

Hypothermia & Shivering

Definition and Measurement

- Hypothermia is defined as a core body temperature less than 36 degrees C
- Temperature is measured from:
 - Nasopharynx (accurately reflects core temp, but can cause epistaxis)
 - Tympanic Membrane (reflects brain temp, but can cause perforation of ear drum)
 - Esophagus
 - Bladder
 - Rectum (slow response to changes in core temp, contraindicated in neutropenic pt, fistula, etc.)
 - Skin (variable accuracy depending on skin perfusion)
 - Thermistor of Pulmonary Artery Catheter

Thermoregulation

Afferent Thermal Sensing

- Thermal inputs travel along A-delta (cold) and C fibers (warm) via the spinothalamic tract.
- Input comes from the skin, deep abdominal & thoracic tissues, spinal cord, brain, and hypothalamus (roughly 20% each).

Central Control

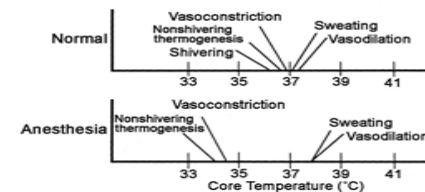
- Thermal inputs are “preprocessed” at numerous levels within the spinal cord and brainstem.
- Modulated by NE, DA, 5-HT, ACh, PGE, and neuropeptides.
- The preoptic-anterior hypothalamus is the central autonomic thermoregulatory center.

Efferent Responses

- Behavioral responses (shelter, clothing, voluntary movement, etc) are most important and are determined by skin temperature.
- Autonomic responses (skin vasomotor activity, nonshivering thermogenesis, shivering, and sweating) are ~80% determined by core temperature.

Interthreshold Range

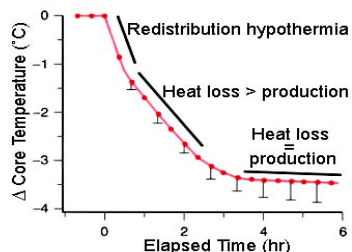
- Interthreshold Range = tight thermoregulatory range between cold-induced and warm-induced responses, usually ~0.2°C.
- General anesthesia inhibits thermoregulation and increases the interthreshold range ~20-fold, to ~4°C.
- Regional anesthesia inhibits thermoregulation to lower half of body, increasing the range ~4-fold, to ~0.8°C.



Development of Hypothermia

Anesthetic-impaired thermoregulation

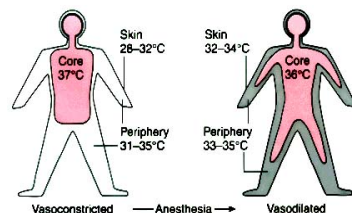
1. Redistribution hypothermia
2. Heat loss > heat production
3. Heat loss = heat production (steady-state heat balance)



Heat transfer to cold OR (in order of importance)

1. Radiation
2. Convection
3. Evaporation
4. Conduction

Redistribution Hypothermia



Benefits of Hypothermia

- Tissue metabolic rate decreases ~8% per 1°C decrease in body temperature.
- CNS protection from ischemic and traumatic injuries.
- Improves neurologic outcomes after cardiac arrest.
- Some protection against malignant hyperthermia.
- Cardiac Protection as decreased metabolic and O2 requirement.

Consequences of Hypothermia

- Increased myocardial morbidity (3x)
- Impaired coagulation (especially platelets), increased blood loss, & increased transfusion rates
- Increased infection rate (3x)
- Prolonged duration of drug action, delayed emergence
- Left-shifts O₂-Hb curve
- Increased SVR
- Difficulty monitoring patient (e.g. S_pO₂)
- Delays wound healing & jeopardizes grafts
- Altered mental status
- Increased sympathetic activity/stress response
- Increased postoperative shivering
- Prolonged PACU stay

Warming Strategies

Prevention of hypothermia is more effective than treatment!

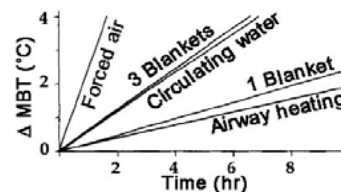
Active Warming

- Forced air (Bair Hugger)
- Circulating warm H₂O pad
- Radiant heat lamps
- IVF warmer
- Airway heating & humidification
- Warm the OR temperature

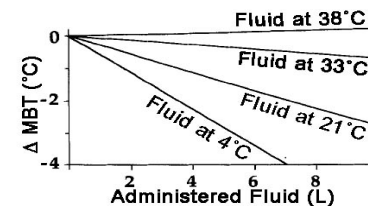
Passive Insulation (not as effective)

- Cotton blankets
- Surgical drapes
- Space blanket (silver plastic)

Effect of Warming Strategies



Effect of IVF Warming



Etiology of Postop Shivering

Intraoperative hypothermia (duh!)... *however...*

- Shivering does NOT always occur in hypothermic patients, and...
- Shivering DOES occur in normothermic patients

Other possible etiologies:

- Recovery from volatile anesthetics
- Pain may facilitate shivering-like tremor
- Fever increases the thermoregulatory set point causing shivering in normothermic patients.

Consequences of Shivering

- Increased O₂ consumption
 - Can be up to a 400-500% increase
- Increased CO₂ production and V_E
- Increased incidental trauma
- Increased intraocular and intracranial pressures
- Uncomfortable and/or painful
- Stresses wound edges
- Disrupts monitoring (e.g. NIBP, EKG, S_pO₂)

Rates of MI do NOT correlate with shivering!

Treatment of Shivering

1. Skin surface warming and passive insulation
2. Pharmacologic:
 - Meperidine 12.5-25 mg IV
 - Muscle relaxants (only in asleep, ventilated patients)

References

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- Sessler DI. Temperature monitoring. In Miller RD (ed), *Miller's Anesthesia, 6th ed*. Philadelphia: Elsevier Churchill Livingstone, 2005.
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