Pulmonary Aspiration

Definitions
• Aspiration Pneumonitis
• Aspiration Pneumonia

Components of aspiration pneumonitis and pneumonia
• Regurgitation
• Aspiration
• Composition of Material

Pathophysiological chain of events

Pathophysiology of pneumonitis
• Immediate irritation
• Atelectasis
• Inflammation
• Infiltration

MYTH: ASPIRATION PNEUMONITIS IS EASY TO DISTINGUISH
Sequelae of Aspiration

- Asymptomatic
- Symptomatic; conservative treatment
- Mechanical ventilation
- Death

Clinical Presentation

- Hypoxemia
- Inc PIP
- Dyspnea, bronchospasm, laryngospasm
- Adventitious lung sounds
- CXR: Infiltrates in dependent lobes
- Differential: PE, allergic bronchospasm, mechanical ETT obstruction

Clinical Presentation

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Patients at Risk for Aspiration

- MYTH: SOME KEY INDICATORS MAKE IT EASY TO IDENTIFY PATIENTS AT RISK FOR ASPIRATION
  - Why is it a problem under anesthesia?
    - Unconsciousness impairs protective reflexes
    - Both lower and upper esophageal sphincter tone reduced by anesthesia
    - Upper airway reflexes continue to be significantly impaired for 2 hours after recovery from anesthesia.
    - Electrolyte abnormalities and hyperglycemia impair gastric motility

Mendelson’s syndrome

- "A survey of New York Lying-in Hospital records of patients that aspirated gastric contents during obstetric anesthesia revealed the following different diagnoses: mumps, amniotocceus, placental abruption, partial deformities, facial deformities, pulmonary edema, aspiration pneumonia, bronchopneumonia, lobar pneumonia, virus pneumonia, atypical pneumonia, tuberculosis, parapneumonic pneumonic, pulmonary embolism, viral infections, pulmonary edema, and parapneumonic tachycardia. Extends a partial understanding of
Risk Factors - Mendelson's

- Gastric pH < 2.5
- Gastric volume > 25ml or 0.4 ml/kg

MYTH: CRICOID PRESSURE WILL PREVENT REGURGITATION.

Barrier pressure protection

LES pressure is raised by succinylcholine, metoclopramide, cholinergic drugs

LES pressure reduced by anticholinergics, ganglion blockers, theophylline, thiopental, opioids, beta-adrenergic agonists, and cricoid pressure

Have we been following the correct procedures?

- Cricoid pressure?!!!
- “Although the use of cricoid pressure seems to make intuitive sense, its scientific basis is weak at best and lacking at worst.”

Have we been following the correct procedures?

- Upper esophageal sphincter tone decreases after induction
- Cricoid pressure reduces tone of lower esophageal sphincter

Have we been following the correct procedures?

- Sellick’s 1961 article
- How applicable?
  - Patients in head-down tilt
  - Did not control for quality of induction
  - No qualitative data on amount of force applied
  - Not randomized
  - Published under “preliminary communications”
Have we been following the correct procedures?

- Problems applying concept of cricoid pressure
  - Distorts anatomy and displaces esophagus
  - Can make laryngoscopy difficult
  - 10% of clinicians have experienced regurgitation in spite of pressure (Anaesthesia 38:457, 1983)
  - 25% of aspiration claims in ASA database had cricoid pressure applied (Engelhardt & Webster Pulmonary aspiration of gastric contents. Br J Anaesth 1999;83:453-460.)
  - Procedure incorrectly applied in 50% of cases
  - 10% of clinicians have experienced regurgitation in spite of pressure (Anaesthesia 38:457, 1983)

- “As a profession we invest a great deal of importance in a technique that is inadequately researched, poorly taught and badly performed.”

A continuing controversy

- “New Explanation for Controversial Old Patient-Care Technique to Prevent Regurgitation”


MYTH: THE PRIMARY DRIVER OF CONTINUED CRICOID PRESSURE MAY BE DEFENSIVE MEDICINE

MYTH: AN INTACT ENDOTRACHEAL TUBE WILL PREVENT ASPIRATION OF REGURGITATED MATERIAL
How well does the endotracheal tube really protect the airway?


Other endotracheal tube options

- Silver-coated tubes reduce biofilm formation
- Polyurethane cuff

Example of how tapered cuff reduces channeling

New Technologies to reduce aspiration
But what about all that gunk sitting above the cuff?

MYTH: A LMA MAY PROTECT AGAINST ASPIRATION


MYTH: ASPIRATION PNEUMONITIS IS A MECHANICAL ISSUE RELATED TO OBESITY, LOWER ESOPHAGEAL SPHINCTER, AND OTHER PHYSICAL FACTORS.

Problem-based prevention

- Gastric dysmotility
  The use of alcohol, anticholinergics, or opioids can increase the risk of regurgitation by reducing gastric motility.

Problem-based prevention

- Medication Effects
  LES tone is reduced by: nicotine, caffeine, alcohol, theophylline, beta-adrenergic agonists, thiopental, calcium-channel blockers, and nitrates.
  Drugs which reduce the formation of bicarbonate-rich saliva indirectly contribute to gastric acidity. These drugs include some antihypertensives, antihistamines, anti-depressants, and anticholinergics.
Problem-based prevention

• Reduced protective reflexes
  Avoid opioids where risk of obtundation exists prior to securing airway

Increase attention to residual relaxation post-op

Problem-based prevention

• Regurgitation Risk
  - airway difficulties, obesity, pregnancy, and lithotomy or prone positioning

Pregnant patient risks: Mechanical and hormonal
  - increase in gastric acid production
  - decrease in LES tone
  - epidural opioids reduce gastric emptying time

Pharmacologic Prophylaxis

• Various Modalities:
  - Diminish gastric acid volume
    • NPO status
    • Clear liquids up to 2 hours pre-op does not increase gastric contents or acidity

NPO Guidelines

Preoperative Fasting Guidelines for various foods

- Clear Liquid
- Breast Milk
- Light Meal
- Animal Milk
- Infant Formula
- Fatty Meal

Minimum Hours Preoperatively

8 6 4 2 0

MYTH: ASPIRATION RISK CAN BE REDUCED PROPORTIONATELY TO THE DURATION OF FASTING

MYTH: NEW GENERATION ANTACIDS ARE MORE EFFECTIVE THAN TRADITIONAL ONES.
Pharmacologic Prophylaxis

• Various Modalities:
  - Diminish gastric acid volume
  - Promote forward flow
  - Reduce acidity of gastric contents

H2 Blockers - Important Facts

<table>
<thead>
<tr>
<th></th>
<th>Dosage IV</th>
<th>Dosage PO</th>
<th>Duration (IV)</th>
<th>Pregnancy Cat.</th>
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<tr>
<td>Famotidine</td>
<td>20 mg</td>
<td>20 mg</td>
<td>12 hour</td>
<td>B</td>
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<tr>
<td>Ranitidine</td>
<td>50 mg</td>
<td>150 mg</td>
<td>8 hour</td>
<td>B</td>
</tr>
<tr>
<td>Cimetidine</td>
<td>300 mg</td>
<td>400 mg</td>
<td>4 hour</td>
<td>B</td>
</tr>
<tr>
<td>Nizatidine</td>
<td></td>
<td>150 mg</td>
<td>12 hour (PO)</td>
<td>C</td>
</tr>
</tbody>
</table>

H2 Blockers - Other considerations

• Cimetidine - inhibits the cytochrome P-450-potential for interactions with theophylline, warfarin, lidocaine, and phenytoin

• Famotidine - no drug interactions, less adverse effects, long duration, less cost

• Ranitidine - thrombocytopenia possible with prolonged use

Pediatric Dosages

* Note: H2 Blockers are not FDA approved for pediatric use

<table>
<thead>
<tr>
<th></th>
<th>Dosage IV</th>
<th>Dosage PO</th>
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<tbody>
<tr>
<td>Famotidine</td>
<td>0.4 mg/kg/dose q12h</td>
<td>0.4 mg/kg/dose q12h 0 mg</td>
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<tr>
<td>Ranitidine</td>
<td>1.5 mg/kg/dose q6h</td>
<td>1.25 mg/kg/dose q8h</td>
</tr>
<tr>
<td>Cimetidine</td>
<td>5-10 mg/kg/dose q6h</td>
<td>5-10 mg/kg/dose q 6</td>
</tr>
</tbody>
</table>

Proton Pump Inhibitors

• Directly reduce acid output from parietal cells
• Omeprazole- *Prilosec*
• Lansoprazole- *Prevacid*
• Pantoprazole- *Protonix*
• Esomeprazole- *Nexium*
• Rabeprazole- *Acifex*
• Dexlansoprazole- *Dexilant*

Proton Pump Inhibitors

• Generally more effective than H₂ blockers

• Slower ramp up to max. effect.
  - At least 2 hours to full effect
  - 3 days for max effect in chronic use
H2 Blockers vs. PPIs

PPIs- Other considerations

- Yet another controversy
- Gastric acid inhibits bacterial growth
- ICU patients on pantoprazole showed 3x rate of pneumonia vs. those on ranitidine
- (834 patients reviewed- Miano et. al. *Chest* 2009)
- Consider benefits of short-term (perioperative) vs. long-term use.

Direct Antacids

- Sodium Citrate
- Sodium Citrate + Citric Acid (Bicitra)

Gastric Prokinetics

- Metoclopramide (Reglan)
- Cisapride (Propulsid)- off market
- Erythromycin 200mg/day as effective as metoclopramide as gastric stimulant

**PHARMACOLOGIC ASPIRATION PROPHYLAXIS**

<table>
<thead>
<tr>
<th>Category</th>
<th>Name</th>
<th>Typical Preop. Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastric Prokinetic agents</td>
<td>Metoclopramide (Reglan)</td>
<td>10-20 mg IV</td>
</tr>
<tr>
<td>Histamine-2 Receptor Antagonists</td>
<td>Nizatidine (Axid)</td>
<td>150 mg PO at bedtime and preoperatively 50 mg IV 20 mg IV</td>
</tr>
<tr>
<td></td>
<td>Ranitidine (Zantac)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Famotidine (Pepcid)</td>
<td></td>
</tr>
<tr>
<td>H+, K+-ATPase pump (proton pump”) Inhibitor</td>
<td>Omeprazole (Prilosec)</td>
<td>30 mg PO at bedtime and preoperatively (30 mg PO)</td>
</tr>
<tr>
<td></td>
<td>Esomeprazole (Nexium)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lansoprazole (Prevacid)</td>
<td></td>
</tr>
<tr>
<td>Antacids</td>
<td>Sodium Citrate</td>
<td>30 ml PO 15 minutes preoperatively</td>
</tr>
<tr>
<td></td>
<td>Sodium Citrate + Citric Acid</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Bicitra)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>“Citric Acid + NaHCO3” (Alka-Seltzer)</td>
<td></td>
</tr>
</tbody>
</table>
Novel Approaches

- Lidocaine immediately before or after acid aspiration attenuated lung injury

- Hyperoxia worsens lung damage after acid aspiration

  (Knight PR, Kurek C, Davidson BA, Nader ND, Patel A, Sokolowski J, Notter RH. Holm BA. Acid aspiration increases sensitivity to increased ambient oxygen concentrations. American Journal of Physiology - Lung Cellular & Molecular Physiology. 278(6):L1240-7, 2000 Jun.)

- Neutrophils, humoral mediators respond to treat, but cause much of damage

Cellular response- helpful?

- Neutrophils, humoral mediators respond to treat, but cause much of damage

Pneumonitis Treatment

- Therapy depends upon severity of symptoms
- Initial course is prognostic
- Majority do not require treatment beyond supportive care

Pneumonitis Treatment

- ORAL suctioning
- Oxygen as needed (enough, but not too much)
- If ventilation required, include PEEP
- Bronchodilators
- Neutrophil aggregation inhibitors
- Antibiotics- many regimens, tailor to situation

Pneumonitis Treatment- What not to do

- Tracheal/bronchial suctioning
- Overzealous oxygen administration
- High dose volatiles as bronchodilators
- Steroids

Experimental/emerging treatments

- Pentoxifylline administration shortly after acid instillation results in significant alleviation of impaired oxygenation, stabilization of BP with higher heart rates, and improved survival after 6 h.
- JTE-607 can inhibit the production of inflammatory cytokines such as tumor necrosis factor-alpha, interleukin-6 and cytokine-induced neutrophil chemoattractant and attenuate acid-induced lung injury in rats.
- Sivelestat at 1 mg/kg/h inhibits neutrophil elastase. 20% more patients off ventilator at 20 days out.
MYTH: IN CASES OF KNOWN ASPIRATION, PATIENTS SHOULD BE TREATED WITH ANTIBIOTICS AUTOMATICALLY

- Antibiotic Recommendations

  Pneumonitis symptoms > 48 hours?
  - Yes
    - Levofloxacin 500 mg/day OR Ceftriaxone 1-2 gm/day
  - No
    - Risk factors for pneumonia?
      - Yes
        - Ciprofloxacin 400 mg bid OR Piperacillin-Tazobactam 3.375 gm q6h OR Ceftazidime 2 gm q6h
      - No
        - Supportive care

  Anerobic Coverage Needed?
  - Yes
    - Piperacillin-Tazobactam OR Imipenem 5-1 gm q6h OR Clindamycin 600mg q8h PLUS Levofloxacin, Ciprofloxacin, or Ceftriaxone
  - No

- CXR of patient following GI bleed and witnessed aspiration.
  - 2nd film 2 days later.

Summary

- Aspiration pneumonitis- chemical irritation of lung, usually caused by gastric acid
- Variety of medical conditions predispose; don’t focus on Mendelson’s
- Prevention focuses on one or all 3 components
  - Regurgitation
  - Aspiration
  - Caustic composition of material
- Majority are asymptomatic- 2 hours to “out of the woods”
- Conservative treatment usually indicated
  - No benefit to tracheal suctioning for non-particulate aspirates
  - Lido as neutrophil inhibitor
  - Antibiotics only if indicated
  - No steroids
  - Oxygen only as needed