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_2O = 1 MAC)

MAC of Inhaled Anesthetics

Gas	Blood:Gas Partition Coefficient	MAC*
Halothane	2.4	0.75%
Enflurane	1.9	1.7%
Isoflurane	1.4	1.2%
Sevoflurane	0.65	2.0%
N_2O	0.47	104%
Desflurane	0.42	6.0%

*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_2O: ~0.6 MAC

MAC-BAR

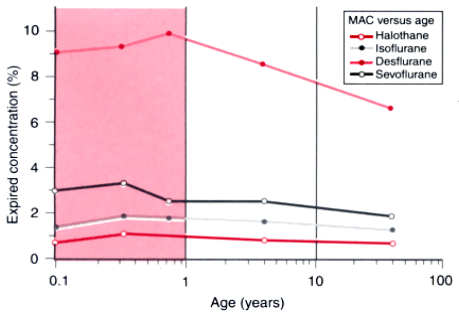
- The MAC necessary to "blunt the autonomic response" to a noxious stimulus
- ~1.6 MAC

MAC-EI

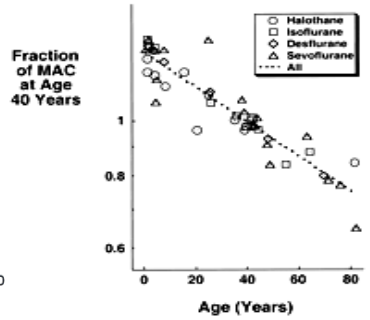
- The MAC necessary to prevent laryngeal response to "endotracheal intubation"
- ~1.3 MAC

Question: If desflurane is less soluble than N_2O, why do patients wake from N_2O 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, α_2-agonists (clonidine, dexmedetomidine), ketamine, lidocaine, lithium, verapamil, hydroxyzine.
- Acute EtOH intoxication
- Pregnancy (after 8-12 weeks gestation)
- Hypothermia (↓50% per 10˚C)
- Hypotension (MAP<40 in adult)
- Hypoxemia (P_aO_2 < 38 mm Hg) or hypercarbia (P_aCO_2 > 95 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 consciouness 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

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