Pre-Operative Assessment and Optimization

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Professor of Anesthesiology and Pediatrics
Loma Linda University
At the end of this talk you should be able to ...

- Explain the purpose and list the essential components of the pediatric pre-anesthetic/pre-operative evaluation
  - History and Physical
  - Laboratory and other testing
- Identify medical issues that may inform the anesthetic plan
Introduction

• 6 million pediatric anesthetics per year
• 1.5 million are in-patient infant cases
• Major Goals:
  – Identify issues that increase risk (safety & comfort) and that may inform anesthetic plan
  – Optimize concomitant medical conditions
  – Educate patient & family and obtain informed consent (assent).
What comprises an effective pediatric pre-anesthetic evaluation?
Pre-Operative Evaluation as a Test

• Outcome Measures
  – Reduce peri-operative mortality
    • Difficult to evaluate as NNTT is very high (e.g. difference between a 10 fold rate of mortality would be 1:10,000 vs 1:100,000 cases)
  – Reduce peri-operative morbidity
    • Easier to assess impact
  – Increased patient/family satisfaction
Pre-Operative Evaluation as Screening Test

• Optimize sensitivity
  – Don’t miss a patient who needs more evaluation or medical optimization prior to anesthetic or who has increased or specific risks

• Specificity is also welcome
  – Most pediatric patients are healthy
    • False positives lead to potentially unnecessary testing, delays, or postponement of (needed) case

• Optimize resource allocation
The Successful Pre-Op

• What parts of pre-op H&P helpful?

  – Seems self-evident, however, that certain information is necessary, helpful, and ....
The Successful Pre-Op

Required elements

(Rev. 37, Issued: 10-17-08; Effective/Implementation Date: 10-17-08)
[The policies must ensure that the following are provided for each patient:]

482.52(b)(1)
-A pre-anesthesia evaluation completed and documented by an individual qualified to administer anesthesia, as specified in paragraph (a) of this section, performed within 48 hours prior to surgery or a procedure requiring anesthesia services.

Interpretive Guidelines 482.52(b)(1)
• The pre-anesthesia evaluation must be performed within 48 hours prior to any inpatient or outpatient surgery or procedure requiring anesthesia services.

At a minimum, the pre-operative anesthetic evaluation of the patient should include:
• Notation of anesthesia risk;
• Anesthesia, drug and allergy history;
• Any potential anesthesia problems identified;
• Patient’s condition prior to induction of anesthesia.
The Successful Pre-Op

• American Academy of Pediatrics Guidelines
  – HPI
  – Past and current medical history
  – Medications (including taken in past, OTC, adherence)
  – Allergies
  – Prior anesthetic experience
  – Family history
  – NPO Status
The Successful Pre-Op

• American Academy of Pediatrics Guidelines
  – Physical Exam
    • Airway
    • CV
    • Pulmonary
    • Neurologic
    • Hydration
    • Area related to procedure
The Successful Pre-Op

• Required elements of pre-op according to ASA Guidelines
  – Pt. Interview
    • Confirm patient identity and procedure
    • In-patient/outpatient status
  • Medical History
  • Anesthetic History
  • Medication/Allergy History
  • NPO Status
  – Appropriate Physical Examination
    • Include vital signs, airway
    – Review of Labs/Results/"Available" Medical Records
    – Consultations (if needed)
    – Determine ASA PS
    – Anesthetic Plan
    – Risks and benefits, informed consent
    – Premedication if indicated

The Successful Pre-Op

• HPI related to operation/anesthetic
  – From parents/guardian and patient

• Review of symptoms and medical history by system
  – The following slides on review of symptoms and history by system are adapted from Cote’s text, but one should tailor the review to patient’s HPI and medical record as well as the planned procedure
Review of Symptoms and History by System

• Respiratory

  – H/o asthma, pneumonia, cough, rhinorrhea or other URI symptoms, croup, A’s and B’s, home respiratory therapies such as oxygen, nebulizers, or CPAP.

  – Implications: bronchospasm, atelectasis, need for oxygen, airway edema or stenosis, need for positive pressure ventilation, post-op monitoring, discussion of respiratory risks
Review of Symptoms and History by System

- Cardiac
  - Prior surgery, ECG, catheterizations, echocardiograms
  - Murmurs
    - If septal defect – bubble precautions
    - Valve disease
  - Cyanosis, low SpO2
    - Right – Left shunting
  - Squatting (with TOF)
  - Hypertension; BP or pulse differential (coarctation)
  - Rheumatic disease (valvular disease)
  - Decreased activity/exercise (CHF)
Review of Symptoms and History by System

• Neurologic
  – Seizures
    • Plan for ACM meds
    • Metabolic/electrolytes
  – Head trauma (increased ICP; bleeding)
  – Spine injury (airway precautions; perfusion)
  – Neuromuscular disease (MH, hyperkalemia risks; Neuromuscular drug choice)
  – Swallowing issues, aspiration risk, GERD
Review of Symptoms and History by System

- Gastrointestinal
  - Vomiting, diarrhea: dehydration, electrolyte abnormalities
  - Mal-absorption: anemia
  - Melena/black stools/hematochezia: anemia
  - GERD: risk of regurgitation and aspiration
  - Jaundice: hepatic issues such as medication metabolism, hypoglycemia
Review of Symptoms and History by System

• Gastrointestinal
  – Vomiting, diarrhea: dehydration, electrolyte abnormalities
  – Mal-absorption: anemia
  – Melena/black stools/hematochezia: anemia
  – GERD: risk of regurgitation and aspiration
  – Jaundice: hepatic issues such as medication metabolism, hypoglycemia
Review of Symptoms and History by System

• Genitourinary/Renal
  – Ins and Outs
  – Frequency, and time of last urination
  – H/o UTIs
  – Hypertension

• Implications: diabetes, UTI, hypercalcemia, hydration status; renal disease
Review of Symptoms and History by System

• Endocrine/metabolic
  – Abnormal development
  – Hypoglycemia or treatment for diabetes
  – H/o steroid therapy
  – Symptoms of hypo/hyperthyroidism

• Implications: endocrinopathy (such as diabetes, hypoglycemia, adrenal insufficiency); metabolic crises
Review of Symptoms and History by System

• Hematologic
  – Anemia (prepare blood products? Impact on post-op apnea)
  – Bruising, h/o excessive bleeding
    • Bleeding disorder: coagulopathy, thrombocytopenia
  – Sickle cell disease
    • Possible need for transfusion, hydration
    • Anesthetic plan to prevent sickling
Review of Symptoms and History by System

• Allergies
  – Medications and reactions
  – Foods (possible cross-reactivity)

• Medications
  – Effect of medications during anesthetic, especially induction
  – Possible drug interaction
  – Identify other medical conditions missed in screening by indications
Review of Symptoms and History by System

• Dental
  – Loose or decaying teeth (common with primary teeth)
    • Aspiration of loose teeth, bacterial endocarditis prophylaxis

• Immunizations
  – Recommendation to delay immunizations until several days after surgery, and postpone elective surgery for several days after immunization
    • To ensure best immune response to immunization
The Successful Pre-Op: Laboratory Tests

• Routine Testing
  – Not indicated for vast majority of pediatric anesthetics

• Targeted Testing
  – Patient indications – disease state that require testing (e.g. h/o thrombocytopenia; h/o bleeding disorder; h/o renal, endocrine, hepatic, or other significant comorbidities)
  – Procedure indications – large blood loss cases – type and screen
The Successful Pre-Op:
evaluation is necessary but not sufficient

- Required elements of pre-op according to ASA Guidelines
  - Pt. Interview
    - Confirm patient identity and procedure
    - In-patient/outpatient status
    - Medical History
    - Anesthetic History
    - Medication/Allergy History
    - NPO Status
  - Appropriate Physical Examination
    - Include vital signs, airway
  - Review of Labs/Results/”Available” Medical Records
  - Consultations (if needed)
  - Determine ASA PS
  - Anesthetic Plan
  - Risks and benefits discussion, informed consent
  - Premedication if indicated*
Comorbid Conditions
GERD associations

• History of esophageal surgery
• Hiatal hernia
• Obesity, abdominal masses
• Recurrent pneumonia (or otitis media?)
• Dental enamel injury
• Abdominal or chest pain
• Neuromuscular disease
GERD

- Continue prescribed PPI and/or H2 blocker
- Pre-treatment with H2 blocker
  - E.g. ranitidine PO (2-2.5mg/kg oral) available IV
  - (cimetidine inhibits many CYPs)
  - Famotidine – more potent, renal clearance
    - Raises gastric pH but does not decrease volume
- Metoclopramide
- Non-particulate antacid
  - Bicitra (0.5-1ml/kg up to 30 ml)
- Consider cricoid pressure for passive GER
  - 30-40 Newtons (3-4 KG of force)
- Avoid positive pressure mask ventilation if possible
GERD and Cricoid Pressure/Sellick

- Avoid cricoid pressure if
  - Active vomiting (risk of esophageal rupture)
  - Airway trauma
  - Sharp foreign object in airway or esophagus
- May decrease upper and lower esophageal sphincter tone
- Esophagus may be lateral to cricoid
- May distort airway
Comorbid Conditions
Upper Respiratory Tract Infections (URIs)
URI}s

• Traditional model is to postpone all elective procedure when s/s of URI present.
• Modern approach is more selective
  – Most respiratory complications associated with URIs are manageable without long term sequelae.
  – Identification of risk factors for more serious complications makes patient selection possible.

Current or Recent URI Complications

- URIs are not just *upper*
- Different viruses may behave differently
  - E.g. parainfluenza, influenza
- Different hosts may behave differently
  - E.g. asthma, cystic fibrosis, ex-preemie
- Effects on PFTs (airway resistance, diffusion capacity, FRC, closing capacity), airway reactivity may persist for weeks
Current or Recent URI Complications

- Bronchospasm (?) (if intubated)
- Laryngospasm (?)
  - 15,183 ambulatory pts in case control study – pts with laryngospasm 2.05x more likely to have had URI symptoms within prior 2 weeks than controls
  - Schreiner et al (1996)
- Breath holding
- Hypoxemia (SpO$_2$<90%)
- Other Respiratory Events
### Does airway instrumentation make a difference?

<table>
<thead>
<tr>
<th></th>
<th>Breath Holding</th>
<th>Laryngospasm</th>
<th>Bronchospasm</th>
<th>Severe Cough</th>
<th>SPO$_2$ &lt;90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETT</td>
<td>40%*</td>
<td>5.40%</td>
<td>7.60%</td>
<td>13%*</td>
<td>21.9%*</td>
</tr>
<tr>
<td>LMA</td>
<td>31%</td>
<td>4.80%</td>
<td>4.10%</td>
<td>8.90%</td>
<td>11%</td>
</tr>
<tr>
<td>FM</td>
<td>18%</td>
<td>2.20%</td>
<td>3.30%</td>
<td>4.30%</td>
<td>8.70%</td>
</tr>
</tbody>
</table>

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**Laryngeal Mask Airway Is Associated with an Increased Incidence of Adverse Respiratory Events in Children with Recent Upper Respiratory Tract Infections**

Britta S. von Ungern-Sternberg, M.D.,* Kristzina Boda, Ph.D.,† Craig Schwab, M.D.,‡ Craig Sims, M.D.,§ Chris Johnson, M.D.,∥ Walid Habra, M.D., Ph.D.‖

*Background:* The laryngeal mask airway (LMA) has been advocated as an alternative technique to tracheal intubation for children with upper respiratory tract infections (URIs). However, the incidence of adverse respiratory events is increased when using the LMA in children with URIs (less than 2 weeks before anesthesia). In addition, we characterized the risk factors leading to an increased incidence of adverse perioperative events.

<table>
<thead>
<tr>
<th>Complication</th>
<th>No URI</th>
<th>URI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laryngospasm</td>
<td>3.1%</td>
<td>7.6%</td>
</tr>
<tr>
<td>O₂ Desaturation</td>
<td>11.4%</td>
<td>19.3%</td>
</tr>
<tr>
<td>Cough</td>
<td>7.5%</td>
<td>17.9%</td>
</tr>
</tbody>
</table>

Therefore, we prospectively evaluated the safety of LMA in children with recent URIs (less than 2 weeks before anesthesia). In addition, we characterized the risk factors leading to an increased incidence of adverse perioperative events.

von Ungern-Sternberg, Anesthesiology. 107(5) 2007
URIs

- Uncomplicated
- Afebrile
- Appears “healthy”
- Noninfectious conditions
- Clear secretions
- Time is of the essence (trauma, chemo/rad regimen, crucial diag procedure)
- Social factors*
- High level of anesthetic experience
- ETT NOT needed (especially < 5 years old)
- “Sick” (or change in behavior)
- Febrile
- Significant Cough/Copious rhinorrhea
- Adventitious pulmonary sounds or increased WOB
- H/o pulmonary, cardiac, or a/w disease (e.g. Asthma, ex-preemie)
- A/W or pulm procedure
- Elective procedure, time not critical
- 2nd hand smoke exposure

Adapted from Tait, Anesthesiology 2001
URI: If you proceed...

- Glycopyrrolate not helpful
- Avoid ETT if possible
- Prepare for bronchospasm
- Supplemental oxygen during transport
- Careful monitoring
- Hygiene

Glycopyrrolate did not decrease respiratory complications of URI

Tait, Anesthesiology 2007
Comorbid Conditions: Asthma
Asthma

- 300 million world wide
- Asthma prevalence increased from 7.3% in 2001 to 8.4% in 2010
- 25.7 million persons had asthma in 2010.
  - CDC, NCHS Data Brief no. 94 May 2012
- 9.5% of 0-17 yo have asthma
### Asthma: Anesthetic Complications (Children)

<table>
<thead>
<tr>
<th>Perioperative Complications</th>
<th>Asthmatic n=111</th>
<th>Non-asthmatics n=824</th>
<th>Relative Risk 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheezing</td>
<td>11%</td>
<td>2%</td>
<td>5.5 (2-12)</td>
</tr>
<tr>
<td>Cough (I)</td>
<td>5%</td>
<td>0.4%</td>
<td>12.5 (3-51)</td>
</tr>
<tr>
<td>Stridor (P)</td>
<td>3%</td>
<td>0.4%</td>
<td>6.8 (1-2)</td>
</tr>
<tr>
<td>SpO2&lt;95% (P)</td>
<td>7%</td>
<td>0.9%</td>
<td>6.4 (2-21)</td>
</tr>
</tbody>
</table>

# Asthma: Risk factors for wheezing

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>p</th>
<th>RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asthma symptoms in past mo.</td>
<td>0.004</td>
<td>10.9 (1.3-90)</td>
</tr>
<tr>
<td>Asthma meds in last month</td>
<td>0.05</td>
<td>**</td>
</tr>
<tr>
<td>Intraoperative Intubation</td>
<td>0.06</td>
<td>5.4 (1.7-42)</td>
</tr>
<tr>
<td>URI in past month</td>
<td>0.07</td>
<td>3.6 (1.7-18)</td>
</tr>
</tbody>
</table>

** Relative Risk cannot be calculated because of a 0 value, 9% vs. 0%
### Asthma

<table>
<thead>
<tr>
<th>Drug Class</th>
<th>Drug Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta-2 Agonist</td>
<td><strong>Short acting (SABA)</strong>-albuterol (ventolin, ProAir, Proventil), salbutamol, levoalbuterol (Xopenex) <strong>Long acting (LABA)</strong>-salmeterol (Advair, Serevent)</td>
</tr>
<tr>
<td>Inhaled steroids</td>
<td>Fluticasone (Flovent, Advair), budesonide (Pulmicort)</td>
</tr>
<tr>
<td>Leukotriene antagonists</td>
<td>Montelukast (Singulair), zafirlukast</td>
</tr>
<tr>
<td>Anticholinergics</td>
<td>Ipratropium (Atrovent)</td>
</tr>
<tr>
<td>Inhibit C-fibers (formerly known as Mast Cell Stabilizers)</td>
<td>Cromolyn Sodium</td>
</tr>
</tbody>
</table>
## Asthma

<table>
<thead>
<tr>
<th></th>
<th>Well Controlled</th>
<th>Not Well Controlled</th>
<th>Poorly Controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptoms</td>
<td>&lt; 2 days/wk</td>
<td>&gt;2 days/wk</td>
<td>Daily</td>
</tr>
<tr>
<td>Night awakening</td>
<td>&lt; 1x/mo</td>
<td>&gt; 1x/mo</td>
<td>&gt; 1x/wk</td>
</tr>
<tr>
<td>Limitation in activity</td>
<td>None</td>
<td>Some</td>
<td>Extremely</td>
</tr>
<tr>
<td>SABA for symptoms</td>
<td>&lt; 2 days/wk</td>
<td>&gt;2 days/wk</td>
<td>Daily</td>
</tr>
<tr>
<td>Exacerbations requiring oral steroids</td>
<td>0-1 x/yr</td>
<td>2-3 X/YR</td>
<td>&gt; 3 x/yr</td>
</tr>
</tbody>
</table>

PRACTALL consensus report. Allergy 2008;63:5-34.
# Asthma

<table>
<thead>
<tr>
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<th>Not Well Controlled</th>
<th>Poorly Controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preop Care</td>
<td>+/- preop SABA</td>
<td>Preop SABA</td>
<td>Preop SABA, consider oral steroids, cancel elective surgery</td>
</tr>
</tbody>
</table>

Liccardi, Curr Opin Anaesthesiol 2012;25:30-7

(If systemic steroids in past 2 months, and patient hypotensive, hydrocortisone)
Asthma

- Prospective, blinded
- Preop salbutamol vs placebo
- Mild-mod asthmatics
- Airway resistance after ETT
- Results
  - Salbutamol-decreased airway resistance
  - Placebo-increased airway resistance

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Salbutamol Prevents the Increase of Respiratory Resistance Caused by Tracheal Intubation During Sevoflurane Anesthesia in Asthmatic Children

Fietro Scalzaro, MD, Peter D. Sly, MD, FRACP, Craig Sims, FANZCA, and Walid Habre, MD

Pediatric Intensive Care Unit, Pediatric Department, CHUV University Hospital, Lausanne, Switzerland; Division of Clinical Science, Telethon Institute for Child Health Research, Perth, University of Western Australia; Department of Anesthesia, Princess Margaret Hospital for Children, Perth, Western Australia; and Pediatric Anesthesia Unit, Geneva Children’s Hospital, Geneva, Switzerland

Asthmatic children having their trachea intubated with sevoflurane often have an increase in respiratory system resistance (Rns). In this randomized, placebo-controlled, double-blinded study, we investigated the preventive effect of an inhaled β-2-agonist. Either salbutamol or placebo was administered 30 to 60 min before arrival at the operating room and maintained at 0.25 mg/kg for children breathing spontaneously via a face mask and Jackson-Rees modification of the T-piece. Airway opening pressure and flow were measured before and after insertion of an oral endotracheal tube. Rns and respiratory system compliance were calculated with multilinear regression analysis. The groups were comparable with respect to age, weight, asthma history, and breathing pattern. Intubation induced a different Rns response in the two groups. Children treated with salbutamol showed a 60% (25.2% to 75.4%) decrease (mean; 95% confidence interval), whereas in the placebo group there was 17.7% (−4.4% to 30.5%) increase (P = 0.04). Neither asthma history nor the serum inflammation marker eosinophilic cationic protein was predictive for this response. We conclude that when using sevoflurane in mildly to moderately asthmatic children, a preanesthetic treatment with inhaled salbutamol is protective of an increase in Rns.


Anesth Analg 2001;93
### Anesthesia and ventilation strategies in children with asthma: part II - intraoperative management.

Regli, Adrian; von Ungern-Sternberg, Britta

DOI: 10.1097/ACO.0000000000000075

Table 1  Impact of anesthetic agents on bronchial smooth muscle tone and their usefulness to blunt reflex bronchoconstriction (e.g. intubation)

<table>
<thead>
<tr>
<th>Agents</th>
<th>Possible underlying involved/other effects relevant to anesthesia in children with asthma</th>
<th>Blunts reflex bronchoconstriction</th>
<th>Therapeutic bronchodilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatile agents</td>
<td>Reduction in parasympathetic nervous [vagal] tone (bronchodilation)</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>Inhibition of voltage-dependent calcium, potassium and chloride channels of bronchial smooth muscle (bronchodilation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desflurane</td>
<td>Activation of nonadrenergic noncholinergic system (bronchoconstriction)</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Propofol</td>
<td>Reduction in parasympathetic nervous tone [bronchodilation]</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Reduction in serotonin SHT receptor activity on bronchial smooth muscle cell [bronchodilation]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inhibition of ATP-induced contraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thiopental</td>
<td>Stimulation of parasympathetic nervous tone [bronchoconstriction]</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ketamine</td>
<td>Catecholamines release stimulating B2 receptors on bronchial smooth muscle [bronchodilation]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NMDA receptor antagonist/altering calcium influx in bronchial smooth muscle [purinergic P2X receptors] [bronchodilation]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Side-effect: increased airway secretions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neuromuscular blocking agents</td>
<td>Anaphylactoid histamine liberating process [bronchoconstriction]</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Allergic IgE-mediated mast cell degranulation with release of histamine and serotonin [bronchoconstriction]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct stimulation of parasympathetic nervous tone due to structural similarities with acetylcholine [M1, M2 and M3 receptors] [bronchodilation]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opioids</td>
<td>Inhibition of nonadrenergic noncholinergic system [bronchodilation]</td>
<td>+/−</td>
<td>+/−</td>
</tr>
<tr>
<td>Morphine</td>
<td>More histamine liberation compared with fentanyl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fentanyl</td>
<td>More cough induction compared with morphine</td>
<td>++</td>
<td>+/−</td>
</tr>
<tr>
<td>α-2-agonist (i.e. clonidine and dexmedetomidine)</td>
<td>Inhibition of nonadrenergic noncholinergic system [bronchodilation] Suppression of intracellular calcium signal transduction</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Prejunctional α-2-induced inhibition of parasympathetic nervous tone [bronchodilation]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lignocaine</td>
<td>Direct relaxing effect on bronchial smooth muscle, blunting of reflex bronchoconstriction</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

+ effect demonstrated or mild effect; ++ moderate effect; +++ great effect. ATP, adenosine triphosphate; IgE, immunoglobulin E; NMDA, N-methyl-D-aspartate receptor.
Asthma (management)

- Avoid endotracheal intubation, if possible.
  - Facemask or LMA associated with significantly lower risk of perioperative respiratory adverse events (PRAE).
- Inhalation anesthetics have bronchodilator action
  - But avoid desflurane
    - increased airway resistance in children
    - Increased risk of PRAEs
  - Sevoflurane best (propofol and ketamine)
- Topical lidocaine may cause bronchoconstriction
- Ventilator Strategies in general
  - Permissive hypercapnea
  - Slow rate
  - Long E time
  - PCV

Anesthesia and ventilation strategies in children with asthma: part II - intraoperative management.
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DOI: 10.1097/ACO.000000000000075
Cerebral Palsy

• Neurologic disease affecting tone, ambulation, and/or posture
  – Symptoms/Signs: Hypotonia, hypertonia/spasticity, choreoathetoid movements, gait disturbances
  – Distribution: monoparesis (single limb); hemiparesis (2 ipsilateral limbs), diparesis (both LEs), tripariesis (three limbs), quadriparesis/tetraparesis (all 4 limbs)
• 1 in 500 births
• Rarely caused by birth asphyxia (<5 %)
• Generally caused by in-uterine events such as stroke, white matter disease, and inflammatory states
• Postpartum causes include infections (e.g. meningitis), trauma, and kernicterus
• Associated with
  – SGA
  – Multi-gestation
  – Abnormal presentation
# Cerebral Palsy

<table>
<thead>
<tr>
<th>Type and Cause</th>
<th>Motor Deficits</th>
<th>Distribution</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypotonic</td>
<td>Low axial tone</td>
<td>Diffuse</td>
<td>Learning disability</td>
</tr>
<tr>
<td>Syndromic</td>
<td>Variable limb tone</td>
<td></td>
<td>Contractures</td>
</tr>
<tr>
<td>Dysgenesis</td>
<td>Deep tendon reflexes usually increased</td>
<td></td>
<td>Epilepsy</td>
</tr>
<tr>
<td>Insult: hypoxia-ischemia</td>
<td></td>
<td></td>
<td>Feeding dysfunction</td>
</tr>
<tr>
<td>Spastic</td>
<td>Increased tone: pyramidal type</td>
<td>Monoparesis</td>
<td>Hearing or vision impairment</td>
</tr>
<tr>
<td>Insult: hypoxia-ischemia, vascular</td>
<td>Increased deep tendon reflexes</td>
<td>Diparesis</td>
<td>Respiratory infections</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hemiparesis</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tripliesis</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tetraparesis</td>
<td></td>
</tr>
<tr>
<td>Choreoathetoid</td>
<td>Involuntary movement: often a mixture of choreaathetosis dystonia</td>
<td>May be diffuse (tetraparesis) or confined to one or more limbs</td>
<td>Hearing impairment</td>
</tr>
<tr>
<td>Insult: hypoxia-ischemia, neonatal</td>
<td></td>
<td>Often coexists with spasticity</td>
<td>Contractures</td>
</tr>
<tr>
<td>hyperbilirubinemia, metabolic</td>
<td></td>
<td></td>
<td>Intellect often maintained</td>
</tr>
<tr>
<td>Ataxic</td>
<td>Usually generalized truncal and limb ataxia</td>
<td>May be diffuse but often associated with diparesis</td>
<td>Few, may be mild</td>
</tr>
<tr>
<td>Cerebral dysgenesis</td>
<td>May coexist with spasticity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From Cote
Cerebral Palsy

• Comorbid Conditions
  – Contractures
  – Scoliosis +/- restrictive lung disease
  – GERD
  – Excessive oral secretions
  – Chronic aspiration and associated lung disease
  – Oromotor and bulbar dysfunction
  – Constipation
  – Epilepsy

• Multiple Indications for Anesthesia
  – Neuroimaging
  – Treatment of comorbidities such as botulinum toxin injection, contracture release, hip procedures, fundoplication, scoliosis surgery
Cerebral Palsy

• Lower MAC (by ~25% for halothane, using tetanic stimulation)
  – Cause?
    • Central sensory impairment?
    • Altered pain threshold?
    • Atypical balance of inhibitory and excitatory neuronal activity in spinal cord.
  – Receive less opioids in perioperative period
    • ? Difficulty communicating pain
    • ? Bias against pain perception by caretakers
    • ? Concern about risk for opioid-related complications
  ‡ Need equivalent pain management plan
Cerebral Palsy

• Consider GERD precautions.
• In general, no significant [K+] increase with succinylcholine with congenital spastic quadriplegia with CP
• Plan for possible need for higher level of postoperative care – pulmonary toilet, pain management
Cerebral Palsy

• Consider concurrent medications
  – Baclofen – avoid withdrawal
    • May have prolonged weakness with NMB, but may be resistant to NMB meds
  – Continue anti-GERD medications
  – Continue anti-convulsants
Premature Infant: Airway

- Preferential/Obligate nasal breather
- Small airways
- NGT can obstruct airway
- Airway easily obstructed
Premature Infant: Respiratory System

- Ventilator System
- Tolerance of positioning and suction
- Secretions
- Blood gas
Prematurity: Pulmonary Disease

• Neonatal Respiratory Distress Syndrome (RDS)
  – AKA hyaline membrane disease
  – Insufficient production or function of surfactant
    • Generally associated with prematurity
    • When surfactant release is delayed – infants of diabetic mothers or meconium aspiration syndrome
  – If untreated
    • Low pulmonary compliance
    • Increased work of breathing
    • Decreased FRC
    • V/Q mismatch
    • Impaired gas exchange
    • Right-left shunt via PDA and/or PFO
    • Pulmonary barotrauma and volumetric trauma oxidative injury, and inflammation

Peterson, S.W., Neonatal Netw, 2009. 28(4): p. 221-9
Prematurity: Pulmonary Disease

- Neonatal Respiratory Distress Syndrome (RDS)
  - Clinical Presentation
    - tachypnea or apnea, retractions and grunting
    - Hypoxemia
    - respiratory and metabolic acidosis
  - Radiograph
    - *Ground glass*: diffuse pattern of reticulogranular opacities
    - air bronchograms: due to air-filled large airways surrounded by atelectatic alveoli.
  - Course if untreated
    - May present in delivery room
    - Tend to worsen for several days and then improve as surfactant production improves
  - Complications
    - with PPV:
      - chronic lung disease
      - pneumothorax
      - infection
  - Co-morbidities
    - Often premature, may have sepsis, other organ system dysfunction – e.g. CNS
Prematurity: Pulmonary Disease

• Neonatal Respiratory Distress Syndrome (RDS)
  – Prevention and Treatment
    • (consider for fetuses 24-34 weeks)
    • Antepartum maternal steroids (beclomethasone)
    • Exogenous surfactant via ETT
      – Generally well tolerated (occasionally airway obstruction, pulmonary hemorrhage, volutrauma with improved compliance)
        [295]
      – Improvement in hours
    • nCPAP starting in delivery room
  – Sequelae
    • ~20% develop chronic lung disease: bronchopulmonary dysplasia

Peterson, S.W., Neonatal Netw, 2009. 28(4): p. 221-9
Prematurity: Pulmonary Disease, Bronchopulmonary Dysplasia

• **Definition**: chronic pulmonary disease of infants, oxygen dependence 28 days after birth.

• **Old BPD**:
  – Prior to steroids, surfactant, and “gentle” ventilation strategies
  – Common in relatively mature preemies
  – Impact of positive pressure ventilation and oxygen exposure
  – Patchy areas of hyperinflation and atelectasis, fibrosis, severe epithelial and endothelial injury
Prematurity: Pulmonary Disease, Bronchopulmonary Dysplasia

• New BPD
  – Features
    • Mostly in ELBW premature infants
    • Large, simplified alveolar structure, Interstitial thickening
  – Disorder of development?
  – More benign nursery course, but characterized by non-asthmatic obstructive pulmonary disease through infancy and childhood
  – Decreased respiratory reserve as adults?

Prematurity: Pulmonary Disease, Bronchopulmonary Dysplasia

<table>
<thead>
<tr>
<th>Grade</th>
<th>Fio2 and Ventilatory Support</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GA at Birth &lt;32 wks assessed at 36 Weeks' PCA</td>
</tr>
<tr>
<td>Mild</td>
<td>0.21</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.22-0.30</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt;0.30 and/or continuous positive airway pressure or mechanical ventilation</td>
</tr>
<tr>
<td></td>
<td>GA at Birth ≥32 wks assessed at 56 Days</td>
</tr>
<tr>
<td></td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>0.22-0.30</td>
</tr>
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<td></td>
<td>&gt;0.30 and/or continuous positive airway pressure or mechanical ventilation</td>
</tr>
</tbody>
</table>

Prematurity: Pulmonary Disease, Bronchopulmonary Dysplasia

- Pre-anesthetic considerations
  - hypoxia, bronchodilators, diuretics, subglottic stenosis

- Preparation
  - baseline O2 saturation, administer bronchodilators, check electrolytes, smaller ETT, no desflurane
### Postoperative apnea

<table>
<thead>
<tr>
<th>Investigator (yr)</th>
<th>Patients #</th>
<th>Apnea incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welborn (86)</td>
<td>38</td>
<td>36</td>
</tr>
<tr>
<td>Kurth (87)</td>
<td>47</td>
<td>51</td>
</tr>
<tr>
<td>Malviya (93)</td>
<td>91</td>
<td>10.9</td>
</tr>
<tr>
<td>Warner</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Combined (95)</td>
<td>255</td>
<td>25</td>
</tr>
</tbody>
</table>
Postoperative Apnea

- The probability of apnea is inversely related to gestational age
- Significant inter-institution variability

Cote et al, Anesthesiology 1995
Postoperative Apnea

- The probability of apnea is inversely related to gestational age and post conceptual age.
- **Anemia** increase probability of apnea
- Anemia makes probability of apnea the same for all
- Apnea < 5% if PCA > 48 weeks with GA >/= 35 weeks
- Apnea < 1% if PCA > 54 weeks with GA >/= 35 weeks

Cote and others, Anesthesiology 1995
Conditions Associated with Prematurity: CNS Disease

• Assess for CNS injury
  – Increased risk with increased prematurity, including ICH
    • Examine for hyper/hypotonia
    • Review neuro ultrasound results
  – H/o asphyxia

• Examine spine for neural tube defect
Conditions Associated with Prematurity: Retinopathy of Prematurity

- 50% for infants 1000-1500g
- >90% for <750g
- Rare in term infants
- In utero, retina exposed to 30-40mmHg PaO2
- Brief (hours) of exposure to 150mmHg or higher have been linked to ROP, but after 31 weeks, PaO2 may have higher targets (80-90)
- Low grade lesions may regress
- High grade (4-5) often result in blindness
- Discuss goal PaO2 with neonatology team
Comorbid Conditions
Assorted Other Conditions
Heart Murmurs

• Most are *innocent*
  – Only definitive test of structural cardiac issue is imaging.

• Reassuring signs
  – Normal growth and physical activity
  – Normal PE (including oxygenation)
  – Low grade (1-2 / 6), Musical Quality, non-radiating
  – Early systolic; short duration

• Pathologic Signs
  – Poor growth; restricted physical activity; sweating;
  – Diastolic or pan-systolic
  – Grade >= 3 /6 or thrill; harsh quality, diffuse
  – Abnormal PE (e.g. hepatomegaly, unequal extremity pulses, hypoxemia, cyanosis, tachypnea, tachycardia, prolonged CRT)
  – New Presentation
Perioperative Anxiety, Pre-medication, and Parental Presence at Induction of Anesthesia (PPIA)
Preoperative Anxiety

• Clinical consequences

• Risk factors

• Interventions
  – Preoperative Preparation Program
  – Premedication
  – Parental Presence for Induction of Anesthesia (PPIA)
“Stormy” Inductions and Postoperative Behavioral Changes


Behavioral Changes (%)
Preoperative Anxiety and Emergence Delirium and Postoperative Maladaptive Behaviors

Zeev N. Kain, MD, MBA, Alison A. Caldwell-Andrews, PhD, Inna Maranets, MD, Brenda McClain, MD, Dorothy Gaal, MD, Linda C. Mayes, MD, Rui Feng, MS, and Heping Zhang, PhD

The Center for the Advanced Study of Affective Disorders, Department of Psychiatry and the Program in Medical Education for Doctors of Osteopathic Medicine, Yale University, New Haven, Connecticut

• Retrospective evaluation of 6 yrs of data
• Preoperative anxiety increased symptoms of emergence delirium
• Postop beh changes more likely in those with emergence delirium

Kain, Anesth Analg 2004
Children's self-reported postoperative pain

Preoperative Anxiety

Risk Factors

1. Age
   - 1-5 yo

2. Temperament
   - Genetic
   - Refers to emotional response

3. Previous experience

4. Parental influences
   - Anxious, divorced, avoidance coping mechanism
Preoperative Anxiety

Behavioral Interventions

1. Preoperative preparation program
   - Narrative information
   - Tour
   - Child life specialist- coping skills
     - Most effective

2. Parental presence for induction

3. Video
PPIA vs Medication
Which Intervention is More Effective?

Kain ZN, Arch Pediatr Adolesc Med 1996;150:1238-1245
Interventions

Midazolam reduced preop anxiety & negative post op behavioral changes

Kain, Anesthesiology 1999
Effects of Age and Emotionality on the effectiveness of midazolam Administered preoperatively to children

Zeev N. Kain, Jill MacLaren, Brenda C. McClain, Haleh Saadat, Shu-Ming Wang, Linda C. Mayes, George M. Anderson
Effects of Age and Emotionality on the effectiveness of midazolam Administered preoperatively to children

Midazolam, PO 0.5 mg/kg (n=262)

N = 37
Cutoff: m-YPAS = 72.90
N = 225
Child’s Response and Midazolam

Emotionality

Resp. Non-responder

Child’s Age

2 3 4 5 6 7 8 9 10

Intensive Review of Pediatric Anesthesia 2015
Parental Presence and a Sedative Premedicant for Children Undergoing Surgery: A Hierarchical Study

- Parental satisfaction of the overall care provided and satisfaction of the separation process was significantly higher among the sedative+PPIA group as compared to the sedative group.

Kain, Anesthesiology 2000
## Preparation for Case

### Appendix 1. Description of Targeted Desired and Undesired Behaviors

<table>
<thead>
<tr>
<th>Behaviors</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desired behaviors</td>
<td></td>
</tr>
<tr>
<td>Nonprocedural, distracting talk</td>
<td>Distracting comments that steer children’s attention away from the medical procedure (e.g., talk about observable toys, or unobservable topics, such as their pets, favorite movies)</td>
</tr>
<tr>
<td>Humor</td>
<td>Jokes that help to change the focus of children’s attention away from the medical procedure</td>
</tr>
<tr>
<td>Actual choices with clear limitations to child</td>
<td>Giving a choice to the child, one that does not allow the child to refuse the procedure completely (e.g., “do you want the strawberry or bubblegum smell?”)</td>
</tr>
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<td>Medical reinterpretation of visible equipment</td>
<td>Statements that reframe the current medical procedure or equipment into something fun and positive (e.g., here’s an astronaut mask)</td>
</tr>
<tr>
<td>Undesired behaviors</td>
<td></td>
</tr>
<tr>
<td>Reassuring, apologetic, and empathetic statements</td>
<td>Reassuring statements such as “It’s okay” and “don’t worry”; apologetic statements such as “I’m sorry”; and empathetic statements such as “I know it’s hard” serve to focus the child on his or her feelings or distress</td>
</tr>
<tr>
<td>Implied, unlimited choices to child</td>
<td>Asking the child questions that the child has no control over (e.g., “Are you ready to go?” or “Do you want to breathe through the mask?”)</td>
</tr>
<tr>
<td>Medical reinterpretation of nonvisible equipment</td>
<td>Reframing the procedure and/or equipment that is not in the child’s immediate environment (e.g., reinterpreting the mask while the child is still in the holding room)</td>
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<tr>
<td>Excessive medical talk</td>
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Preoperative Anxiety

Reduces Anxiety
• Video games
• Clowns
• Hypnosis
• Low sensory environment

Doesn’t Reduce Anxiety
• PPIA
• Music
Pre-Anesthetic Evaluation Plan

• Informed consent (assent)
• Premedication
  – Anxiolysis
  – Analgesics
  – Antacids
  – SABA
• Parental presence (and preparation)
• NPO Instructions
• Additional evaluation (consults, labs, or studies)
NPO status

- Clears 2 hours
- Breast (human) milk 4 hours
- Formula 6 hours
- Solids (cow’s milk) 6 hours
- Non fatty/fried food 6 hours
- Fried/fatty food 8 hours
- may depend on amount ingested, possibly 8 hours

**Practice Guidelines for Preoperative Fasting and the Use of Pharmacologic Agents to Reduce the Risk of Pulmonary Aspiration: Application to Healthy Patients Undergoing Elective Procedures**

*An Updated Report by the American Society of Anesthesiologists Committee on Standards and Practice Parameters*

**METHODOLOGY**

Definiton of Preoperative Fasting and Pulmonary Aspiration

For these Guidelines, preoperative fasting is defined as a prescribed period of time before a procedure when patients are not allowed the oral intake of liquids or solids. Postoperative pulmonary aspiration is defined as aspiration of gastric contents occurring after induction of anesthesia, during a procedure, or in the immediate period after surgery.

Address correspondence to the American Society of Anesthesiologists, 103 North LaSalle, 22nd Floor, Chicago, IL 60602. These Practice Guidelines, as well as all published ASA Practice Parameters, may be obtained at no cost through the Journal Web site, www.anesthesiology.org.

*Reprinted by the American Society of Anesthesiologists, Inc. Appraisal*
NPO status

- 98% of clear fluids have left the stomach within an hour of fasting.
  - Clears include water, carbonated beverages, fruit juices without pulp, clear tea or coffee (no cream).
- Longer periods of fasting are convenient but may
  - Increase risk of hypoglycemia
  - Result in hypovolemia
  - Decrease satisfaction
    (consider IV hydration and dextrose, especially for metabolic disease, preemies, ill)
- If anesthetic is delayed, consider permitting/encouraging clears until 2 hours prior to new start time.
NPO status

• Note wide range of stomach emptying times
• Guidelines are for healthy kids undergoing elective procedures.
• Waiting for NPO for emergency cases may result in small gastric volumes (especially > 4 hours), but assume “less full stomach.”
NPO status

• Chewing gum
  – if swallowed, dangerous as could obstruct airways if regurgitated and aspirated
• Don’t trust kids with respect to NPO! (but ask them directly anyway)
• Examine the patient’s mouth – make sure it’s empty
Pre-Anesthetic Evaluation Plan

• Go/Postpone/Cancel

• Proceed Elsewhere
  – Transfer patient to *pediatric* peri-operative setting (e.g. a children’s hospital)
    • Departmental policy regarding pediatric anesthesia privileges ([http://www.pedsanesthesia.org/policyprovision.iphtml](http://www.pedsanesthesia.org/policyprovision.iphtml))
    • AAP Guidelines for pediatric periop environment
      – Pediatric environment NOT defined just by presence of pediatric anesthesiologist (Hackel, A., J. M. Badgwell, et al. (1999))
    • Complications in patients with complex special health care needs are more likely in PACU than in OR. (Graham, R. J., M. T. Wachendorf, et al. (2009).)

• Tailor Anesthetic Plan to Patient (e.g. avoid ETT)
Additional General Consideration for Pediatric Anesthesia
Basics of Fluids, Electrolytes, and Glucose
Procedures associated with fluid shifts and blood loss

• Fluid Shifts
  – Abdominal Surgery
  – High blood loss cases

• Blood loss
  – Cardiac Surgery
  – Orthopedic Surgery
  – Craniofacial Reconstruction
How fluid deficits are made

- **Pre-operative deficits from**
  - Fasting
  - Gastrointestinal losses
  - Cutaneous losses

- **Hemorrhage**

- **Third space losses**
The critical pieces of fluid management in pediatric patients

- Glucose
- Sodium
- Water
Peri-operative abnormalities in blood glucose

- Risk of pre-induction hypoglycemia 0-10%
- No consistent age association: varied from 1 month – 10 years
- Most children had prolonged fasting (8 – 19h)
- Not demonstrated in children who had clear fluids 2 – 6h before surgery
Risks of Hypoglycemia in Pediatric Patients

- Permanent brain injury
  - Induction of counter-regulatory stress responses
    - Cortisol, Epi, glucagon, growth hormone
  - Increased regional blood flow → Loss of cerebral autoregulation (severe)
  - Altered cerebral metabolism, ion and acid-base homeostasis
Congenital conditions associated with hypoglycemia

- Glycogen Storage Diseases
- 3-Hydroxy-3-Methylglutaryl-CoA Lyase Deficiency
- Inborn errors of metabolism
Risks of Hyperglycemia: The Party Line

• Worsen effects of brain ischemia or anoxia
  – Promotes glucose aerobic metabolism
  – Promotes intracellular acidosis and hydrogen ions
  – Directly injures glia and neurons

• Osmotic Diuresis
  – hypovolemia
Hyperglycemia may be less risky: The Real Deal in the Pediatric Brain

• Increased cerebral metabolic rate for glucose in neonates to about 6 years of age when compared with adults (6.8 vs. 5.5 mg glucose/min/100g)

• Neonatal brain can generate ATP from
  – ketone bodies
  – Free fatty acids
  – Lactate
The ideal amount of glucose in pediatric replacement fluids

• Ideal fluids
  – 2 – 2.5% glucose solutions induce less hyperglycemia
  – 1 or 0.9% glucose solutions prevent hypoglycemia and produce normoglycemia
Acute Decrease in Serum Osmolality

Brain

- Brain Parenchyma
- Water
- Electrolytes
- Blood

ECF

- Electrolytes
- Water
Acute Decrease in Serum Osmolality

Brain

- Brain Parenchyma
- Water
- Electrolytes
- Blood

Low Osmolar ECF

- Electrolytes

Water

Water
Risks of Hyponatremia

• Increased in children
  – Larger intracranial volume ratio compared to adults

• Acute decrease in serum osmolality

• Serum sodium less than 125 mmol/l
  – Animal studies suggest limited Na+-K+ATPase
    • Limited ability to remove sodium
  – Symptomatic at higher sodium levels when compared to adults (120 vs 111 mmol/l)

• Encephalopathy
Dilution Hyponatremia

• Directly associated with intra-operative, hypotonic IV fluids ---Acquired

• Develops post-operatively

• Earlier studies associated administration rate but this was recently refuted
  – Neville K et al., Journal of Pediatrics, 2010
Antidiuretic Hormone

• Unpredictable ADH secretion in pediatric patients
• Increased by
  – Hypovolemia
  – Pain
  – Stress
  – Anxiety
  – Nausea and Vomiting
  – Morphine
Syndrome of Inappropriate Antidiuretic Hormone Secretion

• Post-operative oliguria and hyponatremia caused by
  – Elevated ADH without hypovolemia or hypertonic state
  – high sensitivity of the distal renal tubule and collecting ducts to ADH

• Associated with certain surgeries
  – Cardiac
  – Spine