THERMOGRAPHY RESEARCH STUDIES

Study Index

1. Gautherie M. Thermopathology of breast cancer: measurement and analysis of in vivo temperature and blood flow.
Ann N Y Acad Sci. 1980;335:383-415.

2. Gautherie M. Thermobiological assessment of benign and malignant breast diseases.
Am J Obstet Gynecol. Dec 15 1983;147(8):861-869.

3. Lin QY, Yang HQ, Xie SS, Wang YH, Ye Z, Chen SQ. Detecting early breast tumour by finite element thermal analysis.
*J Med Eng Technol.*2009;33(4):274-280.

4. Lawson RN, Chughtai MS. Breast Cancer and Body Temperature.
Can Med Assoc J. Jan 12 1963;88(2):68-70.

5. Plotnikoff G, Carolyn T. Emerging controversies in breast imaging: is there a place for thermography?
Minn Med. Dec 2009;92(12):37-39, 56.

6. Haberman JD. The present status of mammary thermography.
CA Cancer J Clin. Nov-Dec 1968;18(6):315-321.

7. Isard HJ, Becker W, Shilo R, Ostrum BJ. Breast thermography after four years and 10000 studies. *Am J Roentgenol Radium Ther Nucl Med.*
Aug 1972;115(4):811-821.

8. Keyserlingk JR, Ahlgren PD, Yu E, Belliveau N, Yassa M. Functional infrared imaging of the breast.
IEEE Eng Med Biol Mag. May-Jun 2000;19(3):30-41.

9. Jones CH. *Thermography of the female breast. In: Parsons CA (Ed):*

Diagnosis of breast disease.
Baltimore: University Park Press; 1983.

10. Keith LG, Oleszczuk JJ, Laguens M. Are mammography and palpation sufficient for breast cancer screening? A dissenting opinion.
J Womens Health Gend Based Med. Jan-Feb 2002;11(1):17-25.

11. Report of the Working Group to Review the National Cancer Institute-American Cancer Society Breast Cancer Detection Demonstration Projects.
J Natl Cancer Inst. Mar 1979;62(3):639-709.

12. Baker LH. Breast Cancer Detection Demonstration Project: five-year summary report.
CA Cancer J Clin. Jul-Aug 1982;32(4):194-225.

13. Isard HJ, Sweitzer CJ, Edelstein GR. Breast thermography. A prognostic indicator for breast cancer survival.
Cancer. Aug 1 1988;62(3):484-488.

14. Lapayowker MS, Revesz G. Thermography and ultrasound in detection and diagnosis of breast cancer.
Cancer. Aug 15 1980;46(4 Suppl):933-938.

15. NIH/NCI Consensus Development Meeting on breast cancer screening. Issues and recommendations.
Yale J Biol Med. Jan-Feb 1978;51(1):3-7.

16. Head JF, Wang F, Lipari CA, Elliott RL. The important role of infrared imaging in breast cancer.
IEEE Eng Med Biol Mag. May-Jun 2000;19(3):52-57.

17. Arora N, Martins D, Ruggerio D, et al. Effectiveness of a noninvasive digital infrared thermal imaging system in the detection of breast cancer.
*Am J Surg.*Oct 2008;196(4):523-526.

18. Kennedy DA, Lee T, Seely D. A comparative review of thermography as a breast cancer screening technique.
Integr Cancer Ther. Mar 2009;8(1):9-16.

19. Gonzalez FJ. Infrared imager requirements for breast cancer detection.
Conf Proc IEEE Eng Med Biol Soc. 2007;2007:3312-3314.

20. Head JF, Elliott RL. Infrared imaging: making progress in fulfilling its medical promise.
IEEE Eng Med Biol Mag. Nov-Dec 2002;21(6):80-85.

21. Mikulska D. [Contemporary applications of infrared imaging in medical diagnostics].
Ann Acad Med Stetin. 2006;52(1):35-39; discussion 39-40.

22. Ng EY, Ung LN, Ng FC, Sim LS. Statistical analysis of healthy and malignant breast thermography.
J Med Eng Technol. Nov-Dec 2001;25(6):253-263.

23. Joro R, Laaperi AL, Dastidar P, et al. Imaging of breast cancer with mid- and long-wave infrared camera.
J Med Eng Technol. May-Jun 2008;32(3):189-197.

24. Isard HJ. Other imaging techniques. *Cancer.*
Feb 1 1984;53(3 Suppl):658-664.

25. Salhab M, Keith LG, Laguens M, Reeves W, Mokbel K. The potential role of dynamic thermal analysis in breast cancer detection.
Int Semin Surg Oncol. 2006;3:8.

26. Mital M, Scott EP. Thermal detection of embedded tumors using infrared imaging.
J Biomech Eng. Feb 2007;129(1):33-39.

27. Gautherie M, Gros CM. Breast thermography and cancer risk prediction.
Cancer.
Jan 1 1980;45(1):51-56.

28. Jones CH, Greening WP, Davey JB, McKinna JA, Greeves VJ. Thermography of the female breast: a five-year study in relation to the detection and prognosis of cancer.
Br J Radiol. Jul 1975;48(571):532-538.

29. Ng EY, Kee EC. Advanced integrated technique in breast cancer thermography.
J Med Eng Technol. Mar-Apr 2008;32(2):103-114.

30. Stark AM. The value of risk factors in screening for breast cancer.
Eur J Surg Oncol. Jun 1985;11(2):147-150.

31. Amalu WC. Nondestructive testing of the human breast: the validity of dynamic stress testing in medical infrared breast imaging. *Conf Proc IEEE Eng Med Biol Soc.* 2004;2:1174-1177.

32. de Thibault de Boesinghe L. The value of thermography for the diagnosis, prognosis and surveillance of non-palpable breast cancer.
J Belge Radiol. Oct 1990;73(5):375-378.

33. Feig SA, Shaber GS, Schwartz GF, et al. Thermography, mammography, and clinical examination in breast cancer screening. Review of 16,000 studies.
Radiology. Jan 1977;122(1):123-127.

34. Ohsumi S, Takashima S, Aogi K, Usuki H. Prognostic value of thermographical findings in patients with primary breast cancer.
Breast Cancer Res Treat. Jun 2002;74(3):213-220.

35. Ng EY, Sudharsan NM. Computer simulation in conjunction with medical thermography as an adjunct tool for early detection of breast cancer.
BMC Cancer. Apr 28 2004;4:17.

36. Kerr J. *Review of the effectiveness of infrared thermal imaging (thermography) for population screening and diagnostic testing of breast cancer.*
New Zealand Health Technology Assessment (NZHTA) Tech Brief Series. Volume 3, Number 3, 2004.

37. Agnese DM. Advances in breast imaging. *Surg Technol Int.* 2005;14:51-56.

38. Gautherie M, Haehnel P, Walter JP, Keith LG. Thermovascular changes associated with in situ and minimal breast cancers. Results of an ongoing prospective study after four years.
J Reprod Med. Nov 1987;32(11):833-842.

39. Head JF, Wang F, Elliott RL. Breast thermography is a noninvasive prognostic procedure that predicts tumor growth rate in breast cancer patients.
Ann N Y Acad Sci. Nov 30 1993;698:153-158.

40. Dumitrescu RG, Cotarla I. Understanding breast cancer risk -- where do we stand in 2005?
J Cell Mol Med. Jan-Mar 2005;9(1):208-221.

41. Gros C, Gautherie M, Bourjat P. Prognosis and post-therapeutic follow-up of breast cancers by thermography.
Bibl Radiol. 1975(6):77-90.

42. Ikeda T, Abe O, Enomoto K, Kikuchi K, Fujiwara K. [Contact thermography as a prognostic indicator of breast cancer].
Gan To Kagaku Ryoho. May 1989;16(5):2103-2108.

43. Ciatto S, Palli D, Rosselli del Turco M, Catarzi S. Diagnostic and prognostic role of infrared thermography.
Radiol Med. Oct 1987;74(4):312-315.

44. Mustacchi G, Milani S, Sandri P, et al. Telethermography and axillary node status as predictors of early relapse in breast cancer: preliminary report.
Tumori. Oct 31 1984;70(5):455-458.

45. Sterns EE, Zee B, SenGupta S, Saunders FW. Thermography. Its relation to pathologic characteristics, vascularity, proliferation rate, and survival of patients with invasive ductal carcinoma of the breast.
Cancer. Apr 1 1996;77(7):1324-1328.

46. Sterns EE, Zee B. Thermography as a predictor of prognosis in cancer of the breast.
Cancer. Mar 15 1991;67(6):1678-1680.

47. Head JF, Elliott RL. Thermography. Its relation to pathologic characteristics, vascularity, proliferation rate, and survival of patients with invasive ductal

carcinoma of the breast. *Cancer*.
Jan 1 1997;79(1):186-188.

48. von Fournier D, Weber E, Hoeffken W, Bauer M, Kubli F, Barth V. Growth rate of 147 mammary carcinomas.
Cancer. Apr 15 1980;45(8):2198-2207.

49. Stark AM, Way S. The screening of well women for the early detection of breast cancer using clinical examination with thermography and mammography.
Cancer. Jun 1974;33(6):1671-1679.

50. Nyirjesy I, Billingsley FS. Detection of breast carcinoma in a gynecologic practice.
Obstet Gynecol. Dec 1984;64(6):747-751.

The Breast Journal, Volume 4, Number 4, 1998, 245-251

Infrared Imaging of the Breast: Initial Reappraisal Using High-Resolution Digital Technology in 100 Successive Cases of Stage I and II Breast Cancer.

Study done by:

Department of Oncology,

St. Mary's Hospital, Montreal, Quebec;

Department of Radiotherapy,

London Cancer Center, London, Ontario; and Ville Marie Breast and Oncology Center, Montreal, Quebec, Canada.

CONCLUSION:

Our initial experience would suggest that, when done concomitantly with clinical exam and mammography, high-resolution digital infrared imaging can provide additional safe, practical, and objective information. Our initial reappraisal would also suggest that infrared imaging, based more on process than structural changes and requiring neither contact, compression, radiation nor venous access, can provide pertinent and practical complementary information to both clinical exam and mammography, our current primary basic detection modalities.

Breast Cancer 2000 Apr 25;7(2):142-148

Skin Reactions after Breast-conserving Therapy and Prediction of Late Complications Using Physiological Functions.

Study done by:

Department of Radiology,

Sekine H, Kobayashi M, Honda C, Aoki M, Nakagawa M, Kanehira C;

Division of Radiotherapy,

The Jikei University School of Medicine, 3-25-8 Nishi-Shinbashi, Minato-ku, Tokyo 105-8461, Japan.

CONCLUSION:

The temperature of the skin remains elevated long after breast-conserving treatment with irradiation, perhaps because evaporative cooling is impaired. We investigated physiological changes of the irradiated skin and reevaluated the radiosensitivity of sweat glands on a functional basis to determine whether severe complications can be predicted. METHODS: Breast and axillary skin temperatures were measured with thermography and sweat production in response to local thermal stimuli was measured on the basis of changes in electrical skin resistance with a bridge circuit in 45 women before, during, and after breast irradiation for breast cancer. RESULTS: Breast and axillary temperatures were significantly increased after irradiation. In response to cutaneous thermal stimuli, the electric skin resistance of nonirradiated areas decreased significantly because of sweating, but that of irradiated areas was unchanged. CONCLUSION: Impairment of sweating may play an important role in skin damage after irradiation. Although glandular tissue is not usually radiosensitive, the results of our functional assessment suggest that sweat glands are more radiosensitive than expected.

Int J Fertil Womens Med Sep-Oct 2001 ;46(5):238-47

Circadian rhythm chaos: a new breast cancer marker.

Study done by:

Department of Obstetrics and Gynecology,

Northwestern University Medical School, Chicago, Illinois, USA.
Keith LG, Oleszczuk JJ, Laguens M.;

CONCLUSION:

The most disappointing aspect of breast cancer treatment as a public health issue has been the failure of screening to improve mortality figures. Since treatment of late-stage cancer has indeed advanced, mortality can only be decreased by improving the rate of early diagnosis. From the mid-1950s to the mid-1970s, it was expected that thermography would hold the key to breast cancer detection, as surface temperature increases overlying malignant tumors had been demonstrated by thermographic imaging. Unfortunately, detection of the 1-3 degrees C thermal differences failed to bear out its promise in early identification of cancer. In the intervening two-and-a-half decades, three new factors have emerged: it is now apparent that breast cancer has a lengthy genesis; a long-established tumor-even one of a certain minimum size-induces increased arterial/capillary vascularity in its vicinity; and thermal variations that characterize tissue metabolism are circadian ("about 24 hours") in periodicity. This paper reviews the evidence for a connection between disturbances of circadian rhythms and breast cancer. Furthermore, a scheme is proposed in which circadian rhythm "chaos" is taken as a signal of high risk for breast cancer even in the absence of mammographic evidence of neoplasm or a palpable tumor. Recent studies along this line suggest that an abnormal thermal sign, in the light of our present knowledge of breast cancer, is ten times as important an indication as is family history data.

J Biomech Eng. 2004 Apr;126(2):204-11.

Effect of forced convection on the skin thermal expression of breast cancer.

Study done by:

School of Mechanical Engineering, Purdue University,

West Lafayette, IN 47907, USA.
Hu L, Gupta A, Gore JP, Xu LX.;

CONCLUSION:

A bioheat-transfer-based numerical model was utilized to study the energy balance in healthy and malignant breasts subjected to forced convection in a wind tunnel. Steady-state temperature distributions on the skin surface of the breasts were obtained by numerically solving the conjugate heat transfer problem. Parametric studies on the influences of the airflow on the skin thermal expression of tumors were performed. It was found that the presence of tumor may not be clearly shown due to the irregularities of the skin temperature distribution induced by the airflow field. Nevertheless, image subtraction techniques could be employed to eliminate the effects of the flow field and thermal noise and significantly improve the thermal signature of the tumor on the skin surface. Inclusion of the possible skin vascular response to cold stress caused by the airflow further enhances the signal, especially for deeply embedded tumors that otherwise may not be detectable.

Study done by:

Department of Work Environment,

University of Massachusetts Lowell, 1 University Avenue, MA 01854, Lowell, USA,

Gold JE, Cherniack M, Buchholz B

Eur J Appl Physiol. 2004 Oct;93(1-2):245-51.

PURPOSE:

Infrared thermography for examination of skin temperature in the dorsal hand of office workers.

CONCLUSION:

Reduced blood flow may contribute to the pathophysiology of upper extremity musculoskeletal disorders (UEMSD), such as tendinitis and carpal tunnel syndrome. The study objective was to characterize potential differences in cutaneous temperature, among three groups of office workers assessed by dynamic thermography following a 9-min typing challenge: those with UEMSD, with (n=6) or without (n=10) cold hands exacerbated by keyboard use, and control subjects (n=12). Temperature images of the metacarpal region of the dorsal hand were obtained 1 min before typing, and during three 2-min sample periods [0-2 min (early), 3-5 min (middle), and 8-10 min (late)] after typing. Mean temperature increased from baseline levels immediately after typing by a similar magnitude, 0.7 (0.3) degrees C in controls and 0.6 (0.2) degrees C in UEMSD cases without cold hands, but only by 0.1 (0.3) degrees C in those with cold hands. Using paired t-tests for within group comparisons of mean dorsal temperature between successive imaging periods, three patterns of temperature change were apparent during 10 min following typing. Controls further increased mean temperature by 0.1 degrees C (t-test, P=0.001) at 3-5 min post-typing before a late temperature decline of -0.3 degrees C (t-test, P=0.04), while cases without cold hands showed no change from initial post-typing mean temperature rise during middle or late periods. In contrast, subjects with keyboard-induced cold hands had no change from initial post-typing temperature until a decrease at the late period of -0.3 degrees C (t-test, P=0.06). Infrared thermography appears to distinguish between the three groups of subjects, with keyboard-induced cold hand symptoms presumably due, at least partially, to reduced blood flow.

Study done by:

Department of Obstetrics and Gynecology,

Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel,
Gat Y, Bachar GN, Zukerman Z, Belenky A, Gorenish M. Andrology

J Urol. 2004 Oct; 172(4 Pt 1):1239-40

PURPOSE:

We evaluated the sensitivity of 3 noninvasive methods for detecting left and right varicoceles. MATERIALS AND METHODS: Three noninvasive methods for the detection of varicocele in the left and right internal spermatic veins were evaluated in 214 infertile men, namely, physical examination, scrotal contact thermography and ultrasound Doppler. Venography was used as the reference diagnosis. RESULTS: Varicocele was detected in 195 patients (91.1%), on the left side in 37 (19%), on the right side in 3 (1.5%) and bilaterally in 155 (79.5%). Scrotal contact thermography using varicoscreen proved to be the most accurate method. Sensitivity, specificity, accuracy and positive predictive value were 98.9%, 66.6%, 98.5% and 100%, respectively, for left varicocele, and 95.6%, 91.6%, 94.9% and 98%, respectively, for right varicocele. Doppler sonography was associated with the highest number of false-positive results. Accuracy in evaluating retrograde flow was lowest for both sides for physical examination and highest for the combination of Doppler sonography and contact thermography, with a sensitivity, specificity, accuracy and positive predictive value of 100%, 33.3%, 99.0% and 98.9%, respectively, for the left side, and 97.4%, 58.3%, 90.3% and 91.1%, respectively, for the right side. In 165 (85%) of the 195 patients who underwent internal spermatic vein embolization sperm parameters were improved.

CONCLUSION:

The present study yielded 2 major findings. Thermography is more sensitive and accurate for the detection of varicocele than Doppler ultrasound and physical examination, and it can be used for screening as a single modality in infertile men. Doppler ultrasound and thermography are complementary and their combined use yields the highest sensitivity and accuracy.

Study done by:

Department of Rheumatology,

Duke University Medical Center, Durham, NC 27710, USA.

Varju G, Pieper CF, Renner JB, Kraus VB.

2004 Jul;43(7):915-9. Epub 2004 May 04.

PURPOSE:

Assessment of hand osteoarthritis: correlation between thermographic and radiographic methods.

Anatomical stages of digital osteoarthritis (OA) have been characterized radiographically as progressing through sequential phases from normal to osteophyte formation, progressive loss of joint space, joint erosion and joint remodelling. Our study was designed to evaluate a physiological parameter, joint surface temperature, measured with computerized digital infrared thermal imaging, and its association with sequential stages of radiographic OA (rOA). METHODS: Thermograms, radiographs and digital photographs were taken of both hands of 91 subjects with nodal hand OA. Temperature measurements were made on digits 2-5 at distal interphalangeal (DIP) joints, proximal interphalangeal (PIP) joints and metacarpophalangeal (MCP) joints (2184 joints in total). We fitted a repeated measures ANCOVA model to analyse the effects of rOA on temperature, with handedness, joint group, digit and NSAID use as covariates. RESULTS: The reliability of the thermoscanning procedure was high (generalizability coefficient 0.899 for two scans performed 3 h apart). The mean joint temperature decreased with increasing rOA severity, defined by the Kellgren-Lawrence (KL) scale. The mean temperature of KL0 joints was significantly different from that of each of the other KL grades (P </= 0.002). After adjustment for the other covariates, there was a strong association of rOA with joint surface temperature (P<0.001). The earliest discernible radiographic disease (KL1) was associated with a higher surface temperature than KL0 joints (P = 0.01) and a higher surface temperature than any other KL grade. Joint erosions were not associated with a change in joint temperature.

CONCLUSION:

Joint surface temperature varied with the severity of rOA. Joints were warmer than normal at the onset of OA. As the severity of rOA worsened, joint surface temperature declined. These data support the supposition that digital OA progresses in phases initiated by an inflammatory process. The cooler surface temperatures in later stages of the disease may in part explain the paucity of symptoms reported by patients with hand OA.

Study done by:

Department of Dental Engineering, Tsurumi

University School of Dental Medicine, 2-1-3 Tsurumi, Tsurumi-ku, Yokohama 230-8501, Japan.

Komoriyama M, Nomoto R, Tanaka R, Hosoya N, Gomi K, Iino F, Yashima A, Takayama Y, Tsuruta M, Tokiwa H, Kawasaki K, Arai T, Hosoi T, Hirashita A, Hirano S.

230-8501

PURPOSE:

devise and propose appropriate conditions for the photographing of thermal images in the oral cavity and to evaluate which thermography techniques can be applied to dentistry by evaluating the differences in temperature among oral tissues. Thermal images of oral cavities of 20 volunteers in normal oral condition were taken according to the guidelines of the Japanese Society of Thermography, with five added items for oral observation. The use of a mirror made it possible to take thermal images of the posterior portion or palate. Teeth, free gingiva, attached gingiva and alveolar mucosa were identified on thermal images. There were differences in temperature between teeth, free gingiva, attached gingiva and alveolar mucosa. These were nearly in agreement with the anatomical view.

CONCLUSION:

Thermography need no longer be restricted to the anterior portion using a mirror, and can now be applied to the dental region.

Study done by:

Department of Clinical Veterinary Medicine,

University of Cambridge, Madingley Road, Cambridge, Cambridgeshire CB3 0ES, UK.

Tunley BV, Henson FM;

Equine Vet J. 2004 May;36(4):306-12.

PURPOSE:

Reliability and repeatability of thermographic examination and the normal thermographic image of the thoracolumbar region in the horse.

Thermographic imaging is an increasingly used diagnostic tool. When performing thermography, guidelines suggest that horses should be left for 10-20 mins to 'acclimatise' to the thermographic imaging environment, with no experimental data to substantiate this recommendation. In addition, little objective work has been published on the repeatability and reliability of the data obtained. Thermography has been widely used to identify areas of abnormal body surface temperature in horses with back pathology; however, no normal data is available on the thermographic 'map' of the thoracolumbar region with which to compare horses with suspected pathology.

OBJECTIVES: To i) investigate whether equilibration of the thermographic subject was required and, if so, how long it should take, ii) investigate what factors affect time to equilibration, iii) investigate the repeatability and reliability of the technique and iv) generate a topographic thermographic 'map' of the thoracolumbar region.

METHODS: A total of 52 horses were used. The following investigations were undertaken: thermal imaging validation, i.e. detection of movement around the baseline of an object of constant temperature; factors affecting equilibration; pattern reproducibility during equilibration and over time (n = 25); and imaging of the thoracolumbar region (n = 27).

RESULTS: A 1 degrees C change was detected in an object of stable temperature using this detection system, i.e the 'noise' in the system. The average time taken to equilibrate, ie. reach a plateau temperature, was 39 mins (40.2 in the gluteal region, 36.2 in lateral thoracic region and 40.4 in metacarpophalangeal region). Only 19% of horses reached plateau within 10-20 mins. Of the factors analysed hair length and difference between the external environment and the internal environment where the measurements were being taken both significantly affected time to plateau ($P<0.05$). However, during equilibration, the thermographic patterns obtained did not change, nor when assessed over a 7 day period. A 'normal' map of the surface temperature of the thoracolumbar region has been produced, demonstrating that the midline is the hottest, with a fall off of 3 degrees C either side of the midline.

CONCLUSION:

This study demonstrates that horses may not need time to equilibrate prior to taking thermographic images and that thermographic patterns are reproducible over periods up to 7 days. A topographical thermographic 'map' of the thoracolumbar region has been obtained. POTENTIAL RELEVANCE: Clinicians can obtain relevant thermographic images without the need for prior equilibration and can compare cases with thoracolumbar pathology to a normal topographic thermographic map.

Study done by:

The Centre for Sleep Research

University of South Australia, Level 5 Basil Hetzel Institute, The Queen Elizabeth Hospital, Woodville, SA 5011, Australia

Van den Heuvel CJ, Ferguson SA, Dawson D, Gilbert SS.

Physiol Meas. 2003 Aug;24(3):717-25.

PURPOSE:

Comparison of digital infrared thermal imaging (DITI) with contact thermometry: pilot data from a sleep research laboratory.

Body temperature regulation is associated with changes in sleep propensity; therefore, sleep research often necessitates concomitant assessment of core and skin surface temperatures. Attachment to thermistors may limit the range of movement and comfort, introducing a potential confound that may prolong sleep initiation or increase wakefulness after sleep onset. It has been suggested that contact thermometry may artificially increase temperatures due to insulation. We report here on a method of remote sensing skin temperatures using a digital infrared thermal imaging (DITI) system, which can reduce these potential confounds. Using data from four healthy young adult volunteers (age = 26.8 +/- 2.2 years; mean +/- SEM), we compared measures of skin temperature using a DITI system with contact thermometry methods already in use in our sleep laboratory. A total of 416 skin temperature measurements ($T_{(sk)}$) were collected from various sites, resulting in an overall correlation coefficient of $R = 0.99$ ($p < 0.0001$) between both methods. Regression analyses for individuals resulted in correlation coefficients between 0.80 and 0.97.

CONCLUSION:

These pilot results suggest that DITI can assess skin surface temperatures as accurately as contact thermometry, provided the interest is in relative and not absolute temperature changes. This and some other important limitations are discussed in more detail hereafter.

Study done by:

Department of Cardiology

University Clinic Essen , Germany . Axel.

Schmermund A, Rodermann J, Erbel R.

Herz. 2003 Sep;28(6):505-12.

PURPOSE:

Reliability and repeatability of thermographic examination and the normal thermographic image of the thoracolumbar region in the horse.

Arteriosclerosis is an inflammatory disease. Inflammatory processes play a role in the initiation of plaque development and the early stages of the disease as well as in complex plaques and complications such as intraarterial thrombosis. A method to detect inflammation in coronary arteries has the potential to characterize both local and systemic activation of arteriosclerotic plaque disease. It could help to define in more detail what constitutes a vulnerable plaque or vulnerable vessel and thus improve the prediction of acute coronary syndromes. Intracoronary thermography records a cardinal sign of inflammation. Heat is probably produced by (activated) macrophages. Experimental work has suggested that thermal heterogeneity is present in arteriosclerotic plaques and that increased temperature is found at the site of inflammatory cellular-macrophage-infiltration. Preliminary experience in patients undergoing coronary angiography has demonstrated that it is safe and feasible to perform intracoronary thermography using various systems. A graded relationship between thermal heterogeneity and clinical symptoms has been reported, with the greatest temperature elevation in acute myocardial infarction. Increases in thermal heterogeneity appeared to be associated with a comparably unfavorable long-term prognosis.

CONCLUSION:

Intracoronary thermography has the potential to provide insights into location and extent of inflammation as well as the prognostic consequences. Currently, this novel method and the underlying concepts are extensively evaluated.

Study done by:

Department of Internal Medicine

State University of New York at Buffalo, Buffalo, NY, USA.

Bhatia V, Bhatia R, Dhindsa S, Dhindsa M.

South Med J. 2003 Nov;96(11):1142-7.

PURPOSE:

Atherosclerosis is currently considered to be an inflammatory and thus a systemic disease affecting multiple arterial beds. Recent advances in intravascular imaging have shown multiple sites of atherosclerotic changes in coronary arterial wall. Traditionally, angiography has been used to detect and characterize atherosclerotic plaque in coronary arteries, but recently it has been found that plaques that are not significantly stenotic on angiography cause acute myocardial infarction. As a result, newer imaging and diagnostic modalities are required to predict which of the atherosclerotic plaque are prone to rupture and hence distinguish "stable" and "vulnerable" plaques. Intravascular ultrasound can identify multiple plaques that are not seen on coronary angiography.

CONCLUSION:

Thermography has shown much promise and is based on the concept that the inflammatory plaques are associated with increased temperature and can also identify "vulnerable patients." Of all these newer modalities, magnetic resonance imaging has shown the most promise in identification and characterization of vulnerable plaques. In this article, we review the newer coronary artery imaging modalities and discuss the limitations of traditional coronary angiography.

Study done by:

Department of Neurological Surgery

Mayo Clinic and Foundation, Rochester, Minnesota, USA.

Ecker RD, Goerss SJ, Meyer FB, Cohen-Gadol AA, Britton JW, Levine JA.

J Neurosurg 2002 Dec;97(6):1460-71

High-resolution dynamic infrared (DIR) imaging provides intraoperative real-time physiological, anatomical, and pathological information; however, DIR imaging has rarely been used in neurosurgical patients. The authors report on their initial experience with intraoperative DIR imaging in 30 such patients. A novel, long-wave (8-10 micron), narrow-band, focal-plane-array infrared photodetector was incorporated into a camera system with a temperature resolution of 0.006 degrees C, providing 65,000 pixels/frame at a data acquisition rate of 200 frames/second. Intraoperative imaging of patients was performed before and after surgery. Infrared data were subsequently analyzed by examining absolute differences in cortical temperatures, changes in temperature over time, and infrared intensities at varying physiological frequencies. Dynamic infrared imaging was applied in a variety of neurosurgical cases. After resection of an arteriovenous malformation, there was postoperative hyperperfusion of the surrounding brain parenchyma, which was consistent with a loss of autoregulation. Bypass patency and increased perfusion of adjacent brain were documented during two of three extracranial-intracranial bypasses. In seven of nine patients with epilepsy the results of DIR imaging corresponded to seizure foci that had been electrocorticographically mapped preoperatively. Dynamic infrared imaging demonstrated the functional cortex in four of nine patients undergoing awake resection and cortical stimulation. Finally, DIR imaging exhibited the distinct thermal footprints of 14 of 16 brain tumors. Dynamic infrared imaging may prove to be a powerful adjunctive intraoperative diagnostic tool in the neurosurgical imaging armamentarium. Real-time assessment of cerebral vessel patency and cerebral perfusion are the most direct applications of this technology. Uses of this imaging modality in the localization of epileptic foci, identification of functional cortex during awake craniotomy, and determination of tumor border and intraoperative brain shift are avenues of inquiry that require further investigation.

Study done by:

Department of Pediatrics

University of Graz, Austria.

Christidis I, Zotter H, Rosegger H, Engele H, Kurz R, Kerbl R.

Gynakol Geburtshilfliche Rundsch 2003;43(1):31-5

PURPOSE:

t was the aim of this study to investigate the surface temperature in newborns within the first hour after delivery. Furthermore, the influence of different environmental conditions with regard to surface temperature was documented. METHODS: Body surface temperature was recorded under several environmental conditions by use of infrared thermography. 42 newborns, all delivered at term and with weight appropriate for date, were investigated under controlled conditions.

RESULTS: The surface temperature immediately after birth shows a uniform picture of the whole body; however, it is significantly lower than the core temperature. Soon after birth, peripheral sites become cooler whereas a constant temperature is maintained at the trunk. Bathing in warm water again leads to a more even temperature profile. Radiant heaters and skin-to-skin contact with the mother are both effective methods to prevent heat loss in neonates.

CONCLUSION:

Infrared thermography is a simple and reliable tool for the measurement of skin temperature profiles in neonates. Without the need of direct skin contact, it may be helpful for optimizing environmental conditions at delivery suites and neonatal intensive-care units." Ref. S. Karger AG, Basel

Study done by:

Department of

College of Nursing, NBICU, University of Utah, Salt Lake City, USA.

J Perinat Neonatal Nurs

2000 Mar;13(4):50-66

Findings:

Septicemia is a growing problem among low birth weight infants. Early identification and treatment of sepsis in these infants would help to reduce the high mortality and morbidity seen with this disorder. Newer techniques may make earlier diagnosis a reality. In the following review article, early-onset sepsis in the premature infant is described, specifically focusing on the neonatal inflammatory response, neutropenia, and its somewhat inconsistent and delayed role as a marker for sepsis risk factors. Physiological signs, laboratory indicators, skin temperature, peripheral perfusion, and the interaction of macro-environmental factors are also discussed. Newer (neoteric) immunologic and cytokine markers of sepsis are reviewed. Finally, thermography, a noninvasive bioinstrument measuring vasoactive peripheral perfusion, which has potential for early recognition of neonatal septicemia, is described.

Study done by:

Department of Radiology

Kurashiki Central Hospital, Kurashiki, Japan.

Watanabe Y.

2002 Mar;12(2):149-53

Findings:

Color Doppler ultrasound has been the mainstay for the evaluation of the scrotum in a variety of clinical settings. However, ultrasonography results are not always accurate or conclusive. Despite the high cost and limited availability, magnetic resonance imaging with the dynamic contrast-enhanced subtraction technique provides accurate information on morphology as well as blood flow. Infrared scrotal thermography increases accuracy in the diagnosis of varicocele. This article attempts to summarize recent advances in scrotal imaging with regard to testicular and extratesticular disorders.

Study done by:

Department of Colorectal Surgery

Wilford Hall Medical Center, San Antonio, Texas, USA.

Brooks JP, Perry WB, Putnam AT, Karulf RE

Dis Colon Rectum 2000 Sep;43(9):1319-21

PURPOSE: The aim of this study was to introduce thermal imaging in the intraoperative detection of bowel ischemia by comparing thermal imaging with conventional techniques in detecting acutely ischemic bowel, using histologic evidence for intestinal necrosis as the standard.

METHODS: A prospective study was performed using a porcine model. Laparotomy was performed on four pigs under general anesthesia. A 25-cm segment of mid jejunum was tagged with proximal and distal sutures, and its mesentery was ligated and divided. Thermal imaging, visual inspection, Doppler ultrasound, and fluorescence with Wood's lamp after fluorescein were used to estimate the extent of bowel ischemia five minutes after ligation of the mesentery. Measurements were taken in reference to both the proximal and distal tags to obtain two data points per animal for each method. After two hours of warm ischemia, the jejunum was harvested and sectioned longitudinally. Comparisons were made between the estimated region of necrosis for each method and microscopic evidence of necrosis.

RESULTS: Visual inspection was the only method unable to detect a difference between vascularized and devascularized bowel for each of the eight data points. Fluorescein dye missed 3 cm of ischemic bowel. Doppler ultrasound and thermal imaging were 100 percent sensitive for necrotic bowel, with thermal imaging overestimating necrosis to a greater extent than Doppler ultrasound. The positive predictive value of fluorescein dye, Doppler ultrasound, and thermal imaging for determining nonviable bowel was 91.8, 80.8, and 69.5 percent, respectively.

CONCLUSIONS: Thermal imaging has the potential to be a useful adjunct in the intraoperative determination of bowel ischemia. Further studies are indicated to study this technique.

Study done by:

Department of Neurosurgery

Yongdong Severance Hospital, Yonsei College of Medicine, Seoul, Korea

Zhang HY, Kim YS, Cho YE

Yonsei Med J 1999 Oct;40(5):401-12

Subjective symptoms of a cool or warm sensation in the arm could be shown objectively by using of thermography with the detection of thermal change in the case of radiculopathy, including cervical disc herniation (CDH). However, the precise location of each thermal change at CDH has not been established in humans. This study used digital infrared thermographic imaging (DITI) for 50 controls and 115 CDH patients, analyzed the data statistically with t-test, and defined the areas of thermatomal change in CDH C3/4, C4/5, C5/6, C6/7 and C7/T1. The temperature of the upper trunk and upper extremities of the control group ranged from 29.8 degrees C to 32.8 degrees C. The minimal abnormal thermal difference in the right and left upper extremities ranged from 0.1 degree C to 0.3 degree C in 99% confidence interval. If delta T was more than 0.1 degree C, the anterior middle shoulder sector was considered abnormal ($p < 0.01$). If delta T was more than 0.3 degree C, the medial upper aspect of the forearm and dorsal aspect of the arm, some areas of the palm and anterior part of the fourth finger, and their opposite side sectors and all dorsal aspects of fingers were considered abnormal ($p < 0.01$). Other areas except those mentioned above were considered abnormal if delta T was more than 0.2 degree C ($p < 0.01$). In $p < 0.05$, thermal change in CDH C3/4 included the posterior upper back and shoulder and the anterior shoulder. Thermal change in CDH C4/5 included the middle and lateral aspect of the triceps muscle, proximal radial region, the posterior medial aspect of the forearm and distal lateral forearm. Thermal change in CDH C5/6 included the anterior aspects of the thenar, thumb and second finger and the anterior aspects of the radial region and posterior aspects of the pararadial region. Thermal change in CDH C6/7 included the posterior aspect of the ulnar and palmar region and the anterior aspects of the ulnar region and some fingers. Thermal change in CDH C7/T1 included the scapula and posterior medial aspect of the arm and the anterior medial aspect of the arm. The areas of thermal change in each CDH included wider sensory dermatome and sympathetic dermatome There was a statistically significant change of temperature in the areas of thermal change in all CDH patients. In conclusion, the areas of thermal change in CDH can be helpful in diagnosing the level of disc protrusion and in detecting the symptomatic level in multiple CDH patients.