Objectives

1. Understand what techniques and tools today’s pediatric practice can use.
2. Be able to evaluate patients for appropriateness for ambulatory procedures.
3. Be able to incorporate unique concerns for pediatric patients into an ambulatory practice.

Conflicts of Interest

• Nothing financial
• Medically, I consider myself conservative but like the “frontier”
Pediatric Ambulatory Surgery

- From the CDC survey of ambulatory surgery in the USA in 2009:
  - 53,329,000 procedures
  - 3,266,000 on patients under 15 years old
  - Nearly exactly 50/50 split between free-standing and hospital-based facilities


Pediatric Ambulatory Surgery

1. Nose, mouth, pharynx (T&A)
2. Ear (PE tubes)
3. Musculoskeletal (Fx reduction)
4. Misc and diagnostic
5. Tie: Integument and Male genitalia

Patient Selection
Patient Selection

- Process to screen should seek problems that your facility is not capable of accommodating or would significantly disrupt the schedule:
  - Sickle Cell
  - Asthma
  - Prematurity
  - Congenital Heart Disease
  - Congenital Syndromes
  - Malignant Hyperthermia
  - The dreaded “cold”

Sickle Cell Disease

“Do we need a sickle screen on this patient?”

- We screen our patients to see if they fall into a high-risk ethnic background
- If so, we query the state lab for the results of their newborn screen
- Patients with sickle cell trait still carry a small risk for sickling, but it only occurs in extreme situations that should not occur during a controlled anesthetic
Sickle Cell Disease

- I never do patients that have true sickle cell disease
- Why?

- Since we do not have a blood bank at our doorstep, getting appropriately matched blood would be nearly impossible in the event of a crisis
- Children with Sickle Cell Disease can be transfused up to a hemoglobin of 10 gm/dl
  - Requires much pre-planning
  - Involves hematologist or infusion clinic services
  - Doesn’t entirely eliminate the risk

- A study by H.R. Bainbridge, et al, from University of West Indies, Kingston, Jamaica, demonstrated:
  - 94% of 7-year-olds
  - 96% of 8-year-olds with sickle cell disease were displaying symptoms specific to sickle cell disease
- We stop calling at about age 10 years old
- If unavailable hx (California), I send them for screening or do a POCT hemoglobin on arrival
Asthma

Have you noticed that "everybody has asthma?"

And everyone with asthma shows up with a cold??

• It is a disease that is increasing in prevalence and is the #1 chronic disease in children
• Certainly asthmatics can tolerate outpatient surgery without difficulty, but they should be screened for active disease
• A history should be taken for medications, triggers, and general symptoms
• It may be useful to know how often rescue inhalers or steroids are used, but my experience is that this is more reflective of the care the patient receives
Asthma Recommendations

- Patients treated only with beta-agonists should take them twice a day for the 3 days pre-operative.
- Patients on maintenance steroids should increase to the doses they use during an acute exacerbation
  - This includes inhaled and oral steroids

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Asthma Recommendations

- If the child is febrile with a respiratory illness, I reschedule them for 4 to 6 weeks later
- If they present with wheezing and I can’t clear it with albuterol, I reschedule them for 4 weeks and recommend a visit to the primary care doctor

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Asthma Recommendations

- If they have asthma and present for adenoids or tonsils, I pre-treat them with albuterol
- All of my asthmatics receive steroids IV intraoperatively for emesis prophylaxis and (hopefully) better asthma control later in the day
- Don’t be afraid of recommending a short course of oral steroids preoperatively to a child with a strong asthma history

Colds

Prematurity

• The insidious dilemma that occurs at the desk in the pre-op area is the issue of prematurity
• It is not infrequent to cross a former 24- and 28-week premie in a busy pediatric practice
• How old do they need to be to be done safely?

Prematurity

• Starting 1983, the risk of post-operative apnea in former pre-term infants became widely publicized
• Papers led by Liu, Kurth, and Welborn are among the most widely known
• Scary case reports about full-term infants with post-operative apnea were published by lead authors Coté, Tatzlaif, and Noseworthy

Note: PCA=Post-Conceptual Age=Weeks Gestation + Weeks Since Birth
Prematurity

In 1995, Coté, et al, published a combined analysis of apnea in preterm infants after hernia surgery. Analyzed 8 studies and included 255 infants:

- Found gestational age, post-conceptual age, and anemia (Hct<30) were risk factors.
- Risk of apnea was <5% at 48 weeks PCA, <1% at 54 weeks PCA for 33 weeks gestational age infants.
- Risk of apnea was <5% at 50 weeks PCA, <1% at 56 weeks PCA for 32 week gestational age infants.
- Noted that although apnea frequently occurred within 2 hours post-op, it may occur 10 to 12 hours post-op.

Prematurity

So……..

- I recommend limiting your exposure to recent premies in ambulatory surgery.
- 60 weeks PCA exceeds all recommendations.
- Consider a minimum of 45 week PCA for full-term infants.
- Evaluate your own facility are transfer agreements to accommodate care and transfer if necessary.
Outpatient Infants

- The Children’s Hospital of Wisconsin now approaches infants as follows:
  - Full-term, 45-week-old may go home day of surgery if no respiratory issues
  - Pre-term, 55-week-old may go home day of surgery if no respiratory issues
  - Prematurity is defined as 36 weeks

Congenital Heart Disease

“Doctor, there is a patient for strabismus surgery that had a repair of a double outlet right ventricle. Is he OK for surgery?”

- The rules for children with heart disease for ambulatory surgery are close to those for adults
- Avoid children with:
  - Heart failure
  - Poor general health
  - Cyanotic heart disease
  - Pulmonary Hypertension
- Each of these subtypes has been shown to be at higher risk for post-operative mortality

Congenital Heart Disease

- A simple reference book of pediatric cardiac surgery by E. May
- To assess cardiac function and presence of pulmonary hypertension, an echo report can be invaluable

Congenital Cardiac Disease

- A rule of thumb to **never** do at an ASC or office would be a patient with single-ventricle physiology
  - Fontan
  - Hemi-Fontan (Glenn)
  - Norwood
- Initial diagnosis of HLHS, pulmonary or tricuspid atresia

Congenital Heart Disease

- These patients are very dependent on low pulmonary vascular pressures to maintain preload
- Once they start decompensating there is little you can do to rescue them outside of a tertiary care, pediatric hospital
Congenital Heart Disease-SBE

Only patients with cardiac conditions associated with the highest risk for adverse outcomes should continue following antibiotic prophylaxis before surgery:

- Unrepaired cyanotic CHD
  - Including palliative shunts and conduits
- Completely repaired congenital heart defects with prosthetic material or device during the first 6 months after the procedure
- Repaired CHD with residual defects at the site or adjacent to the site of a prosthetic patch or prosthetic device (which inhibit endothelialization)
- Patients with previous endocarditis


Congenital Syndromes

"Doctor, what should I set up for our 8:15 hernia repair with Hurler's Syndrome?"

- Most are genetic with clear inheritance
  - Down’s Syndrome
  - Cystic Fibrosis
  - Crouzon’s Syndrome
- Some are a result of development in utero
  - Fetal Alcohol Syndrome
  - Amniotic Band Syndrome
  - Gastroschisis
- Good thing is the child usually comes with his parents!
Congenital Syndromes

- Achalasia
- Apert/Crouzon
- Arthrogryposis
- Beckwith-Wiedemann
- Ehler-Danlos type I
- Eisenmenger
- Epidermolysis Bullosa
- Fibrodysplasia ossificans
- Glycogen storage disease
- Hunter/Hurler
- Hypoplastic Left Heart
- Muscular Dystrophy
- Nager/Treacher Collins
- Ondine's Curse
- Pierre-Robin
- Pompe Disease
- Prolonged Q-T (?)
- Prune Belly
- Trisomy >4, < 19

Malignant Hyperthermia

“The 10:00 orchidopexy patient’s mom says she has a uncle who was told that anesthesia would kill him and he should tell everyone in his family the same thing.”

Malignant Hyperthermia

- Pediatric patients tend to be at higher risk because if they are susceptible, but carry no diagnosis, they may reveal themselves as MH patients in your facility
- The riskiest patients may be the ones that present for surgery to correct a muscular problem:
  - Strabismus
  - Scoliosis (not likely outpatient)
  - Tendon release for spasticity
Malignant Hyperthermia

- Patients with the following are **DEFINITELY** MH susceptible:
  - King-Denborough syndrome
  - Central core myopathy
  - Multi-minicore disease with RYR1 mutation
- These more common diseases have **NO** (or have a very weak or unproven) association:
  - Duchene's muscular dystrophy
  - Becker dystrophy
  - Noonan syndrome
  - Arthrogryposis
  - Osteogenesis imperfecta

Anesthesia and Analgesia, Vol 109, No. 4, October 2009.

Malignant Hyperthermia

- Patients with a positive family history need to be investigated for the direct lineage is between your patient and the index patient
- Personally, I don’t select patients with direct parents, grandparents, or siblings with MH to have surgery at my ASC

Malignant Hyperthermia

- MHAUS recommends 12 hours of ICU-type monitoring after performing an anesthetic on an MH-susceptible patient
- There don’t seem to be allowances for non-triggering anesthetics!
- Currently, MHAUS recommendation is for full dose of dantrolene to be available if any triggering agents are present
- SAMBA is currently advocating for no dantrolene if succinylcholine present for airway rescue only
Mitochondrial Disease

- Patients present with myopathy or encephalopathy with a metabolic disorder
- Genetics are combined from direct maternal (mitochondrial DNA) and Mendelian (additional proteins)
- Wide spectrum of disease with variable phenotypes
- Disease of respiratory chain or fatty acid metabolism


Inhalational Anesthetics

- MH trigger
- Mechanism of anesthesia likely related to reduction of mitochondrial function
- Hyperkalemic arrest in muscular diseases
- Likely safe for induction

Propofol

- Non-triggering
- Specific receptor known
- Effects mitochondria at 4 different levels
- PRIS
- Bolus “safe”


When Things Can Go Wrong....
Risk of Adverse Event

- 19,059 charts of pediatric patient undergoing anesthesia for operative or diagnostic (radiology) procedures
- Retrospectively used to develop and validate tool for perioperative respiratory adverse events (PRAE)
- Patients (8,904) done in 2007 to 2009 were used to develop criteria
- Patients (10,155) done in 2010 to 2012 were used to validate criteria and scoring


Risk of Adverse Event

PRAE defined as:
- Apnea/hypopnea= need for bag-mask ventilation
- Bronchospasm=use of albuterol
- Laryngospasm=sux, administration or CPAP >20 cm HO
- Prolonged Oxygen Use=oxygen in recovery >2 hours

Risk of Adverse Event

- Five risk factors identified
  - Age <3 years old
  - ASA II or III (no IV in study)
  - Pre-existing pulmonary disease
  - Morbid obesity
  - SURGICAL vs Radiologic procedure
Risk of Adverse Event

- Score $\geq 4$ is a HIGH risk
- Score 1-3 is INTERMEDIATE risk
- Score 0 is LOW risk
- Total rate of PRAE 2.8%

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<th>P</th>
<th>OR</th>
<th>Risk score</th>
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<td>Age</td>
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<td>1.00</td>
<td>0</td>
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<td>ASA mental status</td>
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<td>1.79</td>
<td>(1.36-2.33) &lt;0.0001</td>
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<td>1.79</td>
<td>(1.36-2.33) &lt;0.0001</td>
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</tbody>
</table>

- Transfer rates about 2%
- Associated factors:
  - Surgery >4 hours
  - Age >80 years
  - ASA III or IV
  - Surgery after 3 pm
  - Urologic surgery

- Transfer rate 0.9% to 9.4%
- Associated factors:
  - ??
  - Looked at Canadian tertiary pediatric hospital’s ambulatory cases from 2005 to 2012

- Looked at 21,957 ambulatory cases
- 213 admissions (0.97% rate)
  - Anesthesia related 47%
  - Surgery related 33%
  - Medical reasons 9%
  - Social reasons 8%
Risk of Adverse Event

- Anesthesia: Hypoxia, pain control, PONV, airway complication, apnea, aspiration, prolonged emergence, other
- Surgery: Surgical complication, pain control post d/c, bleeding, extensive surgery, additional procedure needed
- Medical: Treatment of medical condition (new > existing)
- Social: Parent/surgeon request, late start, no support at home, other

Risk of Adverse Event: Transfer

**Univariate Analysis**
- Age < 2 years
- Prescription medication use
- GERD
- OSA
- Other comorbidities

**Multivariate Analysis**
- Age < 2 years
- ASA class III or IV
- Surgery > 1 hour
- Procedure complete after 1500 hours
- OSA
- Orthopedics, Dental, ENT surgery
- Intra-operative event

Risk of Adverse Event: OSA

- More severe diagnosis of OSA increases risk of transfer
- Hypoxia is listed as precipitating factor
  - Possible to modify care to reduce risk
  - Almost 100% were ENT surgery
- Need a tool to measure degree of OSA
STBUR Score for OSA

- Snoring
  - Loud enough to be heard through a closed door
  - Frequency
- Trouble breathing
  - Gasping
  - Pauses
- Unrefreshed after sleeping
  - Hard to get going in the morning or fall asleep in school

Score of 3/5 is a 3 times greater chance of adverse respiratory event
Score of 5/5 is a 10 times greater chance of adverse respiratory event
Last question is the one that really can separate ambulatory from inpatient procedures


Pediatric Anesthesia: Delirium

- Pediatric PACU Nurse and anesthesiologist’s worst nightmare
- Delays discharge
- Poorly understood pathology
- Frightens or angers parents

Pediatric Anesthesia: Delirium

- Instances of:
  - Bed-wetting
  - Sleep disturbances
  - Temper tantrums
  - Attention-seeking behaviors
  - Fear of loneliness
- May follow Emergence Delirium as they have the same patient associations
- Delayed appearance up to months


Pediatric Anesthesia: Delirium

- Prevention is best
- Treatment is with
  - Fentanyl
  - Midazolam
  - Dexmedetomidine
  - Propofol
  - Sufentanil
  - Clonidine
  - ketamine
Pediatric Anesthesia: Delirium

My experience:
- Dexmedetomidine at 0.25 mcg/kg IV WITH
- Propofol 0.5 mg/kg IV
- Pt will sleep 10 to 20 min
- Wake up much cleaner
- Longer naps may ensue if rampaging for 45 minutes or longer
- Good time to do post-op teaching

Pediatric Anesthesia: PONV

- Risk factors and no anti-emetics:
  - 0 = 3.4% PONV
  - 1 = 11.6%
  - 2 = 28.2%
  - 3 = 42.3%
- Anti-emetics are cheap, but giving to everyone increases risk of side-effects
- Double therapy with 2 or more risk factors

Pediatric Anesthesia: PONV

- Little difference from adult treatment:
  - Different receptors
  - Select based on situational appropriateness
  - Careful of metabolic variation of ondansetron
  - Narcotics seem less of an issue
  - Propofol is still your friend even with sub-therapeutic doses combined with potent agents

Pediatric Discharge

- What is a "reasonable" time to discharge?
- What should be used to score?
- How does it change developmentally?

When It Is Time to Go Home
Pediatric Recovery

- French group adapted Chung’s PADDs score for pediatrics
- Looked at 1061 patients 6 mo to 16 y/o
- Scored patients at 1- and 2-hours into recovery area
  - 97.2% met criteria at 1 hr
  - 99.8% met criteria at 2 hr


Pediatric Recovery Study Parameters

- Inclusion:
  - ASA 1 or 2
  - Age 6 mo to 16 yrs
  - Surgical patients expected to leave
  - Live within 150 km

- Exclusion:
  - Local or sedation only
  - Imaging cases
  - Score of 9 or greater to meet discharge readiness

Pediatric Recovery Values Scored

- Hemodynamic comparison
  - HR only for upset infants
- Balance/ambulation
- Pain scores
- PONV rating
- Surgical bleeding
- Wish to speak with Anesthesiologist
- Respiratory Evaluation

Pediatric Recovery

Compared to historical controls before using the Ped-PADDs scale, hospital was able to decrease PACU times
- Unexpected admission rate of under 1%
- Perhaps due to large use of regional

69 minutes
Pediatric Recovery

- Clinical-based (physiologic) score vs a time-based (experiential) score also supports faster discharge
- PADDS and Aldrete combination scores every 15 min in PACU
- Discharge at score of 12 out of 14 with no zero scores


Special Concerns/Questions
Neurotoxicity

- "Preclinical studies in rodents and primates have shown that anaesthesia is neurotoxic to the developing brain after exposure in the neonatal period."
- "Furthermore, in some studies, the anaesthetic injury is associated with impaired cognition that persists into adulthood."


Neurotoxicity

Animal studies vs Human studies:
- Translation to human results are not perfect
- Anesthesia effects are not limited to immediate post-partum period
- Apoptosis has been demonstrated after an hour exposure to 1 MAC of isoflurane
- Animal doses tend to be greater to achieve surgical plane of anesthesia
- Cognitive function difficult to assess in animals

Neurotoxicity

- Apoptosis is widespread
  - Cortex
  - Thalamus
  - Basal ganglia
  - Hippocampus
  - Spinal cord
- Motor symptoms not seen
- Usually memory and behavior (autism) findings

Neurotoxicity

- Culprits
  - Ketamine
  - Potent inhalational agents
  - Benzodiazepines
  - Thiopental
  - Propofol

- Non-culprits
  - Morphine
  - Clonidine

- Window of opportunity
  - Perinatal
  - In utero (Isoflurane and ketamine)
  - Continued synaptogenesis

- Recognize that parents are already at facility and are committed to proceeding with surgery
- Looking for reassurance
- I lead them down risk/benefit discussions
- Proven not a risk for single-exposure of limited duration (SMART-TOTS)
- Broader discussion to be had with surgeons that book cosmetic procedures

Pediatric Regional

- Movement from 1996 to 2006 is away from neuraxial techniques toward peripheral nerve blocks:
  - Combined GA with block was 4.4% to 8.1%
  - Orthopedics increased from 1.2% to 4.3%

Pediatric Regional

- Techniques are similar to adult
- Blocks can be single-shot or with continuous catheters
- Many are placed under sedation or general anesthesia
- Additives have been studied, but are still off-label

Pediatric Regional

- 403 pediatric patients studied for feasibility of continuous peripheral nerve blocks (age 5 – 22 yrs)
- Looked at brachial plexus, lumbar plexus, femoral nerve, sciatic nerve, and paravertebral blocks
- Placed on On-Q pumps at about 0.24 mg/kg/hr of 0.2% ropivacaine infusion
- Satisfaction was 9-10/10 for patients, parents, and recovery nurses


Pediatric Regional

- 92% of all catheters placed under GA
- 36% of interscalene catheters were under sedation
- 4.6% stimulator only
- 30.2% ultrasound only
- 62.9% combined
- Bolus was either 0.2% or 0.5% ropivacaine (provider preference)
Pediatric Regional

General
- 309/403 home same day
- Half removed catheter at home on POD 3
- 500 ml or 270 ml pump size without bolus feature
- Mean duration 72 hours
- Had daily phone follow up

Pain Scores
- 10% reported no pain
- Daily average pain scores: 1.83/3.55/3.05/2.79 out of 10
- PACU arrival IQR 0 - 3
- Discharge IQR 0.25 - 3

Pediatric Regional

Complications
- 14.4% had issues related to CPNB
- 24.8% had PONV
- 8.4% had catheter issues

CPNB Failures
- 6.9% all failure rate
- 3 patients found with pump clamped on POD 1
- 1 On-Q pump failed to deliver medication
- 4 catheter-pump disconnections occurred

Pediatric Regional

Adductor Canal Blocks vs Femoral Nerve Blocks
- Fairly equal success rates (99% FNB vs 97% ACB)
- Equal analgesia for ACL repairs and TKA (in adults)
- Clear strength preservation of quadriceps
Pediatric Regional

- Caudal analgesia can be ideal for lower abdominal or lower extremity surgery
- Typical is children under 3 y/o
- Walking vs non-walking
- Dogma has been local anesthesia only

- 75 (2-12 years old) patients for caudal with 30/50/75 mcg/kg morphine
- Analgesia 8.3/13.3/19.2 hours in duration
- Respiratory depression in 3 patients in 75 mcg/kg group
- Itching in 1 patient in 30 mcg/kg group
- 1 in each group with PONV


Tonsil Surgery

- Adenotonsillectomy is the MOST common pediatric surgery in North America
- Indications for surgery are
  - Recurrent tonsillitis/strep pharyngitis
  - Sleep disordered breathing or OSA
- 75% of cases done for suspected OSA
- Deaths are likely under-reported

Tonsil Surgery

- 2011 American Academy of Otolaryngology printed a clinical guideline
- Defined number of infections
- SDB with additional growth retardation, behavior disorder, poor school performance
- Give steroid intra-op
- Do not give abx intra-op
- Track annual rate of hemorrhage post-op


Tonsil Surgery

- 2012 French ENT Society released their recommendations:
  - Risk assessment:
    - Age < 3 years
    - Craniofacial abnormality
    - Signs of right heart failure
    - Morbid obesity
    - Morbidity disease
    - Respiratory infection
  - Sleep study
    - If symptoms don’t match exam or doubtful of cure
    - Elevated surgical risk


Tonsil Surgery - French recommendations

### Outpatient
- Age >1
- ASA class 1 or 2
- Home support with phone
- Access to pediatric center
- 6 hour observation
- Additional person besides driver to leave with

### In-patient
- Significant co-morbid dz.
- Coagulopathy
- Respiratory “difficulty” upon induction or emergence
Tonsil Surgery

- Risks in the United States for children with OSA
  - Greater push to do cases at free-standing centers
  - US surveys show deviation of care in T&A patients
  - Socio-economically disadvantaged patients less likely to seek costly care at the Emergency Dept
  - Pain for 7-10 day leads to prolonged narcotic use that puts patients with severe OSA at risk
  - Unknown narcotic metabolism leading to relative over-dosing


Finally…..Conclusions!

- Pediatric patients aren’t just small adults, but do present with some similar issues
- Care should be made to carefully screen patients prior to arrival and assure that the facility can handle them when they arrive
- Neurodegenerative issues are real and you need to be able to have a cogent discussion with savvy parents
- Tonsil surgery is common and risky: prepare for the worst and achieve the best!