Setting the Record Straight....The Myths of Desflurane Deciphered

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Do you know if these are myths or truths?

• You cannot use Desflurane with LMA’s, especially in pediatrics, due to the increased incidence of airway irritability
• If you want the fastest wakeup possible, use Propofol over the inhaled anesthetics
• Desflurane causes too much tachycardia and hypertension
• If you want to be economical and still have a fast wakeup, use Isoflurane throughout the case then switch to Desflurane at the end
Now some things are true...
Some background info on inhaled anesthetics

Inspired and Alveolar Anesthetic Concentrations

- N₂O
- Desflurane
- Sevoflurane
- Isoflurane
- Halothane

Solubility in Blood

Blood: Gas Partition Coefficient

Year of Introduction Into Practice

- **Halothane, 2.54** (1960)
- **Isoforane, 1.46** (1980)
- **Desflurane, 0.42** (2000)
- **Sevoflurane, 0.69** (2000)
Implications of Low Solubility

- More rapid wash-in
- Greater anesthetic control and precision
- More rapid emergence from anesthesia
- Potentially greater economy through more rapid recovery
- May eliminate N₂O without kinetic disadvantage
MAC (Potency)

- Concentration of drug that prevents skeletal muscle movement in response to a surgical incision in 50% of patients
- Reflects the partial pressure at the site of action (brain)
- Most useful index of anesthetic potency
- Similar MAC concentrations produce equal depression of CNS
MAC

- MAC: MAC that prevents skeletal muscle movement in 50% of patients
- MAC-Awake: MAC at which 50% of pts will respond to the command “Open your eyes”
  Usually associated with a loss of recall (~1/3 MAC)
- MAC-BAR: MAC necessary to block adrenergic response to skin incision (↑HR, ↑B/P)
  Expressed as MAC-BAR_{50} or MAC-BAR_{95}
  Exceeds the requirement of MAC
<table>
<thead>
<tr>
<th>Inhaled Agents: Blood/Gas Partition Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Desflurane</strong> 0.42 % (Fast onset)</td>
</tr>
<tr>
<td><strong>Nitrous Oxide</strong> 0.47 % (Fast onset)</td>
</tr>
<tr>
<td><strong>Sevoflurane</strong> 0.69 % (Medium)</td>
</tr>
<tr>
<td><strong>Isoforane</strong> 1.43 % (Medium)</td>
</tr>
<tr>
<td><strong>Ethrane</strong> 1.9 % (Medium)</td>
</tr>
<tr>
<td><strong>Halothane</strong> 2.4 % (Slow)</td>
</tr>
</tbody>
</table>
## Human Tissue: Blood Partition Coefficients

<table>
<thead>
<tr>
<th></th>
<th>Desflurane</th>
<th>Sevoflurane</th>
<th>Isoforane</th>
<th>Halothane</th>
<th>N₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat</td>
<td>27</td>
<td>48</td>
<td>45</td>
<td>51</td>
<td>2.3</td>
</tr>
<tr>
<td>Brain</td>
<td>1.3</td>
<td>1.7</td>
<td>1.6</td>
<td>1.9</td>
<td>1.1</td>
</tr>
<tr>
<td>Heart</td>
<td>1.3</td>
<td>1.8</td>
<td>1.6</td>
<td>1.8</td>
<td>–</td>
</tr>
<tr>
<td>Liver</td>
<td>1.3</td>
<td>1.8</td>
<td>1.8</td>
<td>2.1</td>
<td>0.8</td>
</tr>
<tr>
<td>Kidney</td>
<td>1.0</td>
<td>1.2</td>
<td>1.0</td>
<td>1.2</td>
<td>–</td>
</tr>
<tr>
<td>Muscle</td>
<td>2.0</td>
<td>3.1</td>
<td>2.9</td>
<td>3.4</td>
<td>1.2</td>
</tr>
</tbody>
</table>
Elimination of inhaled anesthetics

Yasuda et al.
Toxicity of Inhaled Agents

- Metabolism to toxic products is the mechanism of occurrence.
- Can damage liver and kidney.
- May lead to “hepatotoxicity” or “nephrotoxicity”.
- Use agents that have very low metabolites to prevent kidney or liver disease.
<table>
<thead>
<tr>
<th>Agent</th>
<th>% Recovered as Urinary Metabolites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halothane</td>
<td>20.00 %</td>
</tr>
<tr>
<td>Sevoflurane</td>
<td>5.00 %</td>
</tr>
<tr>
<td>Ethrane</td>
<td>2.00 %</td>
</tr>
<tr>
<td>Isoflurane</td>
<td>0.20 %</td>
</tr>
<tr>
<td>Desflurane</td>
<td>0.02 %</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>0.004 %</td>
</tr>
</tbody>
</table>
Compound A

• Sevoflurane decomposes in CO2 absorbents to Compound A
• In rats, kidney damage occurs if > 50 PPM
• Humans form Compound A a lot less than rats
• Renal effects in humans is controversial
• More research is needed
Avoiding Compound A Concern

- Potential for damage exists for prolonged sevoflurane anesthesia, especially at higher concentrations and lower FGF rates
- Package insert indicates that it should not be used at a FGF rate of < 1 L/min for more than 2 MAC-hours
- If case is > 2 hours, the FGF rate should be increased to 2 L/min or more
Carbon Monoxide (CO) Toxicity

- Occurs when all IA’s degraded by dry soda lime or baralyme
- Does not occur with fully hydrated absorbents
- Common scenario:
  * Monday morning case and gas has been left on over the weekend, drying the absorbent
Avoiding the problem of CO Toxicity

- Use fresh absorbent
- Use soda lime rather than barium hydroxide
- Use the new CO2 absorbent called “Amsorb”
  - Prevents anesthetic breakdown that would lead to CO formation
- Turn off gas when case complete
Duration of inhaled anesthetics

Terminal Decrement

90% Decrement Time (min)

Enflurane

Isoflurane

Sevoflurane

Desflurane

Duration of Anesthetic Administration (min)

Mask Induction
Pediatric mask induction
Airway irritability

Airway Events During Induction: Desflurane vs Halothane

- Coughing (% of Patients)
  - Desflurane Yes: 78
  - Desflurane No: 91
  - Halothane No: 11

Induction Agent: Desflurane vs Halothane
Premedication: Yes, No

Pediatric maintenance
Airway complications

Maintenance of Anesthesia via Facemask: Desflurane vs Halothane

Airway Complications (% of Patients)

- Desflurane: 0%
- Halothane: 4.3%

Davis et al. Anesthesiology. 1994;80:298.
LMA use in pediatrics

Similar incidence of airway occurrences in both treatment groups
Airway irritability
Sevoflurane vs. Desflurane

Similar incidence of airway occurrences in both treatment groups
Considerations with the pediatric population

Recovery From Desflurane in Children: Emergence Agitation

Davis et al. Anesthesiology. 1994;80:298.
Emergence agitation

Emergence Agitation With Sevoflurane

Emergence Agitation (% of Patients)

- Halothane Preschool Age: 10%
- Sevoflurane Preschool Age: 40%
- Halothane School Age: 15.4%
- Sevoflurane School Age: 11.5%

Aono et al. Anesthesiology. 1997;87:1298.
What Fentanyl Dose May Prevent Emergence Agitation in Children?

- Induction: N₂O, sevoflurane
- Maintenance: N₂O, desflurane 4% to 6%
- Analgesia: fentanyl 1.25, 1.875, 2.8, 4.2 mcg/kg, adjusted by “up-down” technique
- Agitation assessed
- Minimal effective dose to prevent emergence agitation without prolonging emergence time: 2.56 mcg/kg

Effect of Fentanyl Desflurane/Sevoflurane Maintenance: Extubation and Recovery Time

Fast-Track Eligibility After Ambulatory Laparoscopic Surgery

**Table 1**

<table>
<thead>
<tr>
<th>Anaesthetic</th>
<th>Orientation Aldrete Score of 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desflurane</td>
<td>15.7</td>
</tr>
<tr>
<td>Sevoflurane</td>
<td>14.7</td>
</tr>
<tr>
<td>Propofol</td>
<td>11.3</td>
</tr>
</tbody>
</table>

* P<.05 vs. other groups

N=40 per group

Movement during surgery

Percentage of transient movements during surgery

- Desflurane: 5%
- Propofol: 40%
Neurologic Monitor Data: Predictor of Fast-Track Eligibility After Ambulatory Anesthesia?

* P<.05
Total N=60

# Emergence and Extubation: Desflurane vs. Isoforane, Propofol, and Sevoflurane

<table>
<thead>
<tr>
<th></th>
<th>Desflurane</th>
<th>Sevoflurane</th>
<th>Isoforane</th>
<th>Propofol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beaussier et al</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergence (min)</td>
<td>12*</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extubation (min)</td>
<td>16*</td>
<td>33</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Juvin et al</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergence (min)</td>
<td>5.6*</td>
<td>11.5</td>
<td>11.9</td>
<td></td>
</tr>
<tr>
<td>Extubation (min)</td>
<td>6.9*</td>
<td>13.1</td>
<td>9.9</td>
<td></td>
</tr>
<tr>
<td><strong>Nathanson et al</strong>&lt;sup&gt;3&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergence (min)</td>
<td>4.8*</td>
<td></td>
<td>7.8</td>
<td></td>
</tr>
<tr>
<td>Extubation (min)</td>
<td>5.1*</td>
<td></td>
<td>8.2</td>
<td></td>
</tr>
</tbody>
</table>

* P≤.05 vs. other groups

Fast-Track Eligibility: Desflurane vs. Sevoflurane and Propofol

Patients Fast-Track Eligible on Arrival in PACU

Desflurane: 90%
Sevoflurane: 75%
Propofol: 26%*

* P<.05 vs. other 2 groups

Emergence and recovery comparisons

<table>
<thead>
<tr>
<th></th>
<th>Halothane</th>
<th>Sevoflurane</th>
<th>Desflurane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergence (OR)</td>
<td>10</td>
<td>11</td>
<td>*</td>
</tr>
<tr>
<td>Recovery (PACU)</td>
<td>21</td>
<td>17</td>
<td>11</td>
</tr>
</tbody>
</table>
Emergence in Bariatric Patients

- Due to its low tissue & fat solubility, obese patients have less anesthetic agent stored in tissue and fat with desflurane
- Emergence is more rapid
- Recovery is more consistent than propofol or Isoforane

Maybe this is a little more than bariatric surgery
Quicker Bariatric Emergence

- Can move self from OR table
- Less back stress on staff
- Less risk for aspiration
- Less window for nausea
- Less OR time (expensive)
- CRNA “looks good”
- Staff feels CRNA is a good practitioner
- Patient feels more awake and can be discharged quicker
Return to Normal Activity

- Group of patients undergoing outpatient gynecological surgery
- Discharge time
  - Sevoflurane compared to Desflurane
  - 3 hrs vs. 3.5 hrs
- Number who returned to normal activity on first postoperative day
  - Sevoflurane compared to Desflurane
  - 15 vs. 29
Recovery of Cognitive Function

- Agents with low solubility will offer quicker wake up & return of cognitive function
- Will allow ability to assess neurological function quicker
- Low solubility agents work well for long cases, the elderly, the obese
Consideration with Other Patients

- The elderly with increased proportions of fat
- The normal-weight patient who is not in shape and probably has increased proportions of fat
- The elderly patient who is also obese
- The pediatric patient who has a large proportion of fat
- Also, consider the obese patient as an older patient due to the stress on his or her organs
Desflurane and older patients

- Lowest solubility of all agents
- High level of stability
- Low degree of metabolism
- Rapid control of anesthetic depth
- Rapid control of hemodynamics
- Enhanced quality of recovery
## Considerations with the geriatric population

### Effect of Aging on MAC of Desflurane

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>100% O₂</th>
<th>60% N₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>9.2% - 10%</td>
<td>7.5%</td>
</tr>
<tr>
<td>1 - 12</td>
<td>8.1% - 9.1%</td>
<td>6.4%</td>
</tr>
<tr>
<td>18 - 30</td>
<td>7.3%</td>
<td>4%</td>
</tr>
<tr>
<td>31 - 60</td>
<td>6%</td>
<td>2.8%</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>5.2%</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

Suprane® (desflurane, USP) prescribing information.
Hemodynamic Effects

Sympathetic Response to Decreased Blood Pressure

Muscle Sympathetic Nerve Activity (% of control)

* P<.05 vs control for same anesthetic
† P<.05 between anesthetics

Heart Rate

![Graph showing the relationship between MAC (minimum alveolar concentration) and heart rate for different anesthetics: Isoflurane-O2, Sevoflurane-O2, and Desflurane-N2O.](image)

Minimizing the Sympathetic Response to Rapid Increases in Desflurane Concentration

• **Increased heart rate and blood pressure**
  • Transient response
  • Does not occur in all patients, less likely in elderly patients
  • Treatment may not be needed due to brief duration
  • Narcotic pretreatment minimizes the response
Recommendations to minimize hemodynamic response

- Consider IV opioids prior to increasing desflurane concentration
- Initial vaporizer setting: 3% to 6% desflurane
- Increments: 1% delivered concentration
- Consider a short-acting beta blocker such as esmolol
Desflurane Maintenance

Desflurane Maintenance: Achieving Surgical Depth

- Delivered desflurane concentration should be gradually increased in 1% increments (at 4-6 L/min flow rate) every few breaths until desired anesthetic depth is reached.

- Fresh gas flow rates may be reduced to 1-3 L/min once adequate anesthetic depth is attained because of the rapid approach of alveolar to inspired concentrations with desflurane.

- Desflurane concentrations of less than 6% rarely produce clinical manifestations of airway irritation or sympathetic stimulation.

- Such effects may be minimized by administering anesthetic adjuvants (eg, N₂O, opioids, or a short-acting beta blocker).

Suprane® (desflurane) prescribing information.
Desflurane Maintenance: Titrating Anesthetic Depth

- When altering anesthetic depth, increase or decrease desflurane concentration in increments of 1% and increase the fresh gas flow rate to 4-6 L/min until the desired anesthetic depth is reached.
Anesthetic titration

- Anesthetic depth can be more rapidly titrated with desflurane than with isoflurane. This allows more rapid control of elevated blood pressure resulting from surgical stimulus.

Desflurane Maintenance: Emergence and the Postoperative Period

Emergence Recommendations

• Perform all airway manipulation and suctioning while patient is adequately anesthetized
• If patient is intubated, consider extubation while patient is adequately anesthetized
• Avoid stimulation during stage II anesthesia
• To minimize or attenuate cough during emergence, administer a small dose of opioid, propofol, or lidocaine
Significance of Rapid Awakening Seen With Desflurane

- Earlier assessment of cognitive function is possible
- Earlier reversal of muscle relaxants should be considered
- Earlier assessment of analgesic needs may be necessary
Attenuating Sympathetic Stimulation With Fentanyl, Esmolol, or Clonidine


* P<.05 vs. control (no drug)
Cardiovascular Effects of Desflurane in Adults: Summary

- Desflurane decreases arterial pressure, systemic vascular resistance, and myocardial contractility, and increases heart rate; these effects are similar to those seen with isoflurane.

- Desflurane and isoflurane produce similar hemodynamic effects during CABG surgery (similar incidence of ischemic events and adverse cardiac outcomes).
Cardiovascular effects summary

- Desflurane may transiently increase blood pressure and heart rate when concentrations are rapidly increased above 1 MAC; opioid premedication can minimize these effects.
- Desflurane may be rapidly titrated, providing faster control of the hemodynamic state compared to isoflurane.
Components of Anesthesia Cost

- Drugs
- Equipment
- Medical personnel
- OR, PACU, and recovery time
  - 1998 OR Cost at Stanford University:
    - OR: approx. $14/min*
    - PACU: approx. $3/min*
  - Today
    - OR: approx. $40/min
    - PACU approx. $20/min

*Cost rounded-off to the nearest dollar
Cost of Inhaled Agents
Results From an Interplay of Factors

- Cost per milliliter of liquid agent
- Volume of vapor from each milliliter of liquid
- Effective potency of agent (concentration that must be delivered from vaporizer to provide appropriate level of anesthesia)
- Background flow of gases
## Cost During Maintenance Phase of Inhaled Agents at 1 L/min FGF

<table>
<thead>
<tr>
<th>Agent</th>
<th>1 MAC* (%)</th>
<th>mL vapor/ min</th>
<th>mL liquid/ min</th>
<th>Cost/mL</th>
<th>Cost/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoforane</td>
<td>0.42%</td>
<td>4.22</td>
<td>0.022</td>
<td>$0.21</td>
<td>$0.27</td>
</tr>
<tr>
<td>Sevoflurane</td>
<td>0.62%</td>
<td>6.24</td>
<td>0.084</td>
<td>$0.76</td>
<td>$3.80</td>
</tr>
<tr>
<td>Desflurane</td>
<td>2.17%</td>
<td>22.18</td>
<td>0.105</td>
<td>$0.37</td>
<td>$2.33</td>
</tr>
</tbody>
</table>

* With 67% N₂O
Crossover technique

Switching From Isoflurane to Desflurane

* P<.01 vs crossover and isoflurane

Neumann et al. Anesthesiology. 1998;88:914.
So what is the ideal recipe for delivery of an inhaled anesthetic?

- Rapid and smooth induction
- Use a potent inhaled anesthetic with low solubility that provides amnesia
- Use low inflow rates
- Economical
- Maintains normothermia
Recipe cont’d

- **Desflurane vs. Sevoflurane vs. Isoflurane**
  - Sevoflurane may be less economical in longer cases because should not use low inflow rates (<1 L/min) for more than 2 hours

- **Neuromuscular blockade**

- **Rapid awakening**
  - Lower solubility $\rightarrow$ faster wakeup

- **Incidence of PONV/PDNV**
Recipe cont’d

• Postoperative pain
  • Less rapidly eliminated inhaled anesthetics may actually cause hyperalgesia at ~ 0.1 MAC and increase the perception of postoperative pain
Thanks and have a great summer!