 80/49, HR 92.

Key Questions:
1. What age group is appropriate for an outpatient block? What are the indications, contraindications and potential complications of a caudal block?
2. What are the different techniques for confirming appropriate placement of a caudal block?
3. What local anesthetics and concentrations are appropriate?
4. What are the different additives used and the potential side effects?
5. What is the differential diagnosis of apnea in this case? Discuss the common medication errors in the operating room.
6. What physiological signs would indicate an inadvertent intrathecal injection of local anesthetic in a pediatric patient? How is this different than an adult?
7. What physiological signs would indicate an inadvertent intravascular injection of local anesthetic in a pediatric patient? How would you treat cardiovascular collapse from local anesthetic toxicity?

8. How do you approach the family after a complication?

Model Discussion

1. **What age group is appropriate for an outpatient block? What are the indications, contraindications and potential complications of a caudal block?**

   A caudal block can be used for most operations below the umbilicus (e.g. inguinal hernia repair, hydrocele, orchidopexy, circumcision, orthopedic interventions on the lower limb or pelvic girdle, skin grafting, GU and anorectal procedures) and can also be used for certain types of abdominal surgery. The block can help minimize side effects of general anesthesia (requiring lighter plane of anesthesia, hasten awakening, provide several hours of postoperative analgesia and potentially decrease time to discharge for outpatient procedures. The contraindications for caudal epidural anesthesia are similar to those for spinal or lumbar epidural anesthesia and include Coagulation disorders, active infection at the site of injection, patient or parental refusal congenital anatomic anomalies of the spinal cord or vertebral bodies and while scoliosis is not an absolute contraindication the block may be technically difficult. As with any medical intervention caudal block is associated with the potential for some complications, such as unintentional dural puncture with total spinal anesthesia, inadvertent intrapleural or intravascular injection of local anesthetics with potential subsequent systemic toxicity, perforation of the rectum with potential contamination of the epidural space, hematoma, neural injury or a failed or patchy block.

2. **What are the different techniques for confirming appropriate placement of a caudal block?**

   The caudal block is the most easily learned and mastered of all regional anesthetic techniques associated with a high rate of success and relatively low risk of complications. Johr et al have shown that only 32 blocks are needed to reach about the same skill level as older and more experienced colleagues. However, even in experienced hands it can result in failure, with depending on the study, an overall failure rate between 2.8% and 11%. Dalens and Hasnaoui (1) reported an overall success rate of 96% in a retrospective study with the most frequent causes of technical failure to include subcutaneous insertion (19.5%) and vascular penetration (1.6%). Clinical guides used for successful caudal block placement include, identification of anatomical landmarks, loss of resistance or ‘pop’ with piecing the sacrococcygeal membrane, ease of threading an angiocath into the space, negative aspiration of blood and CSF, lack of resistance and subcutaneous swelling with injection and absence of HR or ECG changes during test dose of epinephrine containing solution.

   The classic “whoosh” test first described in 1988 by Lee was a simple test to confirm correct placement of the needle in the caudal space and was thought to be more reliable for successful block than the subjective “pop” when the needle pierced the
sacrococcygeal membrane. The test entailed injecting (after negative aspiration for blood or CSF) 1cc of air with a stethoscope placed over the lower lumbar spine immediately above the tip of the needle. A characteristic “whoosh” heard indicated appropriate placement.

Because of potential neurologic sequelae of injection of air this test has been replaced by the “modified swoosh” test which entails injection of 1cc of normal saline instead of air. The “whoosh” and “swoosh” test in some studies show an overall success rate of up to 96% and 93% respectively.\(^{(2,3)}\)

Ultrasonography-guided regional anesthetic techniques have emerged as the accepted technique with potential decrease in block related complications, decreasing the incidence of failed blocks (as the spread of local anesthetic can be visualized directly) and potential decrease in amount of local anesthetic needed for the block (more accurate placement) and thus decreased toxicity. Ultrasound can also be utilized for caudal block placement in pediatric patients. It can be used to visualize the neural structures, bony landmarks guide needle insertion and can allow visualization of the injectate and dural displacement with injection. The volume of local anesthetic injected causes a progressive widening of the epidural space and compression of the thecal sac. This real time visualization allows adjustment of a misplaced needle immediately and can be useful in caudal placement in children who have cutaneous markers of dysraphism who would otherwise not receive a caudal block.\(^{(4)}\)

Electrostimulation technique is frequently used for peripheral blocks and has also been described for caudal blocks. An insulated needle advanced in the caudal space with correct placement verified by the presence of anal sphincter contraction (S2-S4) to 1 Hz stimulation (1 to 10mA).

### 3. What local anesthetics and concentrations are appropriate?

The main disadvantage of caudal blockade is the relatively short duration of postoperative analgesia, even with the use of relatively long acting local anesthetic agents such as bupivacaine. Higher concentrations of the local prolong the duration of analgesia but also result in an increase in the amount of drug, increasing the risk of toxicity and density of the motor blockade which may be undesirable in the outpatient setting. Numerous studies have compared different concentrations and volumes of ropivicaine, bupivicaine and levobupivicaine (not widely available). Ropivicaine, at equipotent doses is probably as toxic as racemic bupivicaine but provides better analgesia and less motor blockade so that lesser concentrations can be used for equal clinical efficacy effectively decreasing the risk of toxicity. Concentrations of 0.175% and 0.2% have been used with similar durations of analgesia with quicker resolution of motor block with the lesser concentration.\(^{(5)}\) Bupivicaine remains, despite its potential devastating toxicity, the most commonly used anesthetic for caudal analgesia. Concentrations from 0.125%-0.25% have been used successfully for postoperative analgesia.
4. What are the different additives used and the potential side effects? (6)

Opioids:
A number of additives have been used to attempt to prolong the duration of a single caudal injection. Opioids are commonly used as adjuncts for caudal blockade and have been shown to consistently increase duration of analgesia. Unacceptable side effects including nausea, vomiting, priuritis and risk of delayed respiratory depression, have limited the use of opioid additives in children undergoing outpatient surgery.

Epinephrine:
Epinephrine is routinely used to prolong the duration of regional anesthetic blockade. It is also used as a marker of inadvertent intravascular injection. Adrenaline decreases the rate of vascular absorption of local anesthetic solution because of vasoconstriction. The alpha effects of adrenaline may contribute to prolongation of caudal analgesia. There is evidence of increased duration of analgesia with the addition of epinephrine to epidural bupivacaine for labor. Evidence of this effect in caudal blockade, however, is lacking especially for older children. The implication of epinephrine in neurological complications, specifically anterior spinal artery syndrome, following caudal administration, appears to be a theoretical, rather than practical risk when administered in small doses.

Clonidine:
Numerous studies have demonstrated an increase in the duration of extra-dural analgesia when used in combination with local anesthesia. Prolonged duration of analgesia has also been demonstrated when clonidine is combined with local anesthetic for other regional anesthetic procedures. The mechanism whereby clonidine prolongs the duration of local anesthetic blockade when injected into the epidural space remains unclear. It is highly lipid soluble and easily crosses the blood-brain barrier to interact with alpha2 adrenergic receptors at both the spinal and supraspinal sites within the CNS. The analgesic activity of clonidine is mediated through receptors in the dorsal horn of the spinal cord, both pre and postsynaptically. It is also possible that clonidine induces vasoconstriction through receptors in vascular smooth muscle and thus acts by reducing absorption of a local anesthetic agent. The addition of clonidine (1-2 mcg/kg) to local anesthetic produces a consistent increase in the duration of analgesia of 2-3 hrs however sedation scores are increased and the potential for respiratory depression is increased in some infants.

Ketamine
The analgesic effects of ketamine occur via NMDA receptor antagonism, Mu receptor agonism and sodium channel interactions. A significantly increased duration of analgesic is seen with caudal administration compared with intramuscular injection despite lower plasma concentrations with caudal administration. Ketamine has been used as the sole agent (decreased risk with inadvertent intravascular injection) as well
in combination with local anesthetic (0.25-0.5 mg/kg) with a significant increase the duration of analgesia without increase in sedation or emesis. Furthermore, ketamine prolongs analgesia significantly more than clonidine. However, reported risks of neurotoxicity with commercially available ketamine have limited its use. The preservative-free S(+) enantiomer appears to be safer (though not widely available).

Neostigmine
Abdulatif and colleagues, in 2002 16 reported a good analgesic effect but approximately 30% of the patients experienced postoperative nausea and vomiting (PONV) in a dose dependent fashion.

5. **What is the differential diagnosis of apnea in this case? Discuss the common medication errors in the operating room.**

The differential diagnosis of loss of ETCO2/apnea includes anesthesia overdose, disconnect of circuit or ETCO2 cable, dislodged LMA or endotracheal tube, severe bronchospasm, laryngospasm, high spinal, light anesthesia with breath hold, cardiovascular collapse or medication error (syringe swap).

Overall, as many 1.3 million people are injured annually in the United States following "medication errors" the majority of which are related to improper dose, wrong drug, or wrong route of administration. Anesthesia provides are in a unique position as they both prescribe and administer drugs and will do so at least 500,000 times in an average career. Some reports suggest a rate of 1 reported drug error in every 140 anesthetics. ASA Closed Claims Study revealed that 44% of claims for medication error were for wrong drug with all pediatric and majority of adult claims for overdoses. Drug substitution accounted for 30% of claims, and contraindicated drugs were 10%. Greater than 80% were deemed preventable and represented less than appropriate care. Look alike drug vials and ampules, sound alike names, poor syringe labeling all contribute to potential for a medication error or syringe swap. (8)

A 5point checklist for avoiding medication error has been described by the APSF (9) as follows:

1. Read the label
2. Check the labels with a second person or a device before drawing up or giving a drug
3. Labels must be legible
4. Syringes must be labeled
5. Workspaces should be formally organized, particularly to separate or even remove dangerous drugs (e.g. KCL)

Standardization of infusion concentrations, prefilled syringes from pharmacy, better labeling can also decrease the incidence of medication errors in the operating room.
In this case, antibiotics were mixed and administered as the patient was being turned supine after the completion of the caudal block. Along with high spinal medication error (swap of vecuronium instead of cefazolin) may have occurred.

6. **What physiological signs would indicate an inadvertent intrathecal injection of local anesthetic in a pediatric patient? How is this different than an adult?**

In awake adults the first signs of high spinal block are hypotension, bradycardia and difficulty in breathing. Hypotension is due to venous and arterial vasodilation resulting in a reduced venous return, cardiac output and systemic vascular resistance. Bradycardia is caused by sympathetic block leading to unopposed vagal tone and blockade of the cardio-accelerator fibers arising from T1-T4. Heart rate may also decrease as a result of a fall in right atrial filling. Respiratory difficulty is caused by loss of chest wall sensation caused by paralysis of the intercostal muscles. When a total spinal occurs the nerve supply to the diaphragm (cervical roots 3-5) is blocked and respiratory failure develops rapidly. Sudden respiratory arrest may also be caused by hypoperfusion of the respiratory centers in the brainstem. Other signs of total spinal include loss of consciousness and pupillary dilatation.

Numerous reports exist of infants tolerating high or total spinal anesthesia without the significant autonomic changes seen in adults. Although the reason for this finding are unclear, some suggest the cardiovascular stability in infants is due to either a smaller venous capacitance in the lower extremities (less pooling of blood), or a relative immaturity of the sympathetic nervous system which results in less dependence on sympathetic vasomotor tone. (10)

7. **What physiological signs would indicate an inadvertent intravascular injection of local anesthetic in a pediatric patient? How would you treat cardiovascular collapse from local anesthetic toxicity?**

Injection of local anesthetics into very vascular areas leads to greater blood concentrations than the same dose injected into less vascular areas. The order of uptake (i.e., maximum blood concentration) of local anesthetics (in order from greatest to least) with regional blocks in adults is (1) intercostal nerve blocks, (2) caudal blocks, (3) epidural blocks, and (4) brachial plexus and femoral-sciatic nerve blocks (mnemonic ICE Block).

Dose dependent effects from local anesthetics can be divided into neurologic (dizziness, seizure, loss of consciousness) and cardiovascular (tachycardia, hypotension, arrhythmias, cardiac arrest). Bupivicaine has been implicated as the most cardiotoxic with arrest that, until now, has been resistant to resuscitative efforts requiring cardiopulmonary bypass. Intravenous intralipid therapy has emerged as a method for rescue for cardiovascular collapse after inadvertent intravenous injection of local anesthetics once standard resuscitation efforts fail. The literature now reflects several case reports of successful resuscitation after cardiovascular collapse in the
adult population and recently in an infant after inadvertent intravascular injection of local anesthetic.

Infants are at greater risk of bupivacaine toxicity because the level of \([\text{alpha}] 1\)-acid glycoprotein, which binds bupivacaine, is decreased in infants compared with older age groups (reaching adult levels by age 1 yr) allowing for more free drug. Furthermore clearance is diminished (decreased phase I and II metabolism and GFR) in neonates for the first several months of life.

Proposed mechanisms by which intralipid therapy reverses local anesthetic cardiotoxicity include the theory that lipids function as a “lipid sink” and increase the clearance of the local anesthetic from cardiac tissue. The second proposed mechanism is that lipids counteract local anesthetic inhibition of myocardial fatty acid oxidation, thereby enabling energy production and reversing cardiac depression.

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In the event of local anesthetic-induced cardiac arrest that is unresponsive to standard cardiopulmonary resuscitation-

**Intralipid 20% should be given IV in the following dose regime:**
- Intralipid 20% 1.5 ml/kg over 1 minute
- Follow immediately with an infusion at a rate of 0.25 ml/kg/min,
- Continue chest compressions (lipid must circulate)
- Repeat bolus every 3-5 minutes up to 3 ml/kg total dose until circulation is restored
- Continue infusion until hemodynamic stability is restored. Increase the rate to 0.5 ml/kg/min if BP declines (a maximum total dose of 8 ml/kg is recommended)

Premature and small for gestational age infants have poor clearance of intravenous fat emulsion. Deaths have been reported in preterm infants after infusion of intravenous fat emulsion with autopsy findings consistent with intravascular fat accumulation in the lungs. Therefore treatment of premature and low birth weight infants with intravenous fat emulsion must be based upon careful benefit-risk assessment. Total daily dose for nutrition in neonates, not to exceed 1 g fat/kg in four hours, may be a good guide of maximum dose of intralipids for resuscitation. For older patients, the maximum dosage recommended by the American Academy of Pediatrics is 3 g fat/kg/24 hours or an infusion rate of 0.1 g of fat/kg/hr (for nutrition).

8. **How do you approach the family after a complication?**

When an adverse event occurs (whether secondary to error or as a known potential complication) the best approach with the family is honesty. Studies show that families respond better to a straightforward discussion. Patients and families want to understand what happened and the implications of their care. The discussion with the family, however, should occur only after the team (surgeon, anesthesiologist, others
directly involved) have a thorough discussion/understanding of the sequence of events that led up to the complication and how it will be managed (need for escalation of care, etc) to present a unified (and truthful) account. A genuine apology can go a long way with the family. There are many reports that show that children and families often go to lawyers because their questions were not adequately addressed or that full disclosure did not occur. It is important to emphasize that an apology is not meant to imply guilt for the unanticipated event. In fact, some states have passed legislation to protect apologies from being used in litigation. Finally, a thorough note should be written in the patients chart providing a summary of the events, plan of action as well as the family discussions.

References:

11. Weinberg, G. LipidRescue resuscitation for cardiac toxicity. lipidrescue.squarespace.com