Update on Pediatric Anesthesia

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Section of Pediatric Anesthesiology | Children's Hospital Colorado
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Outline

- Perioperative management of the food allergic pediatric patient
- "Child friendly" preoperative NPO guidelines & RSI
- Management of button battery ingestion
- Update on pediatric craniofacial reconstruction

No Disclosures...

The food allergic pediatric patient...

Food Allergy ? Anesthesia

"There is no estimate of true prevalence of food allergy in the U.S."

The National Academies of Science Engineering Medicine
November 2016
History of multiple food intolerance
- Propofol was avoided during anesthetic for MRI
- Pt had concerning bradycardia during that anesthetic

Family history of malignant hyperthermia

Adverse Food Reactions

Immune mediated

Food Allergy

Non-IgE Mediated

Non-immune mediated

Celiac Disease

Toxic Reactions

Most Common Immunodominant Allergens

Egg Ovomucoid, Ovalbumin, Ovotransferrin, Lysozyme
Milk Caseins (a, b, k, g) & Whey (lactoglobulins, immunoglobulin & lactoferrin)
Peanut Cupin, Conglutin, Profilin
Shellfish Tropomyosin, Arginine kinase, Myosin light chain, Sarcoplasmic calcium-binding protein
Soy Contain allergens belonging to all categories of protein superfamilies
Wheat Glutenins, gliadins, profilin

Most Common Likely Outgrown by Adulthood Likely Lifelong

Egg ✔
Fish ✔
Milk ✔
Peanut ✔
Shellfish ✔
Soy ✔
Tree nuts ✔
Wheat ✔

Most Common Likely Outgrown by Adulthood Likely Lifelong

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Wheat ✔

Waserman, S and Watson, W. Food Allergy, Allergy, Asthma & Clinical Immunology. 2011
**Most Common Immunodominant Allergens**

<table>
<thead>
<tr>
<th>Category</th>
<th>Allergens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>Ovomucoid, Ovalbumin, Ovotransferrin, Lysozyme</td>
</tr>
<tr>
<td>Milk</td>
<td>Caseins (a, b, k, g), Immunoglobulin</td>
</tr>
<tr>
<td>Soy</td>
<td>Contains allergens belonging to all categories of protein superfamilies</td>
</tr>
<tr>
<td>Peanut</td>
<td>Cupin, Conglutin, Profilin</td>
</tr>
<tr>
<td>Shellfish</td>
<td>Tropomyosin, Arginine kinase, Myosin light chain, Sarcoplasmic calcium-binding protein</td>
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<td>Soy</td>
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</tbody>
</table>

**Preoperative allergen contamination**

- Peanut allergen is easily cleaned
- We should wash our hands after eating!

**Perioperative Allergy**

Adapted from: Hepner, D and Castells, M. Anaphylaxis During the Perioperative Period. Anesthesia & Analgesia. 2003

**Possible food allergy and anesthesia interaction**

Adapted from: Hepner, D and Castells, M. Anaphylaxis During the Perioperative Period. Anesthesia & Analgesia. 2003

**The latex-fruit syndrome**

Latex precautions should be in place for patients with allergies to these fruits.

**Fish and Seafood allergy . . .**

Iodinated media

Protamine

Fish/Seafood allergy
IODINE ALLERGY AND SEAFOOD = MYTH!

- Reaction to iodinated media is NOT IgE-mediated and NOT due to iodine
- Contact dermatitis is NOT triggered by iodine
- Protein components of seafood are responsible for allergy NOT iodine

PERHAPS THINK ABOUT PROTAMINE

- "patients with a history of allergy to fish may develop hypersensitivity reactions to protamine . . . to date no relationship has been established between allergic reactions to protamine and fish allergy"

Reaction to iodinated media is NOT IgE-mediated and NOT due to iodine.

Contact dermatitis is NOT triggered by iodine.

Protein components of seafood are responsible for allergy NOT iodine.

Propofol is safely used in patients with allergy to egg, soy and peanuts.

The practice of choosing alternatives to propofol in patients with these food allergies is not evidence-based and should be reconsidered.

Contraindications:

- Anesthetic need not be altered
- Atopic patients are at risk
- Reasonable concessions considered
The purposes of these guidelines are to provide direction ... to reduce the risk of pulmonary aspiration and to reduce the severity of complications related to perioperative pulmonary aspiration.

Nil per os (NPO) rules for clear liquids

<table>
<thead>
<tr>
<th>Ingested Material</th>
<th>Minimum Fasting Period (Healthy patients undergoing elective procedures)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear liquids</td>
<td>2 hr</td>
</tr>
<tr>
<td>Breast milk</td>
<td>4 hr</td>
</tr>
<tr>
<td>Infant formula, nonhuman milk, “light meal”</td>
<td>6 hr</td>
</tr>
<tr>
<td>Fried/fatty food or meat</td>
<td>8 hr</td>
</tr>
</tbody>
</table>

...unless there is a contraindication, it is safe and recommended for all children able to take clear fluids, to be allowed and encouraged to have them up to one hour before elective general anesthesia.

Risk of pulmonary aspiration ... U.K.

Aspiration is rare
• Incidence 0.07-0.1%

Sequelae are rarely severe or long lasting

Morbidity is low...

2/10,000 incidence

"Severe deterioration" in 5 cases

All made full recovery
Risk of pulmonary aspiration . . . U.S.A

Aspiration is rare
- Incidence 1/10,000

Similar despite NPO status

What influences risk?

<table>
<thead>
<tr>
<th>Patient Factors</th>
<th>Anesthetic Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full stomach</td>
<td>Opioids</td>
</tr>
<tr>
<td>Bowel obstruction</td>
<td>Appropriate fasting</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>Airway management</td>
</tr>
<tr>
<td>Trauma</td>
<td>Anesthetic technique</td>
</tr>
<tr>
<td>Obesity</td>
<td></td>
</tr>
<tr>
<td>Esophageal pathology</td>
<td></td>
</tr>
<tr>
<td>Renal failure</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
</tr>
</tbody>
</table>

Appropriate fasting
- Airway management
- Anesthetic technique

Actual fasting times

- 12 hrs for solids and nearly 8 hrs for liquids
- NPO > than recommended 70% of cases
- 62% fasted > 4 hours for clear liquids

Unnecessarily Long!

Consequences . . .

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoglycemia</td>
</tr>
<tr>
<td>Metabolic acidosis</td>
</tr>
<tr>
<td>Dehydration</td>
</tr>
<tr>
<td>Cardiovascular instability</td>
</tr>
<tr>
<td>Discomfort</td>
</tr>
<tr>
<td>Grumpiness</td>
</tr>
<tr>
<td>Post-op insulin resistance</td>
</tr>
<tr>
<td>Emergence delirium</td>
</tr>
</tbody>
</table>

Eye exams under anesthesia
- Pediatric Anesthesia Emergence Delirium scale (PAED)
- Prolonged preop fasting → patient anxiety → emergence delirium
Correlation between duration of preoperative fasting and emergence delirium in pediatric patients undergoing ophthalmic examination under anesthesia: A prospective observational study

Accepted: 15 March 2018
DOI: 10.1111/pan.13381

Mean clear liquid fasting 6.3hrs!

PAED score at 15 & 20 minutes correlated with fasting duration

“Choosing Wisely“ in Pediatric Anesthesia

“Perioperative fasting should be safe and child-friendly with shorter real preoperative fasting times... In future guidelines, shorter fasting for light meals/formula milk (4 hours) and clear fluids (1 hour) should be considered”

Liberal fluid fasting...

30 minutes for clear fluids
4 hours for breast milk/formula & milk-based products
6 hours for solids
Patients are assessed by anesthesiologist

↑ Risk of prolonged fasting

Age < 3 years old
First case of the day

Liberal fluid fasting...

6-4-2 Fasting
6-4-0 Fasting

Fasting Median clear liquid fasting Fasting Median clear liquid fasting

Patients are assessed by anesthesiologist

Impact on gastric content...

Liberal fasting → shorter fasting duration
No difference in pH of gastric contents
No difference in residual gastric volume

Benefits of “child friendly” NPO times

Proven Benefit
↓ preoperative fasting times
↓ incidence of unnecessarily prolonged fasting
↓ thirst, hunger & anxiety

Likely (possible) Benefit
↓ perioperative hypoglycemia
Hemodynamic stability
↓ post-op insulin resistance
↓ emergence agitation
**Summary: Child Friendly NPO**

**PRO**
- Most children are starved longer than necessary
- The stomach processes contents rapidly
- No good evidence that current NPO rules are protective
- Aspiration is rare

**CON**
- Maybe this goes too far . . .
- One size does NOT fit all
- Study power and safety?
- If it isn’t broken . . .

**Pediatric RSI: Time for a different technique?**

**CLASSIC RSI . . .**
- Aspiration with anesthesia still occur
- We are preventing aspiration
- Cricoid is easy and effective (ca 1961)

**"BEST PRACTICE" RSI . . .**
- Yeah but how frequent & how significant?
- Are we?
- Really?

**Pediatric RSI: We can all agree . . .**

- Pre-oxygenation is good
- Rapid drug administration → DO NOT fear Sux
- Consider “modified” RSI
- +/- cricoid pressure
**Button Battery Ingestion Update**

Section on Anesthesiology & Pain Medicine

**NEWSLETTER Fall 2018**

*Unsolicited Management Guidelines on Button Battery Ingestion in Children*

Subrahmanian, MD, Young Munoz, J. Hospital, MD

Richard J. Hrg, MBOD, MD, Department of anesthesiology,

Children's Hospital Colorado, University of Colorado School of Medicine, Aurora, CO

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**Button Battery . . . Background**

- ~ 3500 ingestions/year
- 7x↑ in complications and death
- 2006: 20-mm, 3-volt batteries

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**Death**

<table>
<thead>
<tr>
<th>Major Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>59 children</td>
</tr>
<tr>
<td>All &lt; 5 years of age</td>
</tr>
<tr>
<td>Esophageal perforation or stricture</td>
</tr>
<tr>
<td>80% aorto-esophageal fistula</td>
</tr>
<tr>
<td>Tracheoesophageal fistula</td>
</tr>
<tr>
<td>Vocal cord paralysis</td>
</tr>
<tr>
<td>Mediastinitis</td>
</tr>
</tbody>
</table>

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**Button Battery . . . Pathophysiology**

- Battery lodged
- Circuit completed
- Caustic injury

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**Injury severity**

- Timing
- Orientation
- Size/voltage
- Age < 5 years

**Presentation**

- Dysphagia
- Drooling
- Cough
- Bleeding

**Evaluation**

- X-ray halo sign & step off

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**Three Ns**

- Negative
- Narrow
- Necrotic

*Courtesy: Jatana KR. Nationwide Children's Hospital*
**Button Battery . . . Preop Imaging**

- Halo sign
- Step off

**Button Battery . . . Intraop Management**

<table>
<thead>
<tr>
<th>MAIN OR</th>
<th>CATH LAB/CARDIAC OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Stable patient</td>
<td></td>
</tr>
<tr>
<td>- Low risk patient</td>
<td></td>
</tr>
<tr>
<td>- Gastroenterologist or general surgeon</td>
<td></td>
</tr>
<tr>
<td>- High-risk/unstable</td>
<td></td>
</tr>
<tr>
<td>- Sentinel bleed</td>
<td></td>
</tr>
<tr>
<td>- Cardiovascular surgeon or interventional cardiologist available</td>
<td></td>
</tr>
</tbody>
</table>

**Button Battery . . . Postop Management**

- Ongoing Damage
  - Days to weeks
- Serial Imaging
  - CT scan or MRI

**Button Battery Ingestion . . . Mitigation**

- pH 2.4
  - Pops
  - Water
  - Raisin Lemon
- pH 3.3
  - Coke
  - Saline Control
  - Orange Juice


**NCPC Guidelines . . . Prehospital**

- Witnessed or suspected BB ingestion
- Proceed immediately to ED
- Do not induce vomiting

**Patient >12 months old AND lithium battery ingested within 12 hours**
- Give honey 10 mL every 10 minutes (max 6 doses)
- Use commercial honey, rather than specialized or artisanal honey

**NCPC Guidelines . . . Treatment Algorithm**

- **Button Battery in esophagus**
  - Immediate endoscopic removal within 2 hours of ingestion
  - **Consider giving preop sucralfate 10 mL every 10 mins (max 3 doses)**

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**NCPC Guidelines . . . After removal**

- Inspect esophageal mucosa for location and extent of damage
- Note position of BB and orientation of negative pole
  - If no evidence of perforation:
    - Irrigate esophagus with 50-150 mL of 0.25% acetic acid to neutralize residual alkali

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**Button Battery Ingestion . . . Take Home**

- CXR: halo & step off
- Negative/Narrow/Necrotic
- Recognize sentinel bleed
- Emergent removal
- Active surveillance post-op
- Mitigate: honey/sucralfate

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**Pediatric Craniofacial Reconstruction Update**

- Massive blood loss & transfusion
- Hypovolemic cardiac arrest
- Hyperkalemia
- Coagulopathy
- Transfusion reactions
- Venous air embolism
- Difficult airway
- Difficult vascular access

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**Leveraging Multicenter Data**

- Formed in 2021
- Pediatric Craniofacial Perioperative Surgery Registry
- United States, Canada, Columbia and Mexico
- 7 publications since 2017
Complex Cranial Vault Reconstruction (CCVR)

- Fronto-orbital advancement
- Posterior vault reconstruction
- Total vault reconstruction

Benchmarking data

CCVR Procedures
- Anterior vault/FOA: 64%
- Mid/Posterior vault: 27%
- Total vault: 8%
- First craniofacial surgery: 89%

CCVR...Vascular access

- 95% ≥ 2 peripheral IVs
- 99% arterial line
- 12% central line

CCVR...Other monitors

- Precordial Doppler
  - Thromboelastography
  - 21%
  - 7%

CCVR...Blood conservation

<table>
<thead>
<tr>
<th>Modality</th>
<th>% of cases</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute normovolemic</td>
<td>&lt; 0.001 (1 case</td>
<td>Not used</td>
</tr>
<tr>
<td>hemodilution</td>
<td>total)</td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>0.005% (7 cases</td>
<td>Rarely used</td>
</tr>
<tr>
<td>erythropoietin</td>
<td>total)</td>
<td></td>
</tr>
<tr>
<td>Cell saver</td>
<td>16%</td>
<td>Limited by cost and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>availability</td>
</tr>
<tr>
<td>Antifibrinolytics (TXA)</td>
<td>63%</td>
<td>Should be used more</td>
</tr>
</tbody>
</table>

CCVR...Blood transfusion

- 94% transfusion rate
- 28% > 40 mL/kg
- 10% > 60 mL/kg
- 5% > 80 mL/kg
**Transfusion . . . Predictive factors**

<table>
<thead>
<tr>
<th>↑ INTRAOP TRANSFUSION (ML/KG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>➤ Decreased weight</td>
</tr>
<tr>
<td>➤ Greater ASA physical status</td>
</tr>
<tr>
<td>➤ Longer surgery</td>
</tr>
<tr>
<td>➤ Intraop vasopressor use</td>
</tr>
<tr>
<td>➤ Intraop cardiorespiratory complication</td>
</tr>
<tr>
<td>➤ Lack of antifibrinolytic use</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>↓ INTRAOP TRANSFUSION (ML/KG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>➤ Increased weight</td>
</tr>
<tr>
<td>➤ Lower ASA physical status</td>
</tr>
<tr>
<td>➤ Shorter surgery</td>
</tr>
<tr>
<td>➤ Cranial distractor placement</td>
</tr>
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</table>

**Transfusion . . . Non-predictive factors**

- Sex, race, ethnicity
- Preop erythropoietin
- Syndromic/multisuture synostosis
- Redo procedures

**Antifibrinolytic safety . . .**

- 0.6% incidence of post of seizure
- No difference in seizure related to antifibrinolytic use
- 1 instance of postop DVT
- Use is likely safe, but caution in high-risk patients and avoid high doses

**Endoscopic vs Open Repair . . .**

- **Most types of craniosynostosis**
  - Blood product exposure
  - Post-op intubation
  - ICU utilization
  - Hospital length of stay

- **< 3 months old**

**Take home points . . . CCVR**

- Central venous access likely unnecessary
- Certain perioperative factors predict increased blood transfusion
- Use antifibrinolytics
  - TXA: 10 mg/kg bolus over 10 min → 5 mg/kg/hr during surgery
- Future developments? Cell saver use?, Endoscopic-assisted repairs?
- More to come from the PCCG

**Thank You!**