32nd Congress of the American Academy of Thermology: Abstracts

Pierre L. LeRoy, program chairman

THE INFLUENCE OF CAFFEINE ON HUMAN SKIN THERMOREGULATORY RESPONSES

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Thermologist often request that their infrared thermography subjects/patients refrain from using caffeine products for a period of at least one hour prior to imaging. This investigation examined the influence of a single dose of caffeine (120 mg) on thermal measures during standing, work (70% VO2 max, 30 minute duration), and passive recovery periods in a warm environment (30°C, 40% rh). The participant's habituation to caffeine was not determined, but regular daily use of caffeine products was recorded. Subjects refrained from using a caffeine product on the experimental days. Work rates for the five physically active college males were determined from a test for maximal oxygen consumption. During the four randomized double blind investigative trials, all participants either drank 20 ounces of Gatorade™ (G) or Gatorade™ plus caffeine (GC) prior to 60 minutes of passive standing performed at the same time of day and separated by at least 24 hours. During two trials the subjects were followed for an additional 30 minutes of standing, while the remaining two trials consisted of a 30 minute work bout followed by a 30 minute recovery test periods. Physiological measures consisted of thermographically determined skin temperatures, rectal core temperature, heart rate, Physiological Strain Index (PSI), Rating of Perceived Exertion (RPE), weight (sweat) loss, and thermal sensation. A caffeine effect was not observed until 30 minute post ingestion. Core temperature was higher during the caffeine passive trials (0.10°C) and exercise trials (0.20ºC), and recovery (0.10ºC). Post caffeine ingestion the subject's heart rates were slightly elevated, but no differences were observed in the subject's perception of thermal stress, PSI, RPE. Body weight changes indicate greater fluid retention in both the active and passive caffeine trials. Thermal imaging demonstrated slightly elevated temperatures in the chest and slightly cooler in the head with caffeine supplementation while standing in the heated climate. No difference in skin temperatures were observed for the arms and legs. During the caffeine exercise and recovery trials, the arms and legs were substantially cooler while no difference was observed for the chest region. In contrast, the head was cooler during exercise and then continued to rise in temperature during the recovery period. In conclusion, the ingestion of caffeine (120 mg) in a heated environment increased core temperature, increased heart rate, altered skin temperature, but did not disturb the thermal patterns on the skin surface.

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THERMOGRAPHIC EVALUATION OF CERVICAL DERMATOME IN THE BULL

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Neck injuries are not uncommon in some rodeo bulls. A bull was presented to the Large Animal Teaching Hospital with head carriage and slight head tilt after bucking. There were no changes in head tilt and carriage after 2 to 3 weeks post injury. The bull was in good physical condition other than the problem associated with the head carriage. Physical examination and history indicated some cervical neuropathy.

Thermographic evaluation was done using a Computerized Thermal Imaging Processor system. Facial views, along with right and left views of the neck and shoulder were obtained. Lower shoulder thermographic images left and right were similar in temperature and pattern. The left side cervical region (C1-C4) demonstrated warmer skin temperatures and a different thermal pattern when compared to the right cervical region.

Abnormal thermal patterns similar to cervical (neck) injury were observed. The bull had his head tilted more to the left and it seems that he was trying to relieve the pressure and pain presentation associated with the neck injury. In conclusion, both clinical findings and thermographic evaluation indicated neck and cervical area injury. Radiographic examination was postponed because bull weighed about 750 kg, obnoxious behavior, and it would require bull to be under general anesthesia. The bull was put on an anti-inflammatory drug and the owner was advised if condition persisted to return to the clinic in 90 days.

CRITICAL RESEARCH REVIEW OF THERMOGRAPHY IN VETERINARY MEDICINE

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After 30 years of experience and use of thermography in veterinary medicine, we have chosen this opportunity to reflect upon the critical research questions that need further investigative studies. These studies must adhere to the highest standards of scientific inquiry, while meeting the scrutiny and requirements for publication in appropriate referred journals.

1.In addition to the already recognized, normal thermographic patterns in horses, we need to establish thermal patterns and dermatome patterns for the various animal species. This will be a challenge due to the potential use of pharmacological agents that can alter thermal patterns. The thermal variation among animal species, as well as within different breeds of animals, would provide significant contributions to the field of thermology.

2.Even though we have developed considerable listings of thermal imaging standards for equine practice, we have not developed suitable standards for other animals. Indoor thermal imaging standards for environmental control are well known, but we lack meaningful guidelines and standards for outdoor imaging.

3.Skin thickness and hair coat in some animal species has been an extensively debated issue. There are some parts of the body where meaningful diagnostic thermography can be obtained, where there is a lack of hair coat, such as scrotal and perineal areas. In other cases hair clipping may be desirable to obtain diagnostic thermograms. In horses with very thin hair coats, diagnostic thermograms can be obtained without hair clippings. In other thicker or heavy coat species clipping is required prerequi-

site. What criterion needs to be established for hair coat and skin thickness amongst the various species

4.Some animals are not calm and quite or easily controlled during clinical examination. This requires the use of sedatives and tranquilizers to make it easy to handle them. As we know, that same tranquilizer and sedative may alter thermal patterns and temperature gradients. Thus, we need to research appropriate sedatives and dosages which can be used to calm the animal but does not have adverse effects on diagnostic value of the thermograms.

5.We know that exercise, heating, cooling, and the use of tranquilizers before and after thermal examination has been efficacious for diagnosis of various neurovascular and inflammatory conditions. What are the additional challenges of testing that we can use to enhance thermographic examination?

In conclusion, as advanced portable equipment is now becoming available for use in veterinary medicine, do we have a need for standardization of this equipment, and if so, what can we do to make it easier for the practicing veterinarian to use them?

3D VISUALIZATION OF BODY SURFACE THERMAL DATA

William Randy Adams

IRID,Inc. Virginia

IRID Inc. combines the use of Digital Signal Corporation's (DSC) Coherent Laser Radar (CLR), and a high-performance CeDip Infrared (IR) Camera.

CLR is used to measure distance to an accuracy of better than 0.1 mm., the IR camera is a 320x240 pixel array with an NETD of 20 mK.

The CLR can be used in scan mode to measure a 3D surface, or in single-point mode to measure skin movement (respiration and heart signature). The CLR can be used from 3 to 9 meters from the target.

The CeDip IR allows for visualization of small temperature differences (output is radiometric, i.e., true temperature). Time-sequence IR data can also be taken (at up to 200 frames per second) to determine responses to various stimuli. CeDip IR can be used from < ½ meter to 9 meters from the target.

Output from the CLR and IR devices can be precisely overlaid, giving a 3D model showing temperature data. This process can be used to precisely position 3D surface images taken at different times and different conditions.

Third party and proprietary software allows for measurement of volumetric, shape, and temperature data, and for comparison against previous baseline data. IRID has developed specialized software for enhancement of the thermal image data.

This technology is designed as an adjunct to existing technology, and is completely non-contact.

Uses can include

- Initial triage, reducing time for medical staff
- Respiration and heart signature data
- Thermal responses to drug, O2, CO2, etc. stimuli.
- Thermal changes over time indicating possible incipient conditions which are difficult to spot visually.
- Contact-free screening for medical conditions, e.g., SARS
- More, T.B.D.

BLOOD SUPPLY OF THE SKIN/ THE ANGIOSOMES

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Skin is the largest organ of the body. Temperature regulation to maintain homeostasis is one of its major roles. This important function is provided by a rich network of cutaneous arteries and veins, especially in the dermal and subdermal plexi, which supply the sweat glands and allow for heat exchange by convection, conduction, and radiation. Although the cutaneous circulation is rich and vast, the metabolic demands of the skin elements are low so that only a small fraction of the potential cutaneous circulation is necessary for skin viability. The works of Manchot, Salmon and Taylor helps us to understand the blood supply to the skin and the underlying deep tissues and segregate the body anatomically into three-dimensional vascular territories that are named "angiosomes". These three-dimensional anatomic territories are supplied by a source (segmental or distributing) artery and its accompanying vein(s) that span between the skin and the bone. Each angiosome can be subdivided into matching arterisomes (arterial territories) and venosomes (venous territories). Forty angiosomes have been described which can be subdivided further into smaller composite units.

These composite blocks of skin, bone, muscle, and other soft tissue fit together like the pieces of an intricate jigsaw puzzle. In some angiosomes there is a large overlying cutaneous "crust" and a relatively small deep tissue region, in others the reverse pattern exists. Each angiosome is linked to its neighbor, in each tissue, by a fringe of either true (simple) anastomotic arteries without change in caliber or by reduced-caliber choke (retiform) anastomotic vessels. The choke anastomotic vessels are plentiful in the integument (skin and subcutaneous tissues) and may participate in regulating the blood flow to the intact skin. On the venous side avalvular (bidirectional or oscillating) veins often define the boundaries of the angiosome.

The cutaneous arteries arise directly from the underlying source (segmental or distributing) arteries, or indirectly from branches of those source arteries to the deep tissues, especially the muscles. During their subcutaneous course the cutaneous arteries (and veins) often travel with the cutaneous nerves, either as long channels or as chain-linked system of vessels. John Hunter's hypothesis of a fixed number of cutaneous arteries and how growth and differentiation of the tissues could modify the definitive size and relationship of the arteries X and Y in different regions of the body can explain why long vessels converge on the nipple from the periphery as the breast develops in the female.

The density, size and direction of the cutaneous perforators varies from region to region of the body, being modified by growth, differentiation, and the functional demands of the part. The vessels of the head, neck, torso, and proximal limbs are larger and more widely spaced than their counterparts in the forearms, legs, hands and feet. The cutaneous perforators vary in the size and length and they all interconnect for form a three-dimensional "body carpet". The body carpet has a particularly well-developed horizontal strata of vessels in the dermis, in the subdermis, on the undersurface of the subcutaneous fat, and on the outer surface of the deep fascia.

The cutaneous veins also form a three-dimensional plexus of interconnecting channels with a dominant strata in the subdermis. Many of these veins have valves that direct the blood in a particular direction, they are often connected by avalvular veins. These avalvular (oscillating) vessels allow bidirectional flow between adjacent venous territories whose valves may be oriented in opposite direction, thus providing for the equilibration of flow and pressure. In some regions valved channels direct flow radially away from a plexus of avalvular veins as, for example, in the venous drainage from the nipple-areolar summit of the breast. In other areas valved channels direct flow toward a central focus, seen in the stellate limbs of the cutaneous perforating veins.

The skin is fed and drained by a continuous network of arteries and veins formed by vessels whose size, shape, density, and direction vary from region to region in the body.

A knowledge of the basic anatomy of the cutaneous vessels, coupled with an appreciation of the factors that influence its structure in different regions of the body has clinical application for Thermologists. In the words of Michel Salmon, between anatomy and physiology there is room for functional anatomy, for a physiological anatomy. The angiosomes concept and the neurochemical pathology specific to clinical states can be used in correlating infrared imaging clinically.

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FACIAL TEMPERATURE IN SUDDEN INFANT DEATH SYNDROME

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Objective: To present potential application of infrared technology in sudden infant death syndrome (SIDS).

Incidence:Most SIDS cases occur between 2-4 months of age, which coincides with important maturational changes in the central nervous system as the newborn adapts to changes in extra-u terine life.

Risk Factor:Under moderate heat stress at the level of hypothalamic preoptic region marked hypoventilation may occur in infants, an observation that has been experimentally verified in animal studies. Supine sleeping position promotes appropriate thermoregulation via the face and head, which is the major source of infant heat loss. Prone sleeping position has been shown to increase temperature around the head of infants up to 3.5°C above those measured in the supine position.

Pathophysiology:Hyperthermia in cot death was first described in 1979. The 1984 study demonstrated that 94% of SIDS victims were excessively clothed, in an unusually warm environment, hot and sweaty when found dead, or had an infective illness, which in itself, would not be expected to cause death. The infants' ability to dissipate excess heat can be compromised by combinations of overwrapping, co-sleeping, acute febrile illness, and an unusually warm heated environment. This may result in hyperthermia, which can lead to a failure of the cardio-respiratory system during sleep. du Boulay and colleagues have proposed that carotid artery mediated brain cooling is essential to maintain normal temperature homeostasis in the brain. Any failure of this process may increase brain temperature. Loss of heat is primarily via vasdilatation which predominantly occurs from the face and head in neonates. In this context the head, as the site of about 40% of the head production and up to 85% of heat loss for the infant in bed, may be particularly sensitive to thermal stress. Any disturbance of brain hypothalamic temperature homeostasis may have a prolonged effect on face and head temperature in the absence of any change in core body temperature. Hyperthermia enhances laryngeal reflex probably through temperature-dependent changes in synaptic transmission, which have a direct effect on the latency of the laryngeal adductor reflex, causing upper airway induced central apnea of sufficient severity to result in death.

Conclusion:In the first 6 months of life Thermography can help to monitor facial/head temperature over and above core temperature and indicate thermoregulatory stress at the level of hypothalamic preoptic region. This can permit administration of appropriate interventional measures to prevent events that may lead to respiratory apnea and SIDS.

Failure of neural control of respiration has been implicated in SIDS. There is complex interaction between respiratory, cardiac and thermoregulatory control centers and hemeostatic mechanisms. There is causal relationship between thermal stress and failure of respiration, but the mechanism remains unclear.

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ANATOMY, PHYSIOLOGY AND PATHOLOGY OF AUTONOMIC AND SOMATIC NERVOUS SYSTEMS AND THEIR CORRELATION TO PERIPHERAL THERMAL DYSREGULATION

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Somatosensory and autonomic neural systems interact to regulate vascular tone and thermal effects. These complex systems function non-linearly to maintain homeostatic conditions. However, in pathologic disruptions, such nonlinear adaptive processes assume a more linear, progressive pattern. (Similar changes towards linear, dynamical systems disruption can produce autonomic dysregulation and vascular sequelae in exothermic or endothermic processes of inflammation, ischemia, infarction/necrosis, neoplastic and carcinogenic angiogenesis). Characteristic thermal pattern changes frequently result from neurogenic inflammation and sympathetically mediated pain syndromes.

Such pain is clinically enigmatic as it frequently occurs without evidentiary pathology and is refractory to laboratory or imaging diagnosis. This disparity can lead to misdiagnosis and inappropriate management. Chronic pain syndromes may induce hyperactivity of C-fiber afferents evoking antidromic release of substance-P into peripheral tissues. This causes peripheral vaso- dilation both directly and indirectly. Neurogenic inflammation increases temperature within peripheral tissues, stimulating polymodal C-fibers further and augmenting the pain response. While this physiopathologic cascade has been well recognized, to date effective assessment methods applicable in the clinical (i.e. - non-experimental) setting have been unreliable, particularly during the early stages of these disorders. When more salient signs occur, they are often reflective of advanced pathology against which therapeutic intervention is more complicated, invasive, if not entirely unsuccessful. This leads to protracted disability and suffering in the patient.

It is in this light that we have renewed interest in thermographic assessment of peripheral syndromes. Current thermographic technology has significantly improved, with higher resolution, sensitivity, ease of use and cost effectiveness. While some equivocality exists regarding the acceptability of thermography, extensive peer reviewed studies support its validity in depicting thermal changes correlated to neurogenic pain, and other pathologies in which there is concomitant vascular change. By understanding specific pathologic mechanisms, we may gain additional insight to the applicability, strengths and limitations of thermographic assessment, and further study its potential utility in clinical and veterinary medicine.

3D-IR FOR ENHANCED VISUALIZATION OF THERMAL IMAGING

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Simultaneous Imaging by a high performance IR camera and a coherent laser radar can produce a 3D surface thermal map that enhances visualization of thermal features and their changes

over time. Custom software is being developed for the composite sensor imagery to provide true 3D measurements of the area imaged, the ability to rotate images into any desired orientation, and the ability to precisely register images taken at different times.

3D-IR visualization offers potential benefit in many applications such as: detection of incipient pressure ulcers prior to stage one; precise 3D measurements of lymphedema for design of custom compression garments and to determine the effectiveness of treatments; rapid whole-body scans to document skin condition including texture; non-contact quantitative evaluation of on-going burn treatment.

Infrared Identification Incorporated (IRID Inc.) and Digital Signal Corporation (DSC) are collaborating on the IR/CLR integration which is the subject of several issued and pending patents. The companies are currently focused on security uses of their technologies, but hope to also pursue medical applications in collaboration with other organizations.

3D-IR FOR REMOTE MONITORING OF VITAL SIGNS

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Integration of a coherent laser radar and a high performance IR camera allows certain vital signs to be continuously monitored from a distance without contact. Respiration rate, pulse, heart signature, and skin temperature can be directly obtained at one or more locations on the body, and instantaneous blood pressure can be deduced. Anatomical features extracted from the thermal imagery can be used to continuously re-aim the CLR to remain focused on a particular spot in spite of involuntary movements associated with cardiac cycle, respiration, swallowing, blinking, spasms, etc. That reduces movement artifacts in the output signals.

The non-contact aspect of this approach has particular application to telemedicine, and to monitoring of persons under quarantine. It would reduce the risk of exposure to health care workers, and reduce the volume of medical waste created compared to contact procedures. The continuous imaging aspect of this approach provides for tracking the effects of administered drugs over time. The lock-on aspect of this approach allows patient-specific alarm indicators to be set at specific locations on that patient's body. For example: localized bleeding, swelling, temperature change, tremour, break in cardiac or respiratory rhythm could trigger an alarm.

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THE AUTONOMIC CHALLENGE AND ANALYTIC BREAST THERMOLOGY

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The basis of thermology is physiologic and, thus is unique among the diagnostic imaging techniques. Our laboratory employs an adaptive physiologic challenge procedure to differentially indicate the abnormal vasculature associated with malignant breast disease. The adaptive challenge response is used as an analytic element along with pattern recognition, temperature differential and time-based positive evolution the evaluation of breast thermology. To establish the power of the adaptive challenge procedure, I retrospectively reviewed two thousand patient studies that were five to seven years from the time of analysis. One thousand of these patients were normal studies (TH-1 & TH-2) and one thousand patients were abnormal studies (TH-4 & TH-5). Each and every of these patients had received annual multi-modality follow-up (clinical examination, thermology & mammography) from the time of their original thermology studies. The original thermology studies were reviewed in a blinded manner independently by two thermo- logists in a manner that the diagnostic contribution of the adaptive challenge response was separate from that of pattern recognition and temperature differentials. This study concluded that the response of the autonomic challenge increased the diagnostic sensitivity by seven percent and increased the specificity by twenty-eight percent.

SURGICAL THERMOLOGY- A REVIEW OF PREOPERATIVE, INTRAOPERATIVE, AND POSTOPERATIVE APPLICATIONS

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Increasing indications for medical infrared radiation characteristic thermal pattern recognition and expanding surgical fields of neuropathic; vascular; skeletal; and myopathically related disorders represents significant progress for the surgical patient's management in several specialties.

Since previously reported by Abernathy and Umatsu in 1986, by clinical and bioengineering advances in design miniaturization; noncooling; portability and visual analog radiometrics documenting technology. Results from declassified dual military technologies provide enhanced pixel resolution. This now allows for handheld monitoring sensor cameras to be safely employed in a variety of pre and postinterventional surgical settings and procedures.

These new capacities provide Surgeons directly with an immediate selective virtual reality of the outcome of the procedure not requiring a third party interpretation. This allows the Surgeon to determine if the interventional procedure is satisfactory in its outcome or whether additional decompression or other techniques are necessary. This is especially true in the field of neurocompression and endovascular stents.

A review of these four categories is presented by clinical case examples documented by telethermography in the author's experience.

Especially valid is the following:

1.Neurosurgical entrapment neuropathies such as axial radicular decompression; peripheral neuropathy entrapment such as seen in brachial plexus thoracic outlet syndrome and carpal tunnel syndromes.

2.Orthopedic applications provide for the monitoring of cast applications, which may be too tight to help prevent undesired neurovascular compressions leading to reflex sympathetic dystrophy (RSDS) or complex regional pain syndrome (CRPS) we have called the thermal castograms.

3.Vascular surgeons for cardiac arterial bypass; arterial anastomosis for peripheral vascular disease seen especially with diabetic patients and endovascular stents and employed in re- vascularization procedures.

4.General surgery in the evaluation of GI and bowel resection viability. Although the author has no personal experience in this latter, the principals appear to be applicable in this situation.

It is hoped that others will improve on this legacy contributed by so many that have preceded us and also that we have benefit from the critics who have helped to improve our total fund of knowledge.

Improved understanding of the basic pathophysiology as reported by J. Giordano; T. Yakash and others provided the clinical and bridging the basic science concepts elucidated by H. Ringermacher; and V. Klemas reported elsewhere in this symposium

firmly establishing the credibility in assessing these orthoptic systems for the surgical interventionalist and beyond, to see that was not perceived through our limited senses.

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THERMOGRAPHY IN PHANTOM PAIN

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Thermography is usually done with the understanding that the primary somatosensory cortex is intact. Thermal asymmetries are correlated with nervous system lesions after excluding other causes e.g., local vascular etc.

Phantom limb pain is a frequent consequence of the amputation of a body part. Phantom limb pain is closely associated with plastic changes in the primary somatosensory cortex. Animal data indicate that behaviorly relevant training alters the cortical map. The somatosensory system is capable of functional reorganization following peripheral denervation or training. Studies on human amputes with phantom limb pain provided evidence that these reorganizational changes are modulated through nociceptive input. The pain induced hyper responsiveness can cause acute reorganization. Soros et al observed acute pain can elicit phantom sensations in healthy subjects and suspected an underlying pain- induced hyper responsiveness of the cortical hand representation to somatotopically adjacent input from the lip. Flor et al indicated that phantom limb pain is related to and may be a consequence of plastic changes in primary somatosensory cortex. Thermography studies in phantom pain can give us a method to image a peripheral correlate of cortical plasticity and reorganizational changes in the primary somatosensory cortex of neuropathic pain syndromes and can contribute to the understanding of pain pathophysiology. This can help in the development of new treatments.

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THE CORRELATION OF OCEANOGRAPHIC AND TERRESTRIAL THERMAL INFRARED ANALYSIS WITH THE BIOSCIENCES

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Depending on its temperature, every object or life form on Earth radiates thermal infrared energy. Infrared radiation can be used to detect natural or man-made features and to accurately measure their temperature. In nature, rattlesnakes use infrared radiation to find their prey, such as desert squirrels which also have countermeasures. Man uses infrared sensors on space satellites to locate forest fires, track hurricanes and weather fronts; to map ocean currents and temperatures. It is also used to detect enemy troops or vehicles at night. Extensive peer-reviewed data has been accumulated since the 1940 post-war era.

The intensity of the infrared signal our sensors detect depends on both the emissivity and temperature of the target. The emissivity of land surfaces varies depending on the land cover. For instance, dry desert sand has a lower emissivity and forests exhibit a higher emissivity. Therefore, the temperature of land surfaces is difficult to determine since their emissivity is highly variable and frequently unknown. On the other hand, oceanographers are quite successful in accurately mapping sea surface temperatures with thermal infrared sensors on satellites, because the emissivity of seawater is constant and rarely deviates from 98%. Similarly, since water is one of the major constituents of the human body, it is not surprising that physicians can use thermal infrared radiation to precisely outline body regions which are inflamed due to injury or illnesses. For instance, at medical pain clinics they may determine and differentiate if regional muscle, skeletal, vascular and neuropathic injury has occurred based on their characteristic diagnostic thermal pattern, a feat x-rays cannot accomplish. Thermal infrared is also used extensively by veterinarians in equine applications.

Oceanographic and medical applications of infrared radiation are based on the same physical principles and face similar issues. For instance, just as an oil slick on the ocean surface can produce errors in temperature readings obtained from infrared radiation, an oily lotion covering a body part can prevent accurate pain diagnosis and detection. Therefore, continued close collaboration between environmental scientists, oceanographers and medical specialists may prove beneficial to all concerned.

ADVANCES IN INFRARED IMAGING: A GENERAL ELECTRIC PERSPECTIVE

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Infrared Imaging can be divided into two broad categories: Passive IR and Active IR. Passive IR simply "observes" existing radiant heat. Active IR generates its own heating from some transient heat source. The Medical profession utilizes passive IR technology for diagnoses of disease or conditions of the human body. Industry has long benefitted from the same passive technology, but has recently witnessed advances in active IR which, for the first time, permit quantitative imaging of the physical properties of materials and components other than temperature. I will overview both technologies and focus in on recent active IR applications at General Electric. Perhaps the medical community can come up with some good applications of their own!

FEED DEPRIVATION STUDY IN SWINE: VALIDATION OF THERMOGRAPHY IN ASSESSING CHANGE IN METABOLIC RATE

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Introduction: Thermal imaging is a possible alternative to the calorimeter in assessing change in metabolic rate. The primary study was designed to quantify hunger in swine.The validation study was designed to establish the thermal camera as a method for assessing change in metabolic rate.

Method: Sixteen pigs were housed individually in a temperature-controlled building. They were fed ad libitum, twice a day (0800 and 1600). One hour after the a.m. feeding (0900), the feed was withdrawn and the pens were cleaned. Pigs were assigned to five treatment groups: 0, 6, 12, 24 and 36- hours of food deprivation. Thermal images were taken of the flank and the cortical-cranial view of the rump, including the stifle where the saphenous vein comes to the surface; using a FLIR Therma CAM™ PM695.. The summary findings comprise three repetitions of the above measurements.

Images were taken in darkness, 2.3 meters from the animal's surface, accounting for the ambient temperature at each exposure

and holding the thermal camera level with, and perpendicular to, the cranial-cortical line for the flank view and the dorsal-ventral line for the rump view. While the pigs were still on regular feedings, a set of control images at four 6-hour intervals were captured to allow for diurnal temperature fluctuations.

After the appropriate feed deprivation period, another set of images was taken under the same conditions prior to sacrificing the animal. Hence each animal served as its own control.

Analysis:Using 2000 ™ software, I took two measurements from the flank view and two from the cranial-cortical rump view. From the flank view I used the maximum temperature found in the hind ham joint as well as the average temperature of the animal's surface area. From the cortical-cranial view of the rump I used the maximum temperature in the right and left stifle where the saphenous vein comes to the surface. I found the difference between the control and experimental value for each of these four measurements. I then plotted this difference against the hours of feed deprivation.

Conclusions:Of all the data collected, the average surface- area measurement from the flank view most clearly reflects the expected trend of decreasing surface- temperature with increasing hours of feed deprivation. Temperature from the control images show the fluctuation expected due to diurnal rhythms. Hence, this method of measuring differences in metabolic rate in swine appears to warrant further study.

SALMONELLA DUBLIN CHALLENGE IN DAIRY CALVES:VALIDATION OF THERMOGROPHY TO ASSESS FLUCTUATIONS IN CORE BODY TEMPERATURE

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Introduction: Thermal images can conceivably replace rectal thermometers to obtain accurate assessment of body temperature. The primary study examined ß-glucan as effective prophylaxis for Salmonella. The validation study correlates thermal images to rectal temperatures.

Method: Nine calves were assigned to three treatment groups (n=3 per treatment) and inoculations of Salmonella dublin were administered to each calf, varying the dosage according to group; high, medium and low. We took thermal images of the calf eye and rectal temperatures simultaneously, hourly for eight hours prior to, and 72 hours post Salmonella challenge. I took the thermal images with a FLIR®™ PM695 2.2 meters from the animal, holding the camera level to but 45° from the median line in an anterior-posterior view of the face. I noted the ambient temperature and adjusted the camera.

Analysis: Using Reporter 2000™ I framed the tear duct and used the maximum temperature found in this frame to correlate to the rectal temperature. These I plotted in a regression scatter plot and calculated the correlation coefficient.

Conclusions:The amalgamated correlation coefficient was 0.83. ($P<.05$) The correlation between the two methods of measurement increased as the Salmonella dosage increased varying from 0.52 to 0.92. ($P<.05$)

The high correlation of rectal temperatures to thermal image temperatures in this preliminary study indicated that the thermal camera may be a reliable replacement for the rectal thermometer in dairy calf research.

POULTRY WELL-BEING RESEARCH: VALIDATION OF THERMOGRAPHY IN THE DIAGNOSIS OF SUB-CLINICAL BUMBLE FOOT

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Introduction: Bumble foot is a large ball-like staphylococcus infection of the foot pad. When infection occurs, synovial membranes in the joints and tendons of the hock and feet become thickened and oedema is seen. Inflammation occurs and a fluid may be produced around the joints and tendon sheaths. Wounds heal on the outside to leave a hard core of pus inside. If the condition becomes chronic, fibrous tissue can form around the foot. The thermal camera may have the ability to detect sub-clinical levels of bumble foot. The primary objective of this study is to validate the use of the thermal camera to detect sub-clinical levels of Bumble-Foot.

Methods: 150 hens housed in pairs in standard battery cages were randomly selected from a peak-production population. Using a FLIR ThermaCAM®™ PM695 I took thermal images of the footpads at 0.91 meters from each selected hen. Fourteen days later I scored the same hens for signs of clinical bumble foot and, took digital photos.

Analysis: I inspected 150 thermal images and identified those that showed an abnormality that may be the onset of bumble foot. I correlated this to the clinical bumble foot score for each of the 150 hens 14 days later.

Conclusions:Based upon the correlation coefficient 0.93 ($P<0.05$) of incidence of clinical bumble foot to abnormal thermal images, it appears that thermal imaging can be relied upon to identify sub-clinical cases of bumble foot in Chickens. (This was designed as a preliminary study and further study would include culture and positive identification of the staphylococcus infection)