Safe and Effective Use of CO2 Absorbents

Jeffrey M. Feldman, MD, MSE
Chair, APSF Committee on Technology
Children’s Hospital of Philadelphia
Professor of Clinical Anesthesiology
Perelman School of Medicine
University of Pennsylvania
Philadelphia, PA
Disclosures

• Consulting
  – ClearLine MD
  – Draeger Medical
Safe & Effective Use
Are CO2 Absorbents Safe?

• Exothermic Reaction Can Cause Fire
  – Sevoflurane
  – Requires dessicated Baralyme
  – Strong base KOH – Baralyme no longer available

• Compound A Production
  – Sevoflurane
  – Strong Base
  – Clinical relevance?
  – Clinical practices influenced by min flow recommendations

• Carbon Monoxide Production
  – Desflurane > Isoflurane> Sevoflurane
  – Dessicated absorbent is required
  – Strong Base: NaOH, KOH
  – Clinical practices to prevent dessication continue
Articles

CO Poisoning During Anesthesia Poses Puzzles:
New Agent Used in Florida Case

Cause Of CO Poisoning, Relation To Halogenated Agents Still Not Clear
What did we know then?

• Absorbent dessication produced CO
  – Turn off fresh gas flows between cases
  – Change absorbent regularly eg. Mon Morning
  – Change when color indicates “exhaustion”

• Presence of Strong Base increased both CO and Compound A
  – KOH is the worst
  – NaOH a contributor

“create an “Expert Task Force” to define further the characteristics of carbon dioxide absorbents that do not significantly degrade volatile anesthetics”
What have we learned?

• Absorbent Formulations have Evolved
  – Goals
    • Minimize or eliminate anesthetic degradation to CO and Compound A
    • Maximize absorptive capacity
  – Reduce or eliminate strong base catalysts – KOH, NaOH
  – Develop alternate chemistry – LiOH, LiCl, CaCl₂, CaSO₄

• Technology Changes
  – Absorbent Canister designs
Is there an optimal formula?

- No KOH, Reduced or no NaOH
- Efficiency decreases
- Price may increase

### In–Vivo Data CO – Des/Iso

<table>
<thead>
<tr>
<th>Absorbent</th>
<th>% KOH/NaOH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baralyme</td>
<td>4.6/0</td>
</tr>
<tr>
<td>Soda Lime</td>
<td>2.6/1.3</td>
</tr>
<tr>
<td>New Soda Lime</td>
<td>0/2.6</td>
</tr>
<tr>
<td>CaOH</td>
<td>0/0</td>
</tr>
</tbody>
</table>

Sevoflurane Data

Is NaOH OK?

• Draegersorb Free (NaOH<2%) v Amsorb Plus (NaOH=0%)

• Struys 2004 – In vitro, FGF 500
  – Compound A < 1 ppm
  – No CO when dessicated with Des

• Kobayashi 2004 – In vitro FGF 1000
## NaOH and Absorption Capacity

<table>
<thead>
<tr>
<th>Product</th>
<th>NaOH</th>
<th>Mins/100g to 0.5% FiCO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amsorb Plus</td>
<td>0</td>
<td>56</td>
</tr>
<tr>
<td>Litholyme</td>
<td>0</td>
<td>59</td>
</tr>
<tr>
<td>Sodasorb LF</td>
<td>&lt;1%</td>
<td>66</td>
</tr>
<tr>
<td>Draegersorb Free</td>
<td>&lt;2%</td>
<td>69</td>
</tr>
<tr>
<td>Sodasorb</td>
<td>&lt;4%</td>
<td>78</td>
</tr>
<tr>
<td>Draegersorb 800+</td>
<td>2%</td>
<td>91</td>
</tr>
<tr>
<td>Spirolith CA</td>
<td>&lt;1%</td>
<td>95</td>
</tr>
</tbody>
</table>

Safe Absorbent Use

• No Dessication, No CO
• No Sevoflurane, No Compound A
• Selection of Absorbent can eliminate these concerns
  – Minimize or eliminate strong base
  – Options readily available so not a limitation in modern practice
  – Absorbent capacity depends upon presence of strong base
• Modern absorbents support more effective practice
Effective Absorbent Use

• Clinical Comparison is Difficult
  – Cost Differences – loose fill, canister design, product
  – How do you change absorbent?
  – What fresh gas flows do you use?
  – What is the patient population?

• Efficiency: How much CO2 is absorbed per canister

• Efficiency is driven by when you change the absorbent.
  – Schedule irrespective of indicator
  – Indicator change
  – Inspired CO2
Change on Inspired CO2
Change on CO2

- Capnography
- Use of FGF to determine cause of problem
- What level of CO2 to trigger change? 5-10 mmHg?
Is Change on CO2 Safe?

• Special populations eg neurosurgery or pulmonary hypertension
  – PaCO2 is most important
  – Change on indicator or Monitor CO2

• Circuit Leaks
  – Bypasses the leak test
  – Vigilant to detect leaks – exclude canister, set FGF > MV
  – Need a process for testing canisters independently for leaks before replacement
2018 Recommendations

• Choice of Absorbent
  – No KOH
  – NaOH < 2% or NaOH = 0?
    • CO possible with dessication and Desflurane
    • Compound A possible – clinical relevance?
    • Absorbent capacity is the key difference but change on indicator alone erodes efficiency advantage
  – Select packaging that supports change on CO₂

• Fresh Gas Flow
  – Turn off between cases
  – Low flow techniques prevent dessication

• Use the Anesthesia Machine!
  – Reduce FGF to conserve Agent and Maximize CO₂ absorption
  – No limitation on minimum flow
  – Change Absorbent on Inspired CO₂ maximally uses absorbent
    • Concentration: 5 mmHg
    • Know how to manage leaks
    • Need a process for leak testing