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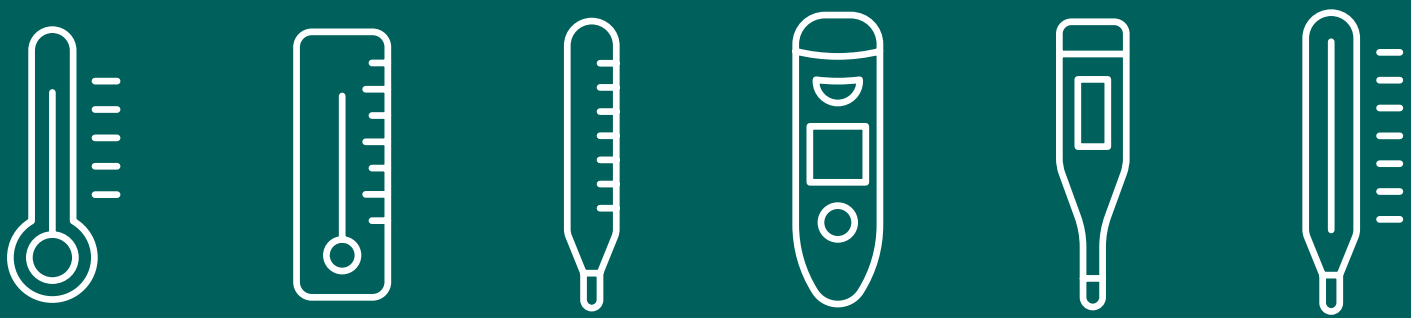

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Reducing the risk of anaesthesia through perioperative temperature management

What influence does good perioperative temperature management have on the risk of anaesthesia in small animal medicine?

In daily practice, general anaesthesia holds a fixed place. However, an important and easily implementable topic is still often given too little attention – perioperative temperature management. Body temperature, as a vital parameter, should be monitored and documented regularly, just like heart rate and oxygen saturation, pre-, intra-, and postoperatively.

One of the most common anaesthesia complications is intraoperative hypothermia, where the core body temperature drops by at least 1 °C below the physiological core temperature for the respective species. This deviation is often overlooked or underestimated, but it can have serious consequences for the patient. Various studies in both human and veterinary medicine have established a link between perioperative temperature management and anaesthesia risk. Poor perioperative temperature management leads to an increased anaesthesia risk. Conversely, well-implemented perioperative temperature management has a positive effect on anaesthesia risk, and patient outcomes can be significantly improved with just a few simple measures.

Normothermia – Why is physiological body temperature crucial?

Small animals and small pets are warm-blooded (homeothermic) animals and must maintain their core body temperature within certain limits depending on the species, in order to sustain vital body functions. Metabolic reactions, as chemical processes, are highly dependent on temperature. Proteins, which are an important component of many body functions, denature at too high a core body temperature (around > 41 °C). Muscle activity is reduced at too low a body temperature, and oxygen transport is also temperature-dependent due to diffusion and the binding affinity to haemoglobin.

Thermoregulation consists of two components. Temperature perception occurs through heat and cold receptors (thermoreceptors), which are found on the skin surface and inside the body, particularly in the spinal cord. The actual regulation is controlled by the hypothalamus. If the hypothalamus detects a drop in core body temperature below the set point (hypothermia), it activates a feedback loop for thermoregulation by releasing TRH (Thyrotropin-Releasing Hormone) and increasing sympathetic tone. This leads to heat production (thermogenesis) and peripheral vasoconstriction (reduced heat loss through the body surface). In the case of a rise above the set point (hyperthermia), a reduction in sympathetic tone leads to peripheral vasodilation (increased heat loss through the body surface) and enhanced sweat secretion (evaporative cooling).

Why is thermoregulation impaired under anaesthesia?

Under general anaesthesia, the lack of muscle activity leads to reduced heat production, resulting in a negative heat balance. This means that heat loss is greater than the body's own heat production. Other causes of perioperative heat loss include losses through the body surface (radiation, convection, conduction, and evaporation) and a disruption of physiological thermoregulation. Since these effects are more pronounced in animals with a large body surface relative to body mass, very small patients such as small mammals, young animals, and dwarf breeds are particularly at risk. Additionally, thermoregulation is still insufficiently developed in newborns.

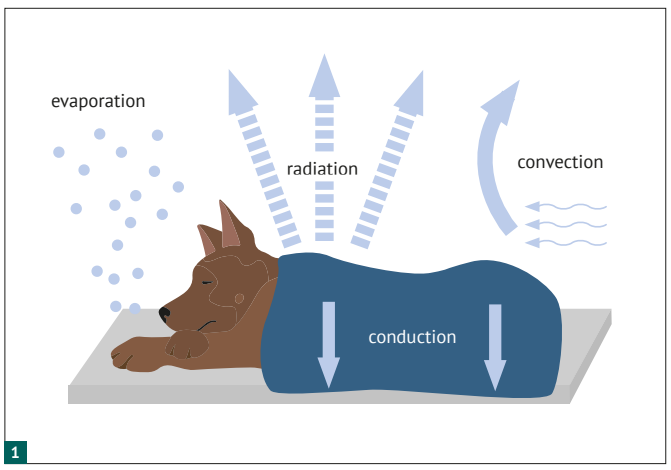


Fig. 1: Heat loss from the body (radiation, conduction, evaporation, convection)

Under anaesthesia, there is a typical three-phase temperature drop

Within the first hour, the core body temperature drops by 1 to 1.5 °C. The cause is known as redistribution, where heat is transferred from the core of the body to the periphery. The core body temperature and the shell temperature approach each other. Even this seemingly small drop is, by definition, considered hypothermia and requires appropriate measures. Subsequently, further heat loss occurs through heat radiation (approximately 60 %), convection (approximately 15 %), evaporation via breathing and skin (approximately 10 – 12 %), and conduction (approximately 3 %), which exceeds the body's heat production. Especially in the first two phases, active perioperative heat management, through measures such as patient insulation (e.g. covering the patient) and active heat supply, has a significant impact. In the final phase, the core body temperature stabilises below the physiological set point.

The drop in core body temperature caused by medications is referred to as secondary hypothermia. It can also be triggered by injuries or diseases and, in the case of anaesthesia, may be further exacerbated by the medication. Common drugs such as isoflurane, propofol, acepromazine, and opioids negatively affect thermoregulation. They delay vasoconstriction, lower the metabolic rate, and lead to a significant reduction or abolition of muscle tone.

Consequences of anaesthesia-induced hypothermia

Hypothermia has serious effects on the organism, which may occur during anaesthesia or only detected postoperatively.

The direct effects on anaesthetic risk involve cardiovascular and respiratory consequences of hypothermia. The increase in sympathetic tone by the hypothalamus initially leads to tachycardia and an increase in stroke volume. Furthermore, peripheral vasoconstriction occurs, leading to hypertension. After some time, these phenomena are reversed due to reduced sensitivity of the baroreceptors. This results in bradycardia, decreased stroke volume, and hypotension. Additionally, atrial and ventricular arrhythmias can occur. The increased vascular permeability results in tissue oedema, and the reduced oxygen delivery to the tissues leads to local hypoxia. Under hypothermic conditions, the metabolic rate decreases, initially resulting in a reduced oxygen demand (about 5 % per °C deviation from the set point). However, overall oxygen demand is increased, as muscle shivering during the recovery phase raises oxygen consumption by 40 – 100 %. Furthermore, it causes discomfort during the recovery phase, known as thermal discomfort, which is reported to be painful by patients, according to findings from human medicine.

Additionally, the reduced metabolism delays the elimination of anaesthetics, thereby prolonging the recovery phase. Less carbon dioxide is produced as a metabolic byproduct, leading to hypoventilation. Due to the reduction in both respiratory rate and tidal volume, there is a risk of respiratory acidosis with hypoxia. Blood viscosity can lead to pulmonary oedema, and reduced muscle tone in the bronchi increases the anatomical dead space. In predisposed patients, bronchospasms are also possible.

In the context of a surgical procedure, the increased bleeding tendency of hypothermic patients presents an avoidable complication risk. This is due to the disruption of platelet function and plasmatic coagulation, which can lead to thrombocytopenia and disseminated intravascular coagulation (DIC). Postoperative complications include wound healing disorders caused by reduced collagen synthesis and an increased risk of wound infections due to leukopenia and a general weakening of the immune system.

Monitoring of the core body temperature

Crucial for the prevention of perioperative hypothermia is the regular monitoring of the core body temperature before, during, and after general anaesthesia. The goal is always to maintain the physiological body temperature, meaning heat retention rather than active heat supply. Therefore, appropriate precautions must be taken to reduce perioperative heat loss, such as insulation through covering the patient. Timely recognition and prompt implementation of suitable countermeasures are essential for the successful treatment of perioperative hypothermia. When measuring temperature, potential sources of error must be considered and eliminated. Digital thermometers, oesophageal (Item No. 32192501/02) or rectal temperature probes are suitable for recording the core body temperature. These are included as standard in the EICKEMEYER® monitoring devices (LifeVet PT, Item No. 321860; LifeVet 10M, Item No. 321915 and LifeVet 10C, Item No. 321920).

Fig. 2 LifeVet PT Pulse Oximeter with Temperature Probe (1), LifeVet 10C Multiparameter Monitor (2)

If there is a lot of faeces in the rectum during rectal measurement, or if a rectal lavage has been performed before the measurement, the displayed temperature will be lower than the actual core body temperature. Similarly, if the oesophageal probe is in the stomach and the abdomen is opened intraoperatively or a lavage solution is used, the temperature reading may be inaccurate. Additionally, the probe slipping out unnoticed must be prevented.

Species	Normal values for healthy small animals
Dog	37.5 – 39 °C
Cat	37.8 – 39.2 °C
Rabbit	38.3 – 39.5 °C
Guinea pig	37.9 – 39.7 °C
Chinchilla	38.2 – 39.4 °C

Table: Normal body temperature of small animal patients

A pre-anaesthetic examination without measuring the core body temperature is incomplete, and a single measurement of the core body temperature at the beginning of the recovery phase is by no means sufficient. It should, just like other vital parameters, be checked at regular, predetermined intervals and documented in the anaesthesia protocol. Postoperatively, standardised temperature monitoring of the recovering patient is also indicated to detect potential postoperative hypothermia in a timely manner and to initiate appropriate measures.

Measures for perioperative heat management

For every general anaesthesia, measures should initially be taken to help maintain the patient's normothermia. The waiting time before surgery, the preparation for the surgery, and the surgery itself should take place in a comfortable room temperature without draughts. The higher the patient's physiological body temperature, the warmer the surrounding temperature needs to be to reduce the risk of cooling. For very small patients and young animals, it is recommended to increase the room temperature to around 26 °C, following the practice commonly used in human medicine.

In particular, patients who are already hypothermic upon arrival at the clinic or practice due to transport, an accident, or pre-existing conditions can benefit from prewarming while they wait for anaesthesia induction. The goal is to align the peripheral body temperature with the core body temperature to reduce the redistribution of heat during the first hour of general anaesthesia. For this, the patient should be warmed on a heating pad or dressed in an insulating coat 30 to 60 minutes before anaesthesia induction.

One of the simplest yet most important measures is insulation to minimise heat loss through conduction and convection. A patient should not be placed on a cold surface (e.g. a bare operating table or cage) but should be provided with an appropriate warming mat, and the patient should, if possible, be at least partially covered. Additionally, it may be helpful to put socks on the patient or wrap the paws to reduce heat loss, as heat loss through the distal limbs is particularly high.

During the preparation for surgery, attention in the following areas can positively influence heat loss. The surgical field should only be shaved as much as necessary for the procedure. When washing the surgical area with water and soap or using volatile disinfectants, these should be applied sparingly to keep evaporation losses minimal. The fluids used should, for example, be warmed using a baby bottle warmer. The surrounding fur of the patient should be kept dry.

In dental procedures, it is useful to cover the area caudal to the oral cavity to avoid moistening the neck and the resulting evaporative losses from the spray mist of the turbine. Furthermore, a gauze bandage or similar materials should not be used to secure the tube, as these materials tend to draw moisture caudally due to their composition.

With regard to anaesthesia, it should be kept as short as possible, as the duration of anaesthesia also influences the extent of heat

loss. Medications such as acepromazine should be administered in low doses, and alpha-2 agonists, and possibly opioids, can be antagonised immediately after the procedure to minimise recovery time.

In the case of inhalation anaesthesia, it is advisable to warm and humidify the anaesthetic gases. For this, devices like gas humidifiers or coaxial hoses can be used, where fresh air is warmed by the exhaled air in the parallel-running second hose. Additionally, using a semi-closed circuit system with low O_2 flow helps reduce evaporation losses. If lavage solutions are used during the procedure, they should always be warmed to body temperature.

For small patients, young animals, or those who were hypothermic before anaesthesia, as well as for longer durations of general anaesthesia, passive measures to maintain body temperature may be insufficient. In such cases, active warming of the patient is necessary. It is crucial to ensure that body temperature does not exceed the physiological set point to avoid iatrogenic hyperthermia. Therefore, regular temperature monitoring is essential to adjust the heat supply as needed.

Suitable products for active heat supply include, for example:

- EickWarm Heat Mats (Item No. 648048 / 648050)
- EickWarm H_2O heating system with circulating warm water (Item No. 648020)
- EickWarm Air heating device with circulating warm air (Item No. 648000).

Fig. 3: EickWarm Heat Mat (1), EickWarm H_2O Heating System (2), EickWarm Air Warming System (3)

Most importantly, electric heating mats should only be used with a blanket or towel placed between the heating mat and the patient to prevent burns, and always under supervision. As with all aids, care should be taken to ensure that they are not damaged by chewing or the patient's claws.

An affordable method during procedures is the use of a red-light lamp (Item No. 645000 and cage holder, Item No. 645002). The disadvantage is that the patient cannot independently avoid the heat if hyperthermia is a risk. It should only be used under constant supervision or, better, solely to warm the environment before the patient is returned to the kennel. A sufficient distance from the patient must be maintained (at least 75 cm) to prevent the risk of burns, and in particular to avoid drying out the cornea. The use is contraindicated in circulatory unstable patients.

Furthermore, warmed infusion solutions can be used in conjunction with an infusion warmer (Item No. 402092). The infusion warmer should be placed as close as possible to the venous access to minimise the subsequent heat loss through the infusion equipment. However, due to the small, infused volumes, the effect is limited.

Fig. 4: Infrared Heating Lamp (1), EICKEMEYER® IV Fluid Warmer (2)

Conclusion

Effective perioperative heat management significantly reduces anaesthesia risks in small animal medicine and improves procedural outcomes. Simple measures can prevent perioperative hypothermia and its negative consequences. Normothermic patients experience fewer intra- and postoperative complications and have a shorter recovery phase compared to hypothermic patients. Overall, maintaining physiological body temperature during the perioperative period leads to better outcomes after general anaesthesia. Modern clinical practices should implement safe, individually tailored perioperative heat management procedures, including appropriate equipment, monitoring, and regular staff training.

Elena Züfle

Trained as a veterinary nurse in a small animal practice near Stuttgart; trained as an equine physiotherapist at the German Institute for Equine Osteopathy (DIPO); since 2020 studying veterinary medicine at the LMU Munich with a specialisation in "Applied Ethology and Behavioural Therapy".

QR code to the Literature

Highcroft Keynsham

EICKEMEYER® EickWarm Air

Current best practice for patient warming during anaesthesia is to use a forced air warming (FAW) device. Our current setup was a completely passive system, comprising an electric blanket, additional standard blanket, and silver and bubble wrap for wrapping extremities. We wanted to improve our patient safety during anaesthesia by reducing peri-operative patient cooling. We chose to compare our current set up with the EICKEMEYER® EickWarm Air FAW system because the MOECK mats do not leak air like other models, keeping warm air within the blanket and minimising the potential for aerosolised bacteria. It is also lincensed to be used with reusable blankets. We have been keenly aware of the environmental impact of disposables and have been looking for ways to reduce waste without compromising patient safety. Many alternative FAW systems rely on single-use blankets which create a lot of landfill waste.

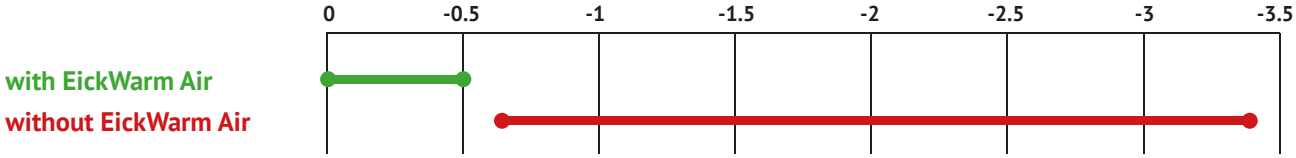
Over the past month, we've been trialing the EICKEMEYER® EickWarm Air FAW System together with the reusable warming mats from MOECK. We liked the internal thicker mat made up of three separate layers. The meshed layers-maintained circulation of air underneath the patient in contrast to other models where the blankets are completely flattened preventing air from circulating and resulting in a potentially higher heat loss to the table.

What we've learned

1. **Patient safety comes first:** Keeping patients warm and safe is always our priority. Comparing the pre-op temperature to the lowest peri-operative temperature for a patient, the EICKEMEYER® EickWarm Air together with the MOECK reusable warming mats resulted in almost no temperature drop (0.21 °C), compared to an average temperature drop of 1.9 °C using our previous passive system.
2. **Reusable mats work well:** The MOECK mats are effective, reusable, and easy to position under patients. They fit comfortably to the body and have been straightforward to clean between uses.
3. **Straightforward Integration:** The system has been easy to incorporate into our routine. It's quiet, quick to set up, and the additional temperature monitoring feature, which improves patient safety requires no set up at all because it is automatic.

Average drop in temperature

Difference in pre and peri-operative temperatures (in °C)



Conclusion

Switching to the EICKEMEYER® EickWarm Air and the MOECK reusable warming mats has been a positive change for us. It has not only achieved our goal of reducing perioperative temperature drop, it has done so in an environmentally sustainable manner.

Amy Wheeler
Clinical Director Highcroft CVS

EICKWARM AIR WARMING SYSTEM FOR SMALL ANIMALS

Prevent Intraoperative Hypothermia with the EickWarm Air Warming System

Intraoperative hypothermia is one of the most common anaesthesia complications in small animal medicine. Effective perioperative heat management is crucial for reducing this risk and ensuring patient safety. The new EickWarm Air Warming System quietly delivers forced air through optionally available warming mats that are specifically designed to evenly deliver diffused warm air to the patient.

- Safe and effective management of patient body temperature
- Optimal performance through uniform heat distribution
- Extremely powerful and quiet (≤55 dB)
- Only 60 seconds to warm up
- Temperature set points: Ambient air, 32 °C, 35 °C, 38 °C and 43 °C
- Three selectable fan levels (air flow)
- Reliable measurement of the hose outlet temperature using sensors
- Multiple alarm options ensure maximum patient safety
- Pole clamp for secure fixation
- Long heat hose (2 m) with flexible fastening clamp
- Compact dimensions (in cm): L 30 x W 37 x H 34
- Weight (including heat hose): 6.5 kg
- Warming mats available separately

Item No. 648000

Trolley

- Suitable for EickWarm Air
- With lockable smooth running castors and basket
- Dimensions (in cm): L 41 x W 50 x H 65

Item No. 648010

MOECK WARMING MATS AND BLANKET

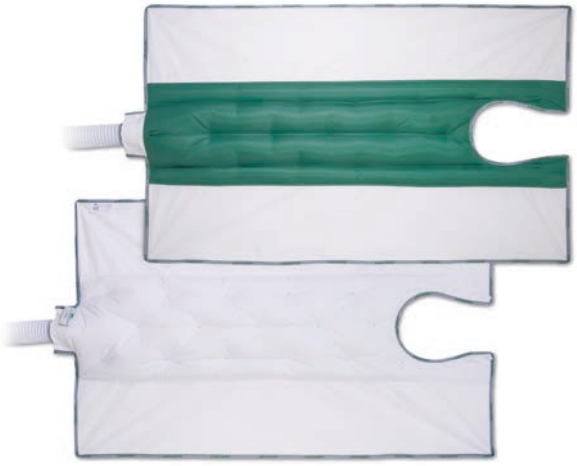
MOECK Warming Mats

These reusable warming mats are placed under the patient and, thanks to their three different textile layers, ensure optimal heat supply. The mat fits under the bodies contour perfectly, making temperature control possible in any position without interruption at the contact points.

- Warm air is distributed evenly under the patient
- Pressure-relieving positioning
- Free operating field
- Reusable and washable at 60 °C (We recommend using a laundry bag (648111 / 648121) when washing your blankets)
- Compatible with most air warming devices

Small	**Medium**	**Large**
Dimensions (in cm): L 55 x W 65	Dimensions (in cm): L 100 x W 55	Dimensions (in cm): L 115 x W 65
Item No. 648110	**Item No. 648115**	**Item No. 648120**

MOECK Thermal Blanket



- Especially suitable for dental procedures
- In combination with the large heat mat, ensures an optimal convective heat supply from above and below
- Variable round neckline suitable for different head and body sizes
- Dimensions (in cm): L 150 x W 95

Item No. 648130

MOECK Air Hose

- For use in the postoperative period
- Recommended for small animals
- Dimensions (in cm): L 150 x W 20

Item No. 648125

EICKEMEYER® IV FLUID WARMER

The EICKEMEYER® blood and infusion warmer reduces the temperature difference between IV fluid and the patient and minimises the occurrence of hypothermia.

- For warming up all intravenously administered liquids
- Easy to use
- LED display with temperature display
- Precise temperature control between 35 °C and 42 °C (0.1 °C steps)
- Alarms: overheating, temperature too low, system error, door open, heating reminder
- Two fastening options: with a lanyard or fastening clamp
- Warm-up time: less than 2 min
- Power supply: 100 – 240 V
- Main's voltage: 50/60 Hz
- Power: 85 VA
- Dimensions (in cm): L 18 x W 7 x D 3.5
- Weight: 200 g (without fastening clamp)

Item No. 402092

EICKWARM HEATING PAD

Ideally used post operatively to maintain body temperature.

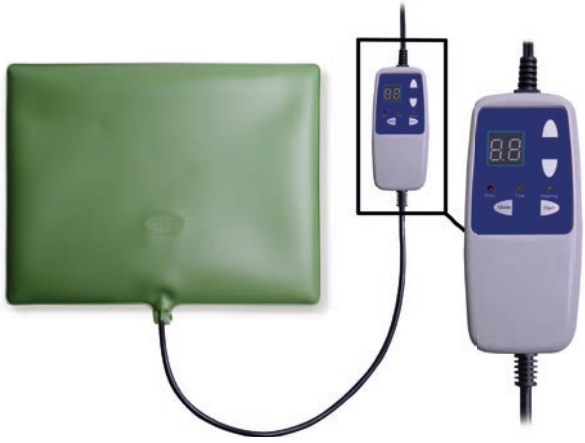
- Temperature range 35 – 45 °C
- Timer: 1 to 9 hours
- Low voltage: 12 V
- Water-resistant
- Easily used in continuous operation

Small
Dimensions (in cm): L 40 x W 30

Item No. 648048

Large
Dimensions (in cm): L 65 x W 50

Item No. 648050



INTENSIVE CARE UNIT VETARIO

Ideal for the postoperative placement of the patients to reduce the risk of hypothermia, shock, etc. The cages offer a comfortable, warm and hygienic environment. The temperature is automatically kept constant by a controller on the display.

- The chamber size is suitable for small animals, such as rodents, birds, kittens and small puppies
- Lifetime calibrated digital temperature control
- Fan ventilation
- Nebuliser connection
- Filter for removal of harmful bacteria and fungi
- A water reservoir for humidity levels reduces the risk of dehydration
- Easy to clean and disinfect

Vetario T40M
Dimensions (in cm): L 48.5 x W 38.5 x H 48
Item No. 219031

Vetario T50M
Dimensions (in cm): L 69 x W 49 x H 56
Item No. 219033

INFRARED HEATING LAMP

The use of a traditional infrared heat lamp prevents post-operative patients from cooling down in the kennels.

- For attachment to the kennel door use holder (Item No. 645002)
- With aluminium shade (Ø 21 cm) and protective basket
- Ventilation slots ensure good air circulation and heat distribution
- Includes long-lasting infrared heater with 150 W

Item No. 645000

Kennel Mount for Infrared Heat Lamp

For attachment to kennel door.

Item No. 645002

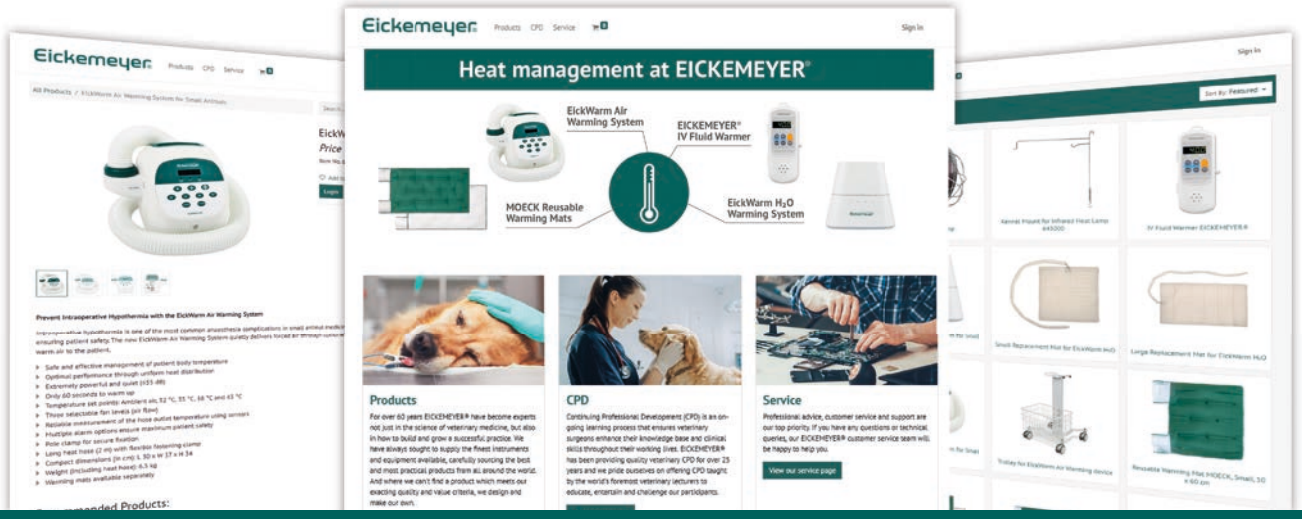
EICKWARM H_2O HEATING SYSTEM FOR SMALL ANIMALS

Prevent Intraoperative Hypothermia with the EickWarm H_2O Patient Heating System

The EickWarm H_2O Patient Heating System provides safe and effective heat therapy with precise temperature control for small animals. By circulating demineralised water through a leak-proof heating mat, the system delivers conductive temperature therapy to prevent heat loss and hypothermia during surgery and recovery. The compact device operates quietly, ensuring a calm environment for both patients and staff. The efficient heating element quickly brings the warming mat to the desired temperature, providing immediate warmth. Additionally, by adding pre-cooled water, the device can be used to cool patients, offering versatile temperature management.

- Safe and effective control of the patient's body temperature
- Continuous temperature adjustment from 10 to 45 °C
- For use with demineralised water
- Digital temperature and water level display
- Three different timer modes
- Locking valves prevent the device from leaking when changing mats
- Includes two warming mats (L 55 x W 55 and L 55 x W 100 cm)
- Compact dimensions (in cm): L 19 x W 19 x H 17
- Length of power supply cord (in cm): 146
- Length of mat tube and power cord (both approx 150 cm)
- Weight: 1.2 kg

Item No. 648020



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