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Warming the Patient



Hypothermia is defined as a lowering or decrease in body temperature below 99°F (37°C).¹ Heat can be lost by a variety of mechanisms, including convection, conduction, radiation, and evaporation.²

Convection refers to heat transfer from the body surface into the surrounding environment. Conduction refers to the loss of heat from the body to cooler surfaces that are in contact with the body. Radiation occurs when heat is exchanged from the body to objects that are not in contact with it. Evaporation decreases body temperature when warm water droplets from the respiratory tract, skin, or open body cavities are expelled into the air and dissipate heat. While some of the mechanisms are useful when environmental temperature is high, the same protective mechanisms can also cause hypothermia.

Primary hypothermia is a lowering of core body temperature secondary to extremely low environmental temperature, such as that observed during cold water near-drowning or lack of appropriate shelter.² Secondary hypothermia is a lowering of core body temperature due to other causes, such as toxins, anesthetic agents that cause peripheral vasodilation, central nervous system disorders, endocrinopathies (eg, hypothyroidism), cardiac disease, sepsis, or immobilization.^{2,3} Extremely small, young, aged, or cachectic animals are at particular risk for hypothermia because of a lack of thermoregulating abilities, increased ratio of body surface area to mass, and lack of adapting behavioral mechanisms (eg, shelter- and warmth-seeking).²

One of the most common causes of secondary hypothermia in the clinical setting is

anesthesia/surgery. Hypothermia can result in

- impaired immune function
- coagulopathies
- cardiac dysrhythmias
- hypoventilation
- metabolic acidosis
- respiratory acidosis
- depressed mentation, and
- increased incidence of postoperative infections.⁴

Although primary hypothermia usually is accidental or due to neglect, secondary hypothermia can often be prevented in the clinic setting. In this article I discuss recognition of and methods to prevent hypothermia and allow rewarming.

Severity of Hypothermia

Hypothermia is often classified according to the magnitude of decrease in core temperature below normal. For adult dogs and cats, normal body temperature ranges from 100.5° to 102.5°F (38° to 39°C). For puppies and kittens, the normal body temperature is lower. For primary hypothermia, the classification scheme in the **Table** applies.

With secondary hypothermia, adverse consequences of hypotension, bradycardia, inappropriate mentation, central nervous system depression, and asystole can occur at temperatures that range from less than 92° to 98°F (33° to 37°C).^{2,4} When anesthetic drugs are administered, body temperature decreases rapidly by more than 1°F during the first hour, followed by

Classification of Hypothermia

Degree of Hypothermia	Temperature
Mild	90° – 99°F (32° – 37°C)
Moderate	82° – 90°F (28° – 32°C)
Severe	68° – 82°F (20° – 28°C)
Profound	< 68°F (< 20°C)

a linear decrease over time.¹ Anesthetic drugs cause vasodilation, which contributes to conductive and convective heat loss, and they also suppress shivering reflexes and depress hypothalamic thermoregulatory mechanisms. A significant amount of evaporative cooling also occurs with condensation in the anesthetic circuit and opening of body cavities during surgery. For these reasons, the anesthetized animal is at particular risk for the development of significant hypothermia. Prevention of hypothermia is therefore crucial in animals undergoing anesthesia and surgery. When hypothermia does occur, a variety of methods can be used to rewarm the patient in a careful, safe, and controlled manner.^{5,6}

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Application of Patient Warming

Rewarming occurs through passive and active mechanisms. *Passive rewarming* is simple, and prevents further heat loss through placement of blankets over the animal and between the animal and the floor or cage. Wrapping bubble wrap or plastic wrap over the animal's paws is a passive means to help minimize heat loss from the footpad surface during anesthesia and surgery. *Active rewarming* increases the temperature of the air and surface around the animal. Forced warm air blankets (Bair Hugger, Arizant Healthcare, www.bairhugger.com/arizanthealthcare/faw.shtml), circulating warm water blankets or tablets, warmed intravenous fluid bags, and warm water bottles can be used for active rewarming, provided that caution and careful monitoring are exercised (**Figure 1**).

The aggressiveness of patient rewarming depends largely on the cause and degree of hypothermia. If an animal presents emergently with moderate to severe primary hypothermia, passive and active rewarming should be considered. As a general rule of thumb, core body temperature should be raised approximately 1°F per hour.¹ When an animal's core body temperature is below 97°F (36°C), too-rapid rewarming can be complicated by ventricular dysrhythmias and metabolic derangements that increase morbidity and mortality.

Iatrogenic Heat Loss Prevention

In the clinic setting, prevention of hypothermia should start when premedication drugs are given before anesthesia. Blankets can be placed on the cage floor and over the animal. Heated cages (Snyder Manufacturing, www.snydermfg.com) and circulating warm water tablets (Gaymar T-Pump, Med1online, www.med1online.com) (**Figure 2**) are available to house the animal in a warmed environment.

Once the animal has been placed under general anesthesia, warmed intravenous fluids should be administered to prevent cooling throughout the



Postoperative patient in a warming incubator with adjunctive active and passive rewarming interventions. Note the forced warm-air blanket (Bair Hugger), towels and blankets above and below patient, and the warmed bag of intravenous fluids adjacent to the animal. Once the animal became normothermic, active rewarming measures were removed, and it was moved to a cage with a padded blanket.

entire anesthesia and surgery period. Isotonic crystalloid fluids can be warmed to body temperature in a warming incubator (Lab-line incubator, MidAtlantic Diagnostics, www.midatlanticdiagnostics.com) or in a microwave oven before administration. Open body cavities should be lavaged with warmed (104°F [40°C]) sterile saline before closure.

Postoperatively, the patient can be placed in a warming incubator with a combination of warmed bags of crystalloid fluids wrapped in towels placed next to the animal, forced warm air blankets over the animal, and circulating warmed water tablets under the animal (**Figure 1**). For very small neonatal or toy breed animals, hot water can be placed in a plastic food tub wrapped in a thick plastic bag. The animal can be placed on a towel over this "warm water bed" for rewarming. Once the patient's body temperature has risen to 99°F (37°C), the active rewarming measures can be removed to avoid rebound hyperthermia. Rebound hyperthermia

is a term used to describe overshooting a normal body temperature after rewarming a hypothermic animal. Body temperature should be evaluated every 30 minutes until the animal is normothermic.

Core Rewarming

Core rewarming is more aggressive and invasive, but can be life-saving when profound hypothermia exists. Profound hypothermia is most often seen with primary hypothermia, but can occur in the clinic setting with prolonged anesthesia and surgical or dental procedures. When body temperature falls below 92°F (33°C), core rewarming should be considered. Core rewarming can be performed by instilling warm water enemas, infusing warm water into the urinary bladder with a urinary catheter, or peritoneal or pleural lavage. Physiologic crystalloid fluids, such as lactated Ringer solution, 0.9% saline, or Normosol-R (Hospira, www.hospira.com) can be heated in a microwave to 104° to 108°F (40° to 42°C). Before the warmed bag of fluids



2 Warm circulating water tablet. This device can be placed on a surgery or dental table or in a cage to provide warmth. In all cases, a blanket or towel should be placed between the animal and the circulating water device for protection against burn injury.

is placed next to a hypothermic animal, the temperature of the fluid is measured with a rectal thermometer placed next to the bag of fluids. The fluid is then infused into the patient.^{1,2,7}

To perform peritoneal lavage, clip and scrub the patient's abdomen as if preparing for an exploratory laparotomy. Cut side ports into an over-the-needle intravenous catheter (18- to 20-gauge, depending on the size of the animal), and insert it just adjacent to the umbilicus. The warmed fluid is infused into the catheter by using a length of intravenous fluid tubing attached to a 3-way stop-cock. Infuse warmed fluid, 10 to 20 ml/kg body weight, and allow the fluid to dwell within the abdominal cavity for 10 minutes. Remove as much of the fluid by using a syringe attached to the 3-way stop-cock. The infusion and subsequent drainage should be repeated 4 to 6 times.¹ During active rewarming, intravenous crystalloid and colloid fluids should also be administered to treat hypotension and shock.^{1,8}

Complications of Rewarming

Unfortunately, one of the more common complications of rewarming is thermal burns (**Figure 3**).⁹ Because heating pads provide an unreliable

heat source and can result in significant thermal injury to the animal, they should never be used. If crystalloid fluid bags are microwaved, their temperature should be tested with a rectal thermometer placed directly adjacent to the fluid bags before they are placed next to the hypothermic animal. Always wrap the fluid bag in a towel to prevent excessive heat in direct contact with the animal's skin. Once the fluid within the bag or hot water bottle has dropped to body temperature, it can act as a source of conductive heat loss and should be rewarmed as necessary.

Rewarming Shock

Rapid rewarming can result in a phenomenon known as "rewarming shock."^{1,2} Overzealous rapid rewarming causes severe peripheral vasodilation and relative hypovolemia, with hypotension. Although there is the inclination to administer large volumes of crystalloid and colloid fluids, their administration can result in intravascular and interstitial volume overload that can cause pulmonary edema.¹ More conservative volumes (ie, 10 ml/kg in a cat, 20 ml/kg in a dog) of intravenous fluids should be administered until the patient is normothermic.

Afterdrop

"Afterdrop" is a phenomenon in which an animal's body temperature continues to decline despite the start of rewarming measures.^{1,2} Severe peripheral vasoconstriction occurs as a result of hypothermia. As the animal's core body temperature increases toward normal, the hypothermia-induced vasoconstriction resolves, and cooler blood from the periphery returns to circulation and is exchanged with the warmer blood from the animal's core. During this time, core body temperature can actually drop in the face of active rewarming interventions.^{1,4}

Monitoring

The hypothermic patient is at particular risk for acid-base and electrolyte derangements, cardiac dysrhythmias, and hypotension. Acid/base status, electrolytes, ECG, and blood pressure should be assessed throughout and after the rewarming process. If hypothermia exists secondary to



3 Thermal burns from an electric heating pad sustained during a routine spay. Electric heating pads are a common source of thermal burns, and should never be used for prevention of hypothermia or for rewarming purposes.

anesthesia and surgery, more conservative monitoring can be performed after the patient becomes normothermic and the anesthetic drugs have been metabolized. More aggressive monitoring should be instituted with primary hypothermia, or with secondary hypothermia that has resulted from an underlying illness, such as sepsis.

In General

Anticipation and prevention of hypothermia should be considered in any hospitalized animal, particularly those that require anesthesia and surgery. Active rewarming equipment is available commercially or can easily be adapted from supplies currently available at most veterinary hospitals. Caution must be exercised to prevent thermal burns. Metabolic and cardiac derangements should be treated as they occur. With the therapeutic measures described, severe hypothermia secondary to anesthesia and surgery can be avoided, and management of the patient with primary hypothermia can be successful. ■

See Aids & Resources, back page, for references, contacts, and appendices.

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