Keeping your Cool Monitoring Body Temperature.

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Abstract

Measuring body temperature is a key part of a thorough clinical examination. Deviations from the normal range can be life-threatening and require immediate action. Despite temperature measurement being one of the most commonly measured clinical parameters – the T in TPR – there is little robust, evidence-based veterinary literature available to support the normal temperature range for many companion animals. There is also limited information on normal temperature ranges for different anatomical sites. This review will outline the options available for monitoring body temperature, the limitations of the thermometers available and the need for more research into this “hot topic”.

Key words: temperature reference range, thermometry, temperature monitoring, rectal thermometer, ear thermometer

What is a Normal Temperature?

Mammals typically control their body temperature within a narrow range through processes of thermoregulation. Basal metabolic rate varies between animals living in arctic or dessert climates, as a considerable amount of energy is used for thermoregulation, either using metabolism to produce heat in colder climates, or using active processes such as sweating or panting to lose heat in hot climates (Careau et al., 2007). Humans and horses use sweating to cool, dogs and horses have extensive physiological adaptations to allow heat loss through breathing mechanisms and most mammalian species use their hair to help manage their body temperature through insulation mechanisms. Deviations from the normal temperature range affect the speed of biochemical reactions, can alter the pH and viscosity of blood and can permanently alter proteins leading to multi-organ failure (Hemmelgarn & Gannon, 2013). It is therefore essential to know the normal range of any animal's body temperature, to accurately detect changes and predict the effect those changes will have on our patients. Table 1 shows some recently reviewed normal temperature ranges for a range of companion animal species.

Table 1. Recently reviewed normal temperature ranges in companion animal species.

Species	Normal temperature reference range (°C)	Site of temperature measurement	Statistical derivation of reference range	Source
Cat	36.7-38.9	Rectal (digital thermometer)	Yes	(Levy et al., 2015)
Dog	37.2–39.2	Rectal (digital thermometer)	Not reported	(Konietschke et al., 2014)
Dog	36.6-38.8	Ear (Vet-Temp thermometer)	Yes	(Hall & Carter, 2017a)
Ferret	37.9-39.9	Rectal (digital thermometer at 2cm depth)	No	(Aguilar et al., 2019)
Horse	36.0-38.0	Rectal (digital thermometer at 5cm depth)	Yes	(Hall, Carter, et al., 2019)
Rabbit	37.4-39.6	Rectal (digital thermometer at 3cm depth)	Yes	(Gallego, 2017)

Normal body temperature is, however, poorly defined in the veterinary literature. When a blood sample is taken, biochemical substances are measured and compared to a reference interval to determine if the level is normal, high or low. These reference intervals are typically established using the largest sample population available and a set of strict inclusion criteria for animals to be used within that sample population (Friedrichs et al., 2012). Statistical analysis is then used to determine the upper and lower limits of the "normal" reference interval, so that 95% of the population should fall within these limits of the normal range. This same method can, and arguably should, be used to determine the normal range of body temperature. Yet the ranges stated within textbooks often fail to state their primary source, meaning there is no way to know the size or criteria of the population of animals we used to calculate the range, or if the range was indeed statistically calculated. This makes it difficult to determine if the reference range is accurate, or even applicable to your clinical patient.

One recent study on cats used a sample population of 200 cats housed in either a rescue centre, private home or veterinary clinic (Levy et al., 2015), measuring rectal temperature with a digital rectal thermometer. The study used the statistical methods suggested by Friedrichs et al. (2012) to calculate the normal rectal temperature range of 36.7-38.9°C. This range is considerably lower than previously published ranges of 38.1–39.2°C (Fielder, 2016) or 38.2-38.6°C (Goddard and Phillips, 2011), particularly at the lower end of the range. This is possibly due to the largely familiar environment in which the cats were examined (Levy et al., 2015), as stress can increase body temperature (Ozawa et al., 2017).

Canine body temperature lacks a robust, statistically derived, recently established reference range for rectal temperature. One study measured the rectal temperature of 62 healthy dogs presenting to a veterinary hospital and determined the normal range to be 37.2–39.2°C (Konietschke et al., 2014). However, this paper did not state the statistical method used to determine this range. This study also took repeated rectal temperatures from each dog during the consultation, introducing the potential for stress to have affected the repeated measures.

Rabbits are the third most common companion animal species presenting to the veterinary clinic, and yet are poorly represented in the veterinary literature (O’Neill et al., 2020). As rabbits are a prey species, any handling or restraint will potentially elicit a stress response, impacting physiological parameters such as heart rate, respiratory rate and temperature (Dallmann et al., 2006; Ozawa et al., 2017). Previously published rabbit rectal temperature reference ranges likely reflect the influence of stress, for example 38.6-40.1°C (Fielder, 2016), but are also potentially derived from laboratory animals subject to very different husbandry from the typical pet rabbit. Gallego (2017) measured rectal temperature from 86 pet rabbits in a veterinary setting, and statistically determined the normal rectal temperature range to be 37.4-39.6°C. Again, this range is considerably lower than previously stated ranges at the lower limit, highlighting the need for accurate, population appropriate and setting appropriate statistically derived reference ranges.

Equine body temperature has been investigated within a familiar setting, using 41 horses to establish a yard specific normal rectal temperature of 36.0-38.0°C (Hall, Carter, et al., 2019). Whilst this study used repeated measures of the same horses, the repeated measures were taken on different days by a familiar person, reducing the likelihood of stress affecting the readings. This reference range was established using digital predictive thermometers at a rectal depth of 5cm. In horses there is the potential to measure rectal temperature considerably deeper (up to 30cm). Measures of intestinal temperature tend to be higher than rectal temperature (Green et al., 2005; Verdegaal et al., 2014), meaning depth of thermometer placement is likely to effect the temperature measured. This highlights the importance of having an appropriate reference range for the specific location temperature is being measured to prevent misinterpretation of results.

"Gold Standard" Temperature Measurement

To measure true core temperature, either blood temperature, oesophageal temperature or urinary bladder temperature must be measured. These methods are invasive and typically require general anaesthesia to place the probe or thermistor meaning their use is limited in conscious patients. When monitoring an anaesthetised patient, placement of an oesophageal thermometer can be considered as this allows true core temperature monitoring and if used with a multi-patient parameter monitor, can provide continuous measurements allowing any changes to be detected quickly (Watson et al., 2015). If an oesophageal thermometer is not available, or the patient is conscious, rectal thermometry is considered the gold standard for estimating core temperature. Rectal temperature and oesophageal temperature show good agreement in cats (Watson et al., 2015), although oesophageal temperature may measure slightly warmer than rectal temperature during abdominal surgery in both cats and dogs particularly when lavage is used (Barnes et al., 2017).

Rectal thermometry requires appropriate restraint of the patient, especially in horses where the operator is at serious risk of injury through kicking. Rectal temperature is not always well tolerated by conscious patients (Gomart et al., 2014; Lamb & McBrearty, 2013; Smith et al., 2015). Careful, positive patient handling can improve tolerance of rectal thermometry in most species, whilst modern predictive digital thermometers provide rapid readings in seconds to limit the discomfort for the patients. To thoroughly disinfect thermometers the use of glutaraldehyde with a 10 minute contact time is recommended (Rutala & Weber, 2019), impractical in most veterinary settings due to both health and safety and time constraints. Thermometer covers and appropriate lubrication should therefore be used to reduce the risk of infection transmission between patients (see Figure 1), and have been shown to have no impact on the accuracy of thermometer results (Jolivet et al., 2020).

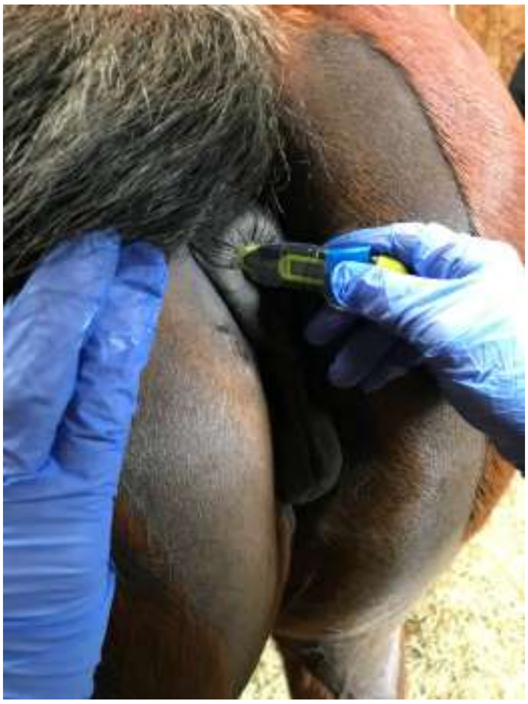

Figure 1. Use of predictive digital thermometer with probe cover to measure rectal temperature in a horse.

The presence of gas or faeces within the rectum can affect the accuracy of measurements, as can the ability and experience of the person performing the temperature measurement (Naylor et al., 2012). If the patient is unconscious, or has poor rectal tone due to nerve damage, this can result in increased air presence within the rectum lowering the temperature of this anatomical site. If peri-anal disease or surgery has taken place, this may render rectal thermometry impossible due to patient pain. Alternative methods of measuring body temperature in conscious patients are therefore essential.

Ear temperature

Ear thermometers use infra-red heat detection to measure the temperature of the tympanic membrane (TM), or at least they do if they are properly positioned. Ear thermometers were first used in human medicine, as this site is typically preferred by patients for positioning of a thermometer. As these thermometers use a small infra-red detection plate to measure emitted temperature from a surface, it is essential that the sensor is kept clean and free from debris or damage (Rexroat et al., 1999). These thermometers must be used with a disposable probe cover to protect the sensor, but the presence of large amounts of cerumen or aural discharge can obscure the sensor and therefore negatively impact the accuracy of the device (see Figure 2).

Figure 2. A Vet-Temp ear thermometer with protective probe cover in place being used to monitor Monty, a willing canine research assistant.

The principle behind aural thermometry is that the blood vessel supplying the tympanic membrane also supplies the brain (Brinnel & Cabanac, 1989), meaning the tympanic membrane temperature approximately matches brain temperature. The anatomy of canine and feline patients means that accessing the tympanic membrane is difficult, due to the bend from the vertical to the horizontal ear canal. Therefore, use of human ear thermometers in cats and dogs cannot be recommended as a reliable method of monitoring temperature (Konietschke et al., 2014; Sousa et al., 2013). Conversely, the veterinary specific ear thermometers, the VetTemp and the PetTemp (Advanced Monitors Corporation, San Diego, CA, USA) have a different shaped probe to facilitate better access of the TM. There is some debate within the literature about the ability of these devices to actually reach the TM, with operator experience commonly cited as key factor affecting their accuracy (Greer et al., 2007). Several studies conducted using these veterinary ear thermometers have reported similar findings. TM temperature typically measures around 0.4-0.6°C lower than rectal temperature (Gomart et al., 2014; Hall & Carter, 2017b; Zanghi, 2016). One study used a clinical population of dogs, including a full range of temperatures, the other two studies used healthy exercising dogs, concluding that the accuracy of the device was not affected by hyperthermia following exercise. A canine specific ear temperature reference range of 36.6-38.8°C has been established using 157 dogs in a non-veterinary setting (Hall & Carter, 2017a). Whilst ear temperature appears to be relatively reliable in dogs, it should be interpreted using the ear specific reference range, and cannot be used interchangeably with rectal temperature.

Ear thermometers have also been tested in cats (Smith et al., 2015), ferrets (Aguilar et al., 2019) and rabbits (Chen & White, 2006), with none of the species tolerating the method particularly well. Tympanic membrane temperature does not appear to be reliable for clinical use in these species. In horses, non-contact infra-red thermometers have been tested measuring ear temperature, but less than 50% of the horses tolerated placement of the thermometer and when the thermometer was tolerated, the thermometer frequently failed to report a readings (Carter et al., 2019).

Temperature Sensing Microchips

A major limitation of ear thermometers is that they still require physical contact with the animal, meaning there is still the potential for poor patient compliance and disease transmission. Temperature sensing microchips such as the Bio-Thermo microchip (Animalcare Limited, York, UK) aim to address that issue, providing a means of monitoring temperature using a microchip scanner which doesn't require physical contact with the animal. These microchips have been used in many species, with varying degrees of success. Rhesus Macaques actually manage to snap and remove the chips from each other through mutual grooming, rendering the devices useless (Brunell, 2012). In horses, temperature measuring microchips appear to offer a reliable and safe method of monitoring temperature (Auclair-Ronzaud et al., 2020).

In both cats and ferrets temperature measuring microchips have been shown to accurately estimate body temperature when compared to rectal thermometry (Maxwell et al., 2016; Quimby et al., 2009). The major advantage of using microchips to monitor temperature, is that no patient restraint is required, therefore the measurement itself is completely stress free (see Figure 3). However, both of these studies were conducted on indoor laboratory animals, so further research to evaluate the reliability of the devices in a range of ambient temperatures is needed.

Figure 3. A Halo microchip scanner used to record ferret microchip temperature in a willing volunteer.

Non-contact infra-red thermometers

A truly hands free method of measuring body temperature is infra-red thermometry. In human medicine, infra-red thermometer has largely replaced ear thermometer use for screening patients (Makic et al., 2011). Whilst in theory such devices offer an ideal stress free, remote method of measuring animal body temperature studies to date have failed to find an appropriate anatomical site that can provide robust, reliable temperature measures. Eye temperature has been measured in cats and dogs (Hall, Fleming, et al., 2019; Kreissl & Neiger, 2015) but fails to reliably detect hypo- or hyperthermia in either species, and is not always well tolerated by patients (see Figure 4). Other anatomical locations have been tested in cats (Nutt et al., 2016) but also failed to provide a clinically reliable measure of body temperature.

Figure 4. Leo the cat barely tolerating the non-contact infra-red thermometer use despite the use of treats.

Figure 5. Non-contact infra-red thermometer use on a horse.

In horses, non-contact thermometry of the medial and lateral canthus of the eye (see Figure 5) has been shown to provide a reasonable estimate of body temperature, when compared to rectal temperature in healthy horses. However, this study lacked horses with abnormal body temperatures, so further research is required before non-contact thermometry can be considered clinically reliable (Carter et al., 2019).

Conclusion

The golden rule of temperature monitoring adopted in human nursing is to compare like with like (Makic et al., 2011). If you measure a patient’s temperature using a rectal thermometer, carry on using that thermometer and that anatomical location to monitor the patient. This ensures that any temperature changes can be attributed to the patient’s changing condition, rather than simply a result of changing the thermometer type or location. As ear temperature is known to report a lower temperature compared to rectal temperature, readings taken with an ear thermometer would be difficult to compare to readings taken from a rectal temperature, meaning a change in the patient’s condition could go undetected. There is no evidence to support using non-contact infra-red thermometers in clinical veterinary practice at present. Similarly, temperature sensing microchips lack robust evidence to support their use clinically in dogs and cats, and a microchip specific temperature reference range would be required to enable accurate interpretation of results. The current evidence supports using rectal thermometry to estimate core body temperature in all domestic species, however robust, reliable reference ranges need establishing for patients in a clinical setting to enable accurate interpretation of temperature readings.

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