MAC & Awareness

Minimum Alveolar Concentration

Alveolar concentration of a gas at which 50% of subjects do not respond to surgical incision

Important Points
- Remarkably consistent across species.
- MAC is a population average; not a true predictor of an individual’s response.
- MAC is an ED$_{50}$ concentration. The ED$_{95}$ is ±25%, so at 1.3 MAC, 95% of patients will not respond to incision.
- MAC values are additive (e.g. 0.5 MAC isoflurane + 0.5 MAC N$_2$O = 1 MAC)

MAC of Inhaled Anesthetics

<table>
<thead>
<tr>
<th>Gas</th>
<th>Blood:Gas Partition Coefficient</th>
<th>MAC*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halothane</td>
<td>2.4</td>
<td>0.75%</td>
</tr>
<tr>
<td>Enflurane</td>
<td>1.9</td>
<td>1.7%</td>
</tr>
<tr>
<td>Isoflurane</td>
<td>1.4</td>
<td>1.2%</td>
</tr>
<tr>
<td>Sevoflurane</td>
<td>0.65</td>
<td>2.0%</td>
</tr>
<tr>
<td>N$_2$O</td>
<td>0.47</td>
<td>104%</td>
</tr>
<tr>
<td>Desflurane</td>
<td>0.42</td>
<td>6.0%</td>
</tr>
</tbody>
</table>

*MAC values for adults 36-49 years old

- **MAC** is an indicator of gas potency.
- The blood:gas partition coefficient is an indicator of solubility, which affects the rate of induction and emergence; it is NOT related to MAC.

More MAC Definitions

MAC-Awake (a.k.a. MAC-Aware)
- The MAC necessary to prevent response to verbal/tactile stimulation.
- Volatiles: ~0.4 MAC; N$_2$O: ~0.6 MAC

MAC-BAR
- The MAC necessary to “blunt the autonomic response” to a noxious stimulus
- ~1.6 MAC

MAC-EI
- The MAC necessary to prevent laryngeal response to “endotracheal intubation”
- ~1.3 MAC

Question: If desflurane is less soluble than N$_2$O, why do patients wake from N$_2$O faster than from desflurane?
Effect of Age on MAC

MAC is highest at 6 months, then begins to decline. After age 40, MAC declines ~6% per decade; MAC for an 80 year old is about 0.75 that of a 40 year old.

Factors Increasing MAC
- Drugs increasing central catecholamines:
  - MAOIs, TCAs
  - Acute cocaine and amphetamine use
  - Ephedrine
  - Levodopa
- Hyperthermia
- Hypernatremia
- Chronic EtOH abuse
- Genetic factors
  - Redheaded females have a 19% increased MAC requirement compared to brunettes.

Factors Decreasing MAC
- Drugs decreasing central catecholamines:
  - Reserpine, α-methyldopa
  - Chronic amphetamine abuse
- Other drugs:
  - Opioids, benzodiazepines, barbiturates, α₂-agonists (clonidine, dexamethasone), ketamine, lidocaine, lithium, verapamil, hydroxyzine.
- Acute EtOH intoxication
- Pregnancy (after 8-12 weeks gestation)
- Hypothermia (\(^{\circ}\)50% per 10°C)
- Hypotension (MAP<40 in adult)
- Hypoxemia (\(P_bO_2 < 38 \text{ mm Hg}\)) or hypercarbia (\(P_bCO_2 > 95 \text{ mm Hg}\))
- Hyponatremia
- Metabolic acidosis
- Anemia (Hct < 10%)

Awareness
- Very rare
- Most common sensation is hearing voices
- Mostly occurs during induction or emergence
- More common in high-risk surgeries where deep anesthesia may be dangerous to an unstable patient (e.g. trauma, cardiac, cesarean section)
- Early counseling after an episode is very important
- Patient handout available at: www.asahq.org/patientEducation/Awarenessbrochure.pdf
### Signs of Light Anesthesia

- Increase in HR or BP by 20% above baseline
- Tearing
- Dilated pupils
- Coughing or bucking
- Patient movement
- Signs of consciousness on EEG monitor (Bispectral Index or Patient State Index)

### BIS & PSI

- Both use EEG monitoring and algorithms to produce numbers (0-100) relating to depth of anesthesia.
  - 65-85 = sedation
  - 40-65 = general anesthesia
  - <40 = too deep
- Both have been shown to be fairly good predictors of loss and regaining consciousness
- Interpatient variability exists
- Both have a noticeable time lag
- BIS is affected by electrocautery more than PSI

### Management

**If you suspect your patient may be aware:**

- Immediately **deepen** the anesthetic with fast-acting agents (e.g. propofol).
- Talk to the patient, **reassure** them that everything is OK (hearing is the last sense to be lost).
- Consider a benzodiazepine for amnesia.
- Talk to the patient after the case to assess if they had any awareness.
- Set up counseling if necessary.
- Contact Risk Management (potential lawsuit?)

### References