Clinical Accuracy of *Vet-Temp™* Instant Ear Thermometer

Comparative Study with Dogs and Cats

Introduction

Instant infrared ear thermometers offer significant advantages over traditional rectal thermometers. One advantage is their ability to read temperature nearly instantaneously, making temperature measurement a quick and easy process. A second advantage is the fact that these devices utilize the ear as the measurement site. This is important because the tympanic membrane region is located very close the body's thermostat, the hypothalamus. Through extensive research, human infrared ear thermometers have been proven to clinically correlate with "core" body temperature [1].

The ear canal is not affected by breathing, food digestion, intestinal gases or muscle tone. The ear canal is also easy to access and relatively clean. The most important benefit of ear thermometers is that they are incredibly fast. Although, these advantages are beneficial only if the operator uses the *correct technique* and places the probe in the ear canal so that the infrared energy is collected from the vicinity of the tympanic membrane.

Over the last several years, to realize the benefits of ear thermometry, many veterinarians have attempted to measure animal ear temperatures with human ear thermometers. Unfortunately, often these devices have not performed with the desired results due to the following reasons:

1. Animals have a wide variety of ear canal shapes while human ear canals are quite similar.
2. In many animals, the ear canal is longer and includes a much more severe bend before reaching the tympanic membrane.
3. Some human ear thermometers take 2-5 seconds to complete a measurement. This time, while acceptable to humans, is too long for most animals. Many animals will not tolerate taking temperature in the ear for more than 1 second.
4. Normal and febrile temperature ranges differ between humans and animals.

Realizing that veterinary applications for an instant ear thermometer require a different design, Advanced Monitors Corporation (San Diego, CA, U.S.A.) developed the Vet-Temp™ (Model VT-100). This instant ear thermometer is engineered specifically for professional veterinary use primarily on dogs and cats. Several design features have been incorporated in the VT-100 to accommodate its use on animals. These include an extended sensor arm, a smaller (5mm) probe tip and a one second temperature readout.

This study was conducted to compare the clinical accuracy of Vet-Temp™ and conventional rectal contact thermometers when used on dogs and cats.

Definitions

Blackbody - a laboratory source of a precisely defined infrared signal that is used for calibration and verification of instant infrared ear thermometers.

Instant Infrared Ear Thermometer - a non-contact infrared opto-electronic thermometer (sometimes called tympanic) which takes a thermal "picture" of the interior of the ear canal and converts the magnitude of the heat wave into a temperature reading. The instant thermometer measures the infrared signal that naturally emanates from the ear tissue in proportion to the temperature.

Probe Cover - a disposable sanitary barrier that envelops the tip of a contact or infrared ear thermometer.

Rectal Thermometer - a device having a contact sensing tip which is inserted into animal's rectum and brought into direct intimate contact with the anal tissue. Rectal thermometers can be glass-mercury (GM) or electronic digital (ED). The latter are sub-divided into two classes: equilibrium and predictive. In this study, equilibrium thermometers were employed.

Reference Thermometer - a stable contact thermometer whose calibration is traceable to U.S. National Institute of Standards and Technology. A reference thermometer is used for calibration and verification of contact thermometers and blackbodies.

Background

Since prehistoric times, it has been known that fever is associated with sickness. The Bible recalls the covenant God made with the Jewish people - "*But break my covenant, then be sure that this is what I will do: I will bring upon you sudden terror, wasting disease and recurring fever*". In the 17th century Galileo and Leopold, The Grand Duke of Tuscany, developed the first thermometers for physical experiments. It was not until 1868 when Carl Wunderlich, a German physician, used large glass-mercury thermometers to measure human body temperatures from the axilla (armpit). When glass thermometers were sufficiently reduced in size by the end of the 19th century, various researchers began to use them for rectal temperature measurement on animals. It took nearly 100 years before a non-contact infrared ear thermometer was developed [2].

The operation of an infrared ear thermometer is based on a fundamental physical principle: every material object is a source of electromagnetic radiation whose intensity and spectral characteristics are directly associated with the object's temperature. All warmblooded animals naturally emanate such radiation in the near and far infrared spectral ranges (wavelength from 3 to 15 μm). Since intensity of thermal radiation is a function of temperature, the measurement requires detection of the magnitude of the infrared signal and its conversion to a temperature reading in degrees C or F. An instant ear thermometer is a non-contact instrument resembling a photographic camera. The sensing probe is positioned inside the animal's ear canal. At the end of the probe, there is a window that allows passage of heat waves from the ear canal to the detector.

Before the advent of Vet-Temp™, many researchers attempted, with mixed success, to use human ear thermometers in animals. However, reports concerning such use are fairly limited. Use of human models were reported in cats [3, 4, 5], swine, cattle, calves [6], goats, horses, sheep [7], rhesus macaques [8] and rodents [3]. A short probe of a relatively large diameter, which is typical for a human thermometer, prevents correct positioning inside the animal ears, especially in animals having deep and bent ear canals. The speed response is also a limiting factor, especially in cats. When the fastest available human instant ear thermometer (*Thermoscan*™ Model HM-2) was employed to take temperatures in cats, a correlation with rectal readings was strong (r=0.995, p<0.001) [5]. In dogs and larger animals, such as goats, horses and sheep, the human ear thermometers consistently showed lower readings as compared with rectal (from 0.5 to 1.5ºC), while producing higher variations [7, 9]. This primarily can be attributed to the inappropriate infrared probe shape.

Temperatures obtained by traditional rectal thermometers are typically used as a "gold standard" for comparison purposes even though they are hardly gold or standard. There are many reasons why the rectum does not have a temperature that is a reliable representative of the brain (core) temperature [10]. Rectal heat is affected by digestion, peristaltic movements, intestinal air, fecal masses, muscle tone, physical activity, thickness and coat type. This can be further aggravated by incorrect user techniques, such as depth and time of insertion. On anesthetized animals, the rectal sphincter is often relaxed, thus dilating the anal opening. This prevents a rectal probe from making a good contact, resulting in lower readings. Rectal thermometers also pose a significant risk to animals due to potential glass breakage, mercury contamination and bowel perforation. In spite of the potential inaccuracy of rectal temperatures, they are widely used in veterinary practices, mainly due to their availability and low cost.

It would be logical to assume that a more appropriate comparison of the ear and core temperature is performed with direct temperature measurement of blood in the vicinity of the brain or heart. This is not only generally impractical, but also can be inaccurate as an intubated and anesthetized animal with an open chest or head hardly has the same thermal dynamics as a conscious subject. Thus, in the present study, a comparison was done with traditional rectal temperatures while every effort was made to minimize temperature gradients and thermal dynamics within bodies of the studied animals.

Method and Instruments

Procedure.

Temperatures were taken from animals by two methods: with a Vet-Temp™ instant ear thermometer and two types of rectal thermometers (glass and electronic digital.) A total of four data points were collected from each animal: Vet-Temp™ readings from left ear (LE) and right ear (RE), rectal temperatures with both a glass-mercury thermometer (GM) and an electronic digital thermometer (ED). The study was conducted in the veterinary clinic of the San Diego Humane Society. A total 53 animals of mixed breeds and sexes were tested (40 dogs and 13 cats). Ages ranged from 2 months to 6 years and weights ranging from 0.6 to 30.5 kg (1.4 to 67 lb.) All animals were healthy and brought to the veterinary clinic for various purposes, including check-up, tagging, teeth cleaning, neutering, etc. If a surgery was to be performed, the temperatures were taken prior to anesthesia. Animals with infected or discharging ears or rectum were excluded.

Ear temperatures were taken from both ears by a right-handed operator using the Vet-Temp™ VT-100. A new clean disposable probe cover was utilized with each temperature measurement. Ambient room temperature ranged from 20° to 24°C (68° to 75° F). Animals were mildly restrained to limit head movement during the ear temperature measurement. Before temperature measurement, the ear canal was examined with an otoscope to determine its condition and the location of the tympanic membrane. Next, the pinna of the ear was lifted and a strong traction was applied outward and down. This “ear tug” brings the vertical and horizontal ear canals into a more aligned position. Next, the tip of the infrared probe was inserted as far as possible, directing it toward the point of the opposite jaw of the animal. After full insertion of the probe, the "activation" button was depressed. Completion of the temperature measurement was indicated by an audible beep and then the probe was removed.

Rectal temperatures were taken sequentially, first with the GM and then with the ED thermometer. Disposable probe covers coated with Vaseline were used on the rectal probes. Before the rectal probe insertion, the rectum was visually examined. The probe was inserted into the rectum to the depth of at least 25 mm (1 inch) and held for 3 minutes (using GM) or until the measurement was complete (using ED).

Instruments.

The Vet-Temp™ instant ear thermometer (Model VT-100) is a handheld device with a digital display, an "activation" push-button and °C/°F switch (Fig. 1). The infrared probe is positioned at the end of an extended folding sensor arm which is inserted into the animal's ear until it reaches the intersection of the vertical and horizontal canals. Measurement time is less than 1 second, signaled by a short audible beep. The device displays an adjusted temperature (rectal equivalent) which is +0.6°C (+1.0°F) over the blackbody setting. The calibration of the VT-100 was tested with a laboratory cavity-type blackbody having emissivity of 0.99 and temperature uncertainty of no greater than 0.03 °C. To compensate for the device calibration shift of +0.11°C, the collected data were corrected by -0.11°C.

Fig. 1 Measuring temperature with Vet-Temp™ (model VT-100) instant ear thermometer

A rectal equilibrium GM thermometer was a PS Cornell type having resolution of 0.2 °F. A rectal equilibrium ED thermometer was a PolyMedica Healthcare, Inc. type, having resolution of 0.1 °F. The end of the measurement is indicated by an audible signal. Accuracy of both rectal thermometers was checked in a stirred temperature controlled water bath against a reference thermometer having uncertainty of no greater than 0.03 °C. It was found that the GM thermometer had a calibration shift with respect to reference of +0.17°C and ED had shift of +0.11°C. Rectal readings were corrected accordingly to compensate for the calibration shift.

Analysis

Data collected in this study were analyzed by comparing the infrared readings from the left and right ears, by comparing each ear to the GM thermometer, by comparing each ear to the ED thermometer and by comparing the readings between the two types of rectal thermometers (GM and ED). Outliers were not removed because clinicians rely on every single measurement to form an overall opinion of the accuracy and repeatability of a thermometer. The following characteristics were calculated: the bias (average difference between two types of thermometers), standard deviation, and maximum and minimum differences.

Results

The average ear temperatures were 37.87°C (100.17°F) for the left and 37.92°C (100.26°F) for the right. The average rectal temperatures were 37.88°C (100.18°F) for GM and 37.81°C (100.06°F) for ED. The statistical summary is shown in Table 1.

Table 1. Statistical Summary (LE-left ear by Vet-Temp™, RE-right ear by Vet-Temp™, GM-glass-mercury rectal, ED- electronic digital rectal)

	Bias °C	Standard Deviation °C	Max.	Min.
LE-RE	-0.05	0.35	0.78	-1.17
LE-GM	-0.01	0.38	0.83	-0.94
RE-GM	0.04	0.33	0.67	-0.78
GM-ED	0.07	0.23	0.72	-0.28

A scatter plot of both Vet-Temp™ ear measurements versus rectal GM measurements is shown in Fig. 2. For comparison, the scatter plot of the two types of rectal readings, GM and ED, is shown in Fig. 3.

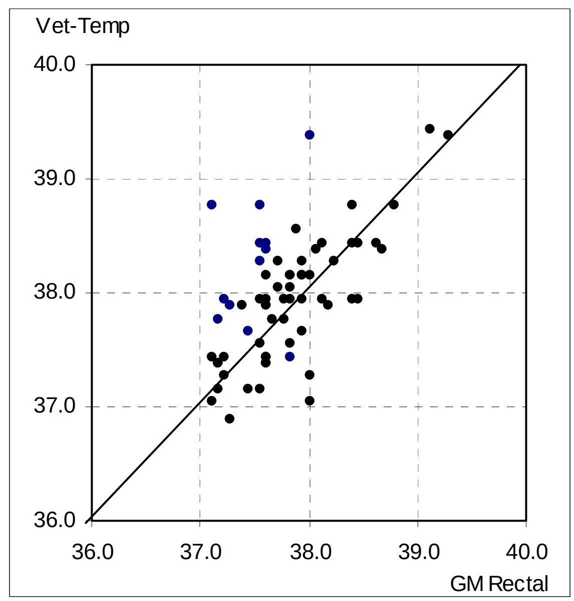

Fig. 2 Left and right ear vs. GM rectal temperatures (°C)

Discussion

The test results clearly indicate a strong correlation between the infrared ear temperatures taken with the Vet-Temp™ and rectal readings by either GM or ED thermometers in dogs and cats. The bias between right and left ears is small, indicating that either ear can be used for temperature taking. The biases of both ears to rectum are also very small and do not result in a diagnostic error. It is interesting to note that relative readings of two rectal thermometers (GM and ED) have statistical characteristics comparable with those of the ear temperatures. This suggests that a rectal measurement is a significant contributing factor to data variability.

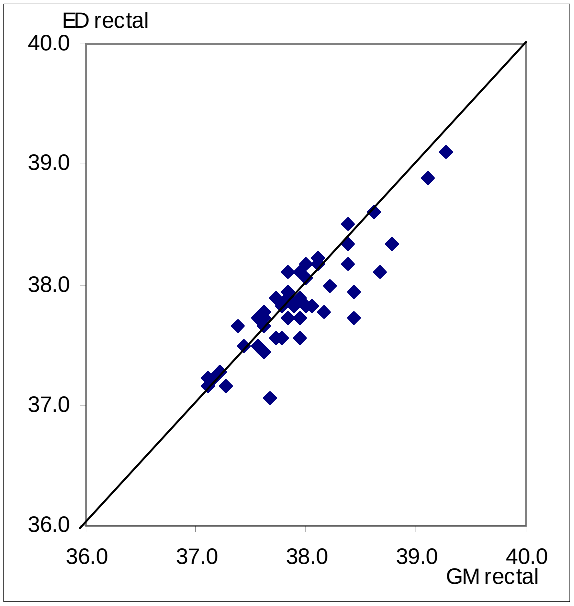

Fig. 3 Rectal ED vs. GM readings (°C)

Conclusion

The study was intended to determine validity of ear canal temperature measurement utilizing the Vet-Temp™ VT-100 Instant Animal Ear Thermometer as compared to traditional rectal temperature measurements in dogs and cats. It was found that, on the average, the Vet-Temp gives readings close (within 0.1°F) to traditional rectal thermometers. When a correct operator's technique is employed, the variability of readings while slightly larger, is still comparable with traditional rectal thermometers. The experimental data confirm that the clinical accuracy of the Vet-Temp™ thermometer is of an acceptable level. Many other benefits of this device, including speed, ease of operation, cleanliness, and safety are further arguments for recommending the Vet-Temp™ thermometer for the professional veterinary temperature measuring needs.

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