Hypothermia - “The Big Chill”

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Small veterinary patients commonly lose heat when anesthetized but the negative impact of this is greatly underestimated. Maintaining body temperature within a narrow range is important for cardiac function, metabolism, normal enzyme activity, nerve conduction, and haemostasis.

Thermal balance

Homeothermy, a balance between heat loss and heat gain involves complex sensing mechanisms that drive the mechanisms controlling heat loss or gain in the correct direction. Heat gains can be obligatory or facultative. Obligatory gains occur independently of thermoregulation and include heat from basal metabolism, eating and exercise. Facultative gains act to restore thermal balance and the most important source is from shivering.

Three-quarters of heat loss occurs from the body surface and the remainder is lost from the respiratory tract. Losses occur through convection (transfer of heat from the animal to the air), conduction (transfer of heat from the animal to a surface that is cooler), evaporation (heat dissipated by evaporation of moisture from wet skin or the respiratory tract) and radiation (exchange of heat between the body and objects in the environment).

Temperature sensors exist centrally (hypothalamus, spinal cord, brain stem, abdominal organs and skeletal muscles) and peripherally (warm and cold receptors in the skin). The hypothalamus acts by integrating thermal input and controlling effector organs; in many ways acting as a thermostat.

Anaesthesia and thermoregulation

When an animal is anesthetized many factors interrupt normal thermoregulation. Anaesthesia abolishes behavioural responses (the animal cannot seek out a warm environment), reduces metabolic rate, alters hypothalamic function, reduces muscle tone and effector responses (shivering). In addition theatre environments and surgical procedures impose large thermal stresses on patients.

Under general anaesthesia there is wider range of core temperature where the animal does not respond to maintain normothermia. Vasoconstriction can occur in anesthetized patients and although it may slow down the rate of heat loss it has a negative effect on tissue perfusion. However this reflex will be counteracted if vasodilating agents such as acetylpromazine or isoflurane are used.

The greatest amount of heat is lost immediately after induction and during the first 20 minutes of anaesthesia due to redistribution of heat from the core to periphery. Heat continues to be lost after the initial steep drop but at a lower rate. There is also an increase in the difference between core (oesophageal) and peripheral (rectal) temperature over time. The smaller the animal the greater its body surface area: weight ratio and the more prone it is to hypothermia. When no attempt was made to preserve body heat, dogs and cats weighing < 10 kg dropped below their normal temperature by 3.4°C after one hour of anaesthesia (1). The severity of hypothermia is also influenced by the environmental temperature, duration of anaesthesia, and exposure of body cavities.

Measuring temperature

Ideally core temperature should be monitored with a probe placed in the oesophagus or on the tympanic membrane. Rectal temperature reflects the peripheral temperature and this lags behind core temperature changes, giving a falsely high estimate of the animal’s true body temperature.

Negative impact of hypothermia

A drop in core temperature to 34°C is cause for concern. As core temperature falls, the myocardium becomes more irritable and the sino-atrial node beats more slowly. This is in part associated with increases in circulating catecholamines. There is a drop in cardiac output and blood pressure and at subnormal temperatures, atropine and glycopyrrolate are unlikely to correct bradycardia. Changes in cardiac rhythm may be noted and at temperatures approaching 32.2°C asystole or fibrillation may occur.
Fluid shifts result in haemoconcentration, increased blood viscosity and red blood cell sludging. Increased bleeding occurs secondary to prolonged coagulation times and altered platelet function. Tissue perfusion is impaired by hypothermia and shifting of the oxyhaemoglobin curve to the left decreases oxygen unloading. This may be counteracted by the developing metabolic acidosis. Lactate levels rise secondary to poor perfusion and decreased hepatic metabolism. Blood glucose levels may rise and complicate interpretation of laboratory results.

Metabolism is slowed and liver function is impaired, delaying breakdown of anaesthetic drugs which delays recovery. The requirements for inhalant agents drop and if anaesthetic depth is not closely monitored, animals will receive a relative overdose. As a patient cools, the amount of anaesthetic required to produce apnoea decreases and responses to hypercapnia and hypoxia are blunted. In human studies, intra-operative hypothermia has been linked to increased post-operative wound infection. This is a result of poor perfusion to the periphery, vasoconstriction and low oxygen tension at the surgical site. Hypothermia also impairs immune function, including the killing ability of neutrophils. One veterinary study linked wound infection to duration of surgery (2) and there is no doubt that maintaining normothermia is in the best interests of the patient.

Cold animals take longer to recover, shiver and look miserable. Shivering increases their metabolic rate and heat production, but also increases oxygen demand by up to 400%. This, combined with a decreased ventilatory drive can lead to hypoxemia. Pain from the surgical incision is likely to be worse when an animal shivers.

Techniques for maintaining body temperature
Thermal losses should be minimized. Although re-warming is possible in the post-operative period, rapid re-warming can cause vasodilation, which is not well tolerated by some surgical patients.

Suggestions for preventing hypothermia:
- Surgical preparation - avoid cold solutions especially alcohol. Warm sterile saline is a good choice.
- Surgery time should be kept to a minimum
- Ambient temperature - Normal theatre temperatures are often 24-26°C. Warmer temperatures would benefit the patients but may increase discomfort for personnel. The induction and recovery areas should be kept warm.
- Warm inspired gases - this requires specialized anaesthetic equipment. If a circle system is used, low flow anaesthesia minimizes heat loss from the respiratory tract.
- Circulating warm water blankets are effective in small patients (3) and are more effective when placed on the limbs than on or under the trunk (4). Electric blankets must be avoided as severe skin burns can occur in hypothermic animals.
- Forced warm air devices are effective (5).
- Blankets - fleece blankets and thermal insulating blankets can minimize radiation and convective losses.
- Infra-red lamps - great care should be used when using these as skin burns can occur.
- Warm intravenous fluids - when large volumes of fluid are given to patients they should be warmed to minimize thermal stress.

References