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Uses and limitations of thermography

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Thermography provides the examiner with a method to examine the entire horse. When combined with a thorough clinical examination, thermography is extremely useful in identifying soft tissue injuries that may have otherwise gone undetected.

Thermography is the pictorial representation of the surface temperature of an object (*Purohit* and *McCoy* 1980, *Turner* et al. 1986). It is a non-invasive technique that measures emitted heat. A medical thermogram represents the surface temperatures of skin making thermography useful for the detection of inflammation. This ability to non-invasively assess inflammatory change, makes thermography an ideal imaging tool to aid in the diagnosis of certain lameness conditions in the horse.

Two different types of devices are used for thermography: contacting and non-contacting, both of which have advantages and disadvantages (*Hall* et al. 1987, *Turner* et al. 1986).

Contacting thermography utilizes liquid crystals in a deformable base (*Hall* et al. 1987, *Turner* et al. 1986). Liquid crystals reflect polarized light within a narrow spectrum of wavelengths. The crystals change shape according to the temperature that contacts them, and as they do they reflect a different color of light. Therefore, the color of a crystal represents a specific temperature. In order to use this technology for medical purposes, the liquid crystals are first embedded into a latex base. The base is then made into a flexible and durable sheet which allows for easy application to various skin contours. Crystal impregnated sheets respond to temperature changes between 28° and 34°C (82.4° and 93.2°F). When applied in direct contact with the skin, the crystals change shape, reflect a specific color of light, and form a colored thermal picture of the heat patterns of the skin assayed. Commercially available contact thermography units usually have an accompanying photographic system so that a recording of the thermogram can be made instantly.

This equipment is relatively easy to use, it is durable, provides immediate results, and a permanent record can be made of the thermogram (*Hall* et al. 1987, *Turner* et al. 1986). The greatest disadvantage of this equipment is that it must contact skin (*Turner* et al. 1986). Direct skin contact may produce false readings because the latex sheets could either cause heating or cooling of the skin. For example, if the temperature of the sheets is markedly different from the skin they are contacting, heat conduction through the material may cause an abnormal reading. This is particularly true of cold sheets falsely cooling warm skin. Technically, the manner of application is also a source of error. Excessive pressure of latex application on an area like a bony tubercle could cause a false "hot spot".

Non-contacting thermography utilizes a detector of infrared radiation to measure temperature (*Purohit* and *McCoy* 1980, *Turner* et al. 1986). Commercially marketed thermographic units employ either an infrared thermometer or a thermographic camera to provide the thermal information. The infrared thermometer determines a point temperature on the skin. With advancements in technology, there are now some hand held models that, instead of indicating specific temperature, determine the temperature difference between two adjacent or bilaterally symmetrical areas particularly helpful in scanning an area to find a significant difference in temperature.

The thermographic camera is a more complex device (*Turner* et al. 1986). The camera utilizes an infrared detector but, in addition, a series of focusing and scanning mirrors are used to systematically measure an entire field of view. The camera/detector is usually coupled to a cathode-ray tube and the intensity of the detected radiation is converted to an electrical signal. This signal is displayed on the cathode-ray tube as a black and white (gray scale) image of the object. The radiation intensity is directly proportional to the gray scale. Through the use of microchips, the black and white image can be made into a colored image of the thermal picture (thermogram), hence a classic thermogram.

As with many of the new imaging modalities, the purchasing costs of thermographic cameras is high, but the investment is easily recovered by frequent use in a clinical setting (*Turner* et al. 1986). Infrared thermometers, can be procured for a much lower cost, and they are being used for the same purposes as thermography. However, these instruments can only evaluate the temperature of a small area of skin. Because skin temperature is variable, the limited assay of a thermometer can be misleading if a broader thermal pattern of the subject is not assessed, and the operator is not familiar with normal variations (*Turner* et al. 1986). Using the hand held thermometers to map out thermal patterns is time consuming and tedious work. Although this method is not as accurate as a thermogram, it can still be useful clinically.

In human medicine, thermography is performed under very controlled environmental conditions (*Weinstein* and *Weinstein* 1985). Unfortunately, in veterinary medicine this is not always possible, but even in the field standards can be followed so that reliable thermograms are produced (*Turner* et al. 1986). Factors that must be controlled are motion, extraneous radiant energy, ambient temperature, and quantification of the thermogram.

Motion can be controlled by immobilizing the horse in stocks, which also provides a safe working area for the equipment and personnel (*Turner* et al. 1986). Stocks are not always available, but the use of chemical restraining agents to keep the horse from moving should be avoided because these drugs affect the peripheral circulation and cardiovascular systems. This could cause false thermal patterns to be produced. Thermal imaging equipment that produces an image in real time makes it possible to produce a motionless image. Real time thermography is a must in veterinary medicine. This equipment produces a thermal image almost instantaneously as compared to equipment that averages thermal images taken over a period from 19 seconds to 6 minutes to produce a visual readout. Consequently, motion is not only a potential source of error, it can be a real annoyance with this type of equipment. Telephoto lenses also allow the thermographer and equipment to maintain a safe distance from the horse while producing detailed thermal images. Other than for safety, distance is unimportant in producing a reliable thermogram. However, the closer the camera is to the object being scanned the more detailed the image. The author utilizes a camera object distance of 1–2 meters or simply include the entire object of interest in the thermogram.

To reduce the effects of extraneous radiant energy, thermography should be performed under cover shielded from the sun (*Turner* et al. 1986). Preferably, thermography should be done in darkness or low-level lighting. Ideally, ambient temperature should be in the range of 20°C (68°F) but any temperature below 30°C (86°F) is acceptable. Heat loss from sweating does not occur below 30°C, as radiation and convection are responsible for heat loss below that temperature. The thermographic area ideally should have a steady, uniform airflow so that erroneous cooling does not occur. Practically, the horse should be kept from drafts. Likewise, the horse should be allowed 10–20 minutes to acclimate to the environment or room where thermography is performed.

Quantification of temperature variations is important only to the degree the thermographer needs to differentiate if symmetrical areas are of similar temperature. For example, when assessing a thermal image, asymmetry of 1°C or more is significant and indicates possible pathology. To this effect, hair and hair length are important (*Turner* et al. 1986). Hair insulates the leg and blocks the emission of infrared radiation. But, as long as the hair is short and of uniform length, the thermal image produced is accurate. The skin should always be evaluated for changes in hair length that may cause false "hot spots" in the thermogram.

Multiple thermographic images of a suspect area should be made (*Weinstein* and *Weinstein* 1985). The area in question should be evaluated from at least two directions approximately 90° apart, to determine if a "hot spot" is consistently present. The horse's extremities should be examined from 4 directions (circumferentially) (*Turner* et al. 1986). Some authors feel that 2–3 replicate examinations should be performed a minimum of 1 minute apart (*Weinstein* and *Weinstein* 1985). Significant areas of inflammation will appear over the same spot on each replicate thermogram. This technique is a simple way to have barnyard quality assurance.

The main indication for thermography is to assess entire regions of the horse and determine if "heat" (inflammation) is present when it is not clinically apparent. This gives the clinician the ability to also determine if areas of palpable soreness on the horse are associated with "heat" or inflammation. This is invaluable in helping the clinician determine possible areas of injury and also corroborating the physical examination. The author has found this tool to be invaluable in the assessment of upper limb lameness where the analgesic "blocks" that can be used to help identify areas of pain are limited. Another indication for thermography is the detection of subclinical inflammation. That is many lesions of the tendons and joints will show inflammatory changes up to 2 weeks before clinical lameness is present (*Stromberg* 1974). In this manner, horses can be screened thermographically and injuries detected before they become clinical problems. The ability for thermography to identify "heat" allows the clinician to have an objective, measurable assessment of the inflammatory reaction. In this manner, the animal can be subsequently followed by thermographic examination and the healing process assessed. As the inflammation subsides from the tissues the clinician can more accurately determine when changes in therapy are needed. Finally, thermography provides a qualitative assessment of the vasculature and blood flow to tissues. Thermography allows the clinician to follow the course of blood vessels and it becomes readily appparent when blood flow has been disrupted because tissues distal to the damage become "cooler" and begin to approach room temperature. Also pre and post exercise thermography can determine if adequate circulation is present in any region. Typically, the temperature of skin should increase by at least 0.5°C after exercise.

There are pitfalls with thermography. First, thermography is measuring surface temperature and skin is only a reflection of the deeper structures. In some cases a joint such as the sacroiliac joint could be inflamed but not show up thermographically because of the massive overlying musculature. Also the thermographic scan is highly sensitive to extraneous contact. That is anything that comes into contact with the object being thermographically scanned will affect the scan. For instance, if someone touches the limb the heat from the individual touching the limb will be detected, this could lead to false positive readings. This type of interference can occur by any means of heat transference such as evaporating from sweating, convection, or conduction. That means drafts could artificially cool the object or direct light could artificially heat the object. Thermography measures infrared radiation emitted from the skin which means anything that blocks these emissions will interfere with thermography. Leg braces, ointments, salves etc. will interfere with the normal radiation and false thermogram will be the result. These pitfalls can be avoided by following the recommendations under reliable use.

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