Hypothermia Overview

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YOU HAVE ASKED...

What is best way to treat hypothermia?

THE EXPERT SAYS...

Thermoregulation occurs when temperature variations detected by thermal receptors in peripheral (eg, skin, extremities, and subcutaneous tissues) and core zone (eg, brain, heart, and great vessels) regions are transmitted to the posterior hypothalamus via the spinal cord to maintain thermal homeostasis. Thermal homeostasis is further achieved by modifying the flow of blood to organs, viscera, and skin via vasoconstriction or vasodilation.[1,2] Layers of skin, subcutaneous fat, and hair are involved with thermoregulation.

While frostbite is considered a form of local hypothermia, generalized forms of hypothermia can be severe and life-threatening. Heat loss occurs in 2 stages. In stage 1, internal heat is shifted from the core to the skin. In stage 2, heat is ultimately lost or transferred to the environment by conduction, convection, radiation, or evaporation.[1-4]

- **Conduction** occurs when heat is transferred away from the body by direct contact from a warmer object to a cooler object (eg, stainless steel table) or surface (eg, electrocautery plate).
- **Convection** is the "wind chill" effect; it is influenced by air and/or fluid flow within the environment.
- **Radiation** occurs via passive dissipation of heat through air or space into the environment. Approximately 70%

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of heat loss is due to radiation and convection.[1-2,5]

- Evaporation heat loss occurs from respiration, sweating, open body cavities, or surgical prep solutions (eg, alcohol or scrub solutions.)[5-6]

Patient temperatures can be obtained via rectal, oral, axillary or tympanic routes, but tympanic membrane measurements are most accurate due to the shared blood supply between the middle ear and the hypothalmus.[4]

Causes of Hypothermia

Primary (accidental) and secondary causes of hypothermia are seen in veterinary patients. *Primary* causes may include ice water immersion or exposure to frigid environments, and *secondary* hypothermia may be attributed to diseases such as hypothyroidism, hypoadrenocorticism, renal failure, cardiac disease, hypotension, or shock.

The ability to thermoregulate may also be impacted by the patient's size and/or age.[7,8] Smaller patients are at the greatest risk for hypothermia due to their surface-to-mass ratio. Moreoever, neonates are normally hypothermic (when compared with adults) until about 4-7 weeks of age (see ***Normal Rectal Temperature of Neonates***).[7] Changes in relative fat-to-muscle mass, decreased basal metabolic rate, and age-related blunting of thermoregulatory function can occur in geriatric patients.[8,11]

Anesthesia-induced hypothermia is common.[5] Except for some adult Nordic breeds (eg, Samoyed, Siberian husky, Alaskan malamute), almost all anesthetized or sedated patients lose body heat under general anesthesia.[4,6]

Most heat loss occurs within the first 20 minutes of general anesthesia (see ***Causes of Anesthesia-Induced Hypothermia***).[9] For every 1ºC (1.8ºF) decrease in body temperature, there is

NORMAL RECTAL TEMPERATURE OF NEONATES[8]

- Newborn: 36-37°C (96.8-98.6F)
- 1 month: 38°C (100F)

CAUSES OF ANESTHESIA-INDUCED HYPOTHERMIA[5-6, 9-10]

- Loss of thermoregulatory compensation mechanisms
- Cooler ambient operating room temperature
- Noninsulated (stainless steel) induction tables
- Bypass of nasal warming of inspired gases caused by tracheal intubation
- Administration of drugs (eg, acepromazine) and inhalant anesthetics that cause vasodilation
- Use of cool, dry anesthetic gases
- Removal of protective layer of insulation due to surgical clipping
- Surgical prep solutions (eg, alcohol or alcohol-based surgical antiseptics)
- Evaporation of surgical preps or other fluids soaking the hair coat and body surfaces
- Prolonged anesthesia or surgical procedures
- Open body cavities

Hypothermia can cause decreased cardiac output, increased risk of arrhythmia, hypoxia, suppression of immune function, and reduced tissue perfusion.

HYPOTHERMIA PREVENTION STRATEGIES

- Work efficiently to minimize overall induction and anesthesia times.
- Prewarm surgical prep solutions.
- Avoid overly wetting the patient with surgical prep solutions.
- Increase thermostat settings in preoperative areas, the operating room, and recovery wards.
- Place warmed towels, blankets, or other articles of clothing around the patient throughout perioperative period.
- Use insulated or heated operating room tables or warm water blankets, BAIR Huggers (solutions.3m.com), or HotDog Warmers (vetwarming.com) placed on top of and below the patient, in the operating room suite.
- Wrap exposed extremities with baby socks, cellophane, bubble wrap, or warming blankets.
- Heat IV fluids with the use of IV fluid line warmers placed as closely as possible to the intravenous catheter.
- Heat intraoperative lavage fluids using commercial fluid warmers.
- One study demonstrated that abdominal lavage fluid warmed to 43.3°C (111.0°F) and left inside the abdomen for 2-6 minutes increased the patient's temperature from 34.4°C to 36.1°C (94.0°F to 97.0°F)[5]
- Use low flow anesthesia techniques.
- Use Humid-Vent adapters (jorvet.com) and coaxial (F-circuit) wye hoses.
- Promptly dry excess moisture or lavage spilled onto patient's hair coat.

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a 5% decrease in minimum alveolar concentration (MAC) requirements.[3-4]

Adverse Effects

With few exceptions, almost every major organ and system is adversely affected by hypothermia. Hypothermia can cause decreased cardiac output, increased risk of arrhythmia, hypoxia, suppression of immune function, and reduced tissue perfusion.[4,6]

Decreased hepatic metabolism results in delayed drug clearance, which can prolong anesthetic recovery and/or increase potential drug toxicities.[2,4,5-9] Hypothermia-induced GI hypomotility, coagulopathies, and suppressed immune function lead to increased infection rates and delayed wound healing.[2-5] The net effect of hypothermia is increased morbidity and mortality.[6]

When vasoconstrictive efforts by the body fail to mitigate heat loss and maintain core temperature, heat production is augmented via increasing muscle tone and shivering.[2] Shivering is effective in restoring body temperature but can be uncomfortable and is associated with a significant increase in metabolic oxygen demand (40% to >200%).[3] In addition, metabolic aberrations due to shivering are associated with glycogen storage depletion, which can prove detrimental to hypoglycemic patients or fasted neonates.

Prevention of hypothermia is as essential as the treatment of it. Fortunately, there are myriad ways to prevent anesthesia-induced hypothermia in the veterinary hospital (see ***Hypothermia Prevention Strategies***).

Treating Hypothermia

Passive external rewarming, active external rewarming, and active core rewarming are the 3 techniques for rewarming patients.[11] (see ***Rewarming Methods***)

REWARMING METHODS

- **Passive external rewarming (PER)** techniques are used to treat mild hypothermia. PER candidates must be able to generate endogenous heat (eg, shiver) to be effective.[2,5] PER is the slowest method of rewarming.[2]
  - Examples include:
    —placing patient in warm environment
- Using towels, blankets, or articles of clothing (eg, sweaters) to facilitate rewarming.

- **Active external rewarming** (**AER)** requires the use of external heat sources.[2,5] At least 60% of the body surface area must be in contact with the external heat source for rewarming efforts to be most effective ***(Figure 2)***.[4]
  - Convection-type warm air devices (eg, BAIR Huggers) and electrically conductive fabric warmers (eg, HotDog Warmer).[4,12]
  - Circulating warm water blankets.
  - Warm water baths.[2,5]

- **Active core rewarming** (**ACR)** is the most rapid method of rewarming. ACR involves invasive core-warming techniques; it is reserved for patients with severe hypothermia. Severely hypothermic patients should be treated with combined AER and ACR methods.[2]
  - Warmed, humidified, inhaled oxygen (40°C [104.0°F] to 42°C [107.6°F])
  - Warmed peritoneal, thoracic, gastric, rectal, or urinary bladder lavage
    – The efficacy of warmed gastric, rectal, or bladder lavage has not been well documented.[2]
    – Warm fluid enemas will preclude the use of a rectal thermometer.[5,13]
  - Esophageal warmers[13]
  - The efficacy of IV fluid warmers (eg, warmer) is greatly dependent on the fluid rate and volume administered.

▲ At least 60% of the body surface area must be in contact with the external heat source for rewarming efforts to be most effective.

REWARMING PRECAUTIONS[4,6,14]

- For rewarming efforts to be effective, hypothermic patients must possess the ability to transfer externally applied heat into their core regions. This ability will be impaired in debilitated patients with poor peripheral perfusion (eg, DIC, severe hypotension, hypoalbuminemia, shock), which can increase the likelihood of thermal burns.

- Use of a microwave to heat rice bags or socks, reusable plastic discs, water bottles, water-filled latex gloves, lavage, or IV solutions has been associated with an increased risk of thermal burns and is not recommended.

- Commercially available wire electric heating pads and heat lamps have also been associated with thermal injury and/or electrocution and should be avoided.

- Any equipment or device, when used inappropriately or in conflict with the manufacturer's instructions, is capable of causing inadvertent burns to the patient.

An "after-drop" occurs due to a large temperature gradient created by colder peripheral blood being transferred to the relatively warmer core, which can decrease the body's core temperature. Therefore, warming the torso region while the (cooler) extremities remain vasoconstricted can be advantageous (see ***Rewarming Precautions***).[2]

Step-down rewarming efforts should be used as the patient's temperature approaches normal to avoid rebound hyperthermia, especially in cats and small dogs.[2,5,13] Monitor the temperature of hypothermic patients every 30 minutes.[5,13]

Combating hypothermia should be paramount for every hospitalized patient; it is easy, non-invasive, inexpensive, and a vital component of providing good patient care.

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