Contact-Thermography: a scientific evaluation

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Abbreviations

CT	Contact thermography
DVT	Deep Vein Thrombosis
LCCT	Liquid crystal contact thermography
MVD	Microvessel density
US	Ultrasound

Summary

We have examined approximately 200 publications that were associated with thermography from the National Centre for Biotechnology Information and catalogued at the National Library of Medicine (www.ncbi.nlm.nih.gov/). Of these we have reviewed 29 articles for their content, methodology and results.

Although we have not identified any level I or level II evidence associated with contact thermography (CT) nevertheless there is ample evidence to support the use and continued evaluation of this adjuvant screening technique.

Thermography is predominantly a risk marker for breast pathology procedure, which is non-invasive and non-compressive. Perhaps the most pertinent evidence comes from an extensive cohort study of 58,000 patients over a 12 year span that made a significant contribution to the evaluation of patients suspected of having breast cancer. Thermography was then labelled a useful and non toxic tool in the detection of breast cancer. The advent of powerful computers and advances in electronic imaging techniques has further enhanced medical thermography. Today there are systems and detectors with high resolution and temperature sensitivity. Computer algorithms can process raw thermal data and produce high quality profiles of thermal images.

We conclude from the evidence that is currently available that contact thermography may constitute a low cost adjuvant intervention that could be a yearly evaluation as part of a routine physical assessment for women who find mammography a painful and difficult procedure. Therefore as soon as a suspicious (positive) breast thermal examination is performed, the appropriate follow-up diagnostic and clinical testing can be ordered. This would include mammography and other imaging tests, clinical laboratory procedures, nutritional and lifestyle evaluation and training in breast self examination. Thermography is a simple, non-invasive, highly accurate, inexpensive form of diagnostic imaging as well as a ‘breast friendly’ procedure.

Contact-Thermography: Literature Review

Thermoregulation is the control of body temperature. The liver produces a lot of heat, which is transported around the body by the blood. Normal body temperature in humans is 37°C. Stability and circadian variation in core body temperature are homeostatic responses that have been well documented for many decades.[1] Research in thermal physiology has illuminated several of the deficits present in the understanding of temperature regulation, and while these discoveries are still evolving, existing information provides valuable clues about physiological responses to heat loss or over-heating that could improve clinical assessment and intervention. Hence, in a healthy individual, body temperature is kept constant in a very small range despite large differences in temperature of the surroundings and also those in physical activity. Strict regulation of body temperature, necessary for optimal progress of enzymatic reactions, is developed in all homoiotermic animals that include humans.

The pathophysiology of heat patterns assumes the diseases of the inner organs and irregularities of their functions are reflected in the heat pattern of the epidermis and can be used diagnostically. The physiology of thermodiagnosis is intimately associated with the brain, the parasympathetic and sympathetic nervous systems (Figure 1). Moreover, the skin circulation and its heat value are largely influenced by processes within the body. The physiology and anatomy of the vascular supply to the skin produces a certain temperature pattern that may be within certain limits that are considered normal. Yet humans show strong deviations from this ideal pattern. Such deviations may have underlying chronic illness correlations. For example in neonatal medicine middle ear infections in neonates often present as a unilateral complaint. That is one side of the head and face produces a pattern of local area temperature increases such as reddening of that side of the face whilst the other side remains normal.[2]

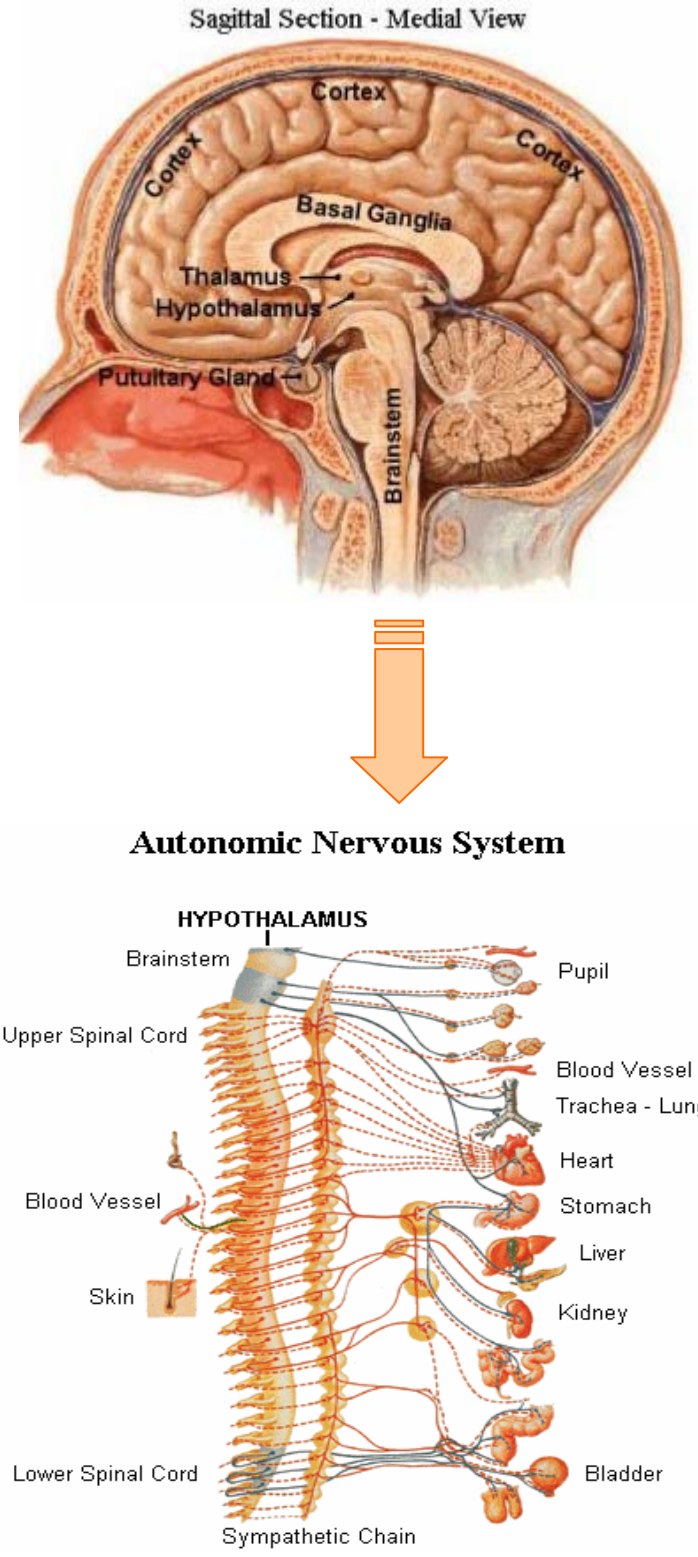
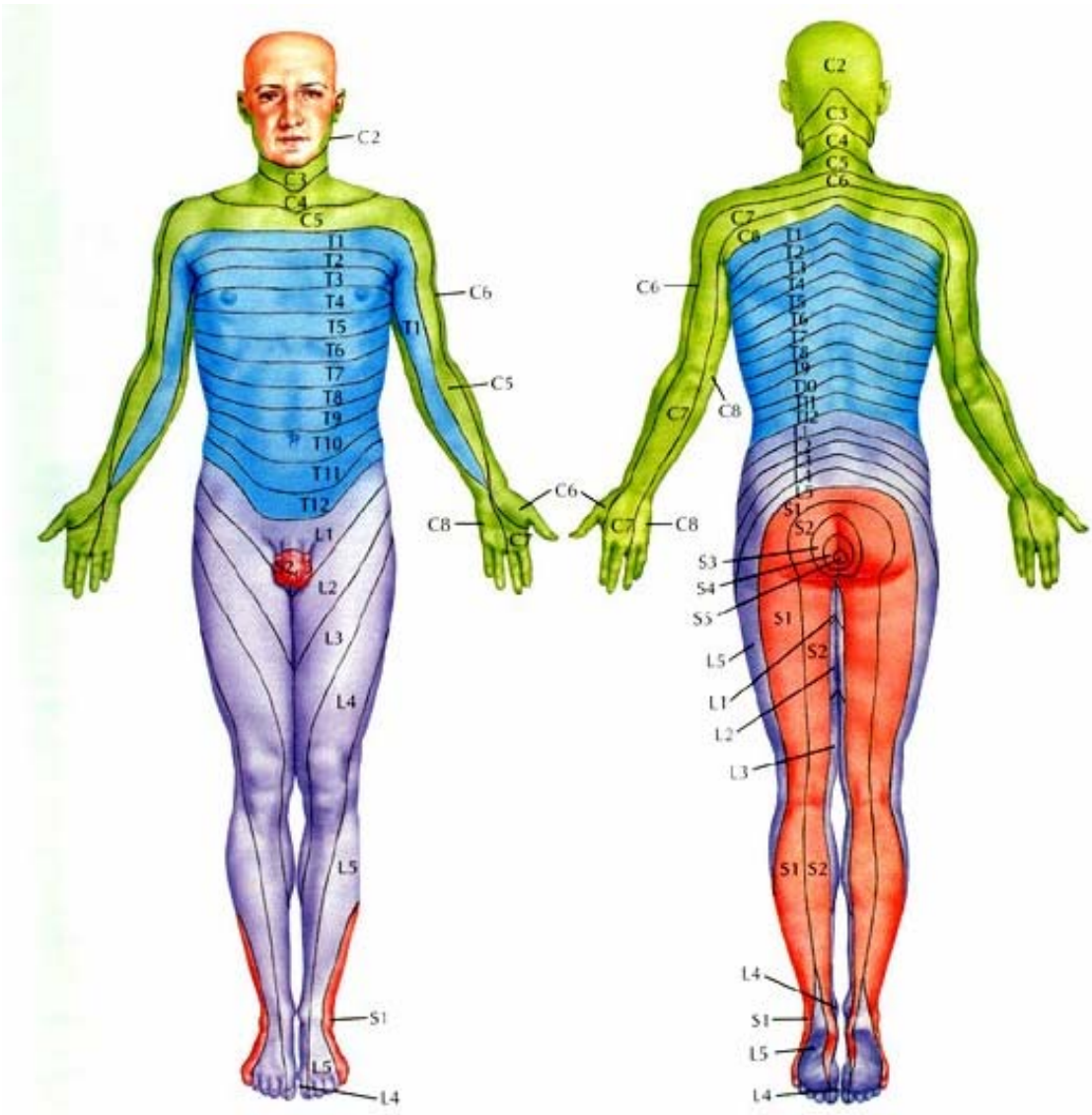


Figure 1 – Brain and autonomic nervous system

Nerves coming from the spinal cord supply the accompanying body segment with skin and internal organs in their sensitive, vegetative and motor development (Figure 2).



Levels of principal dermatomes

C5	Clavicles
C5, 6, 7	Lateral parts of upper limbs
C8, T1	Medial sides of upper limbs
C6	Thumb
C6, 7, 8	Hand
C8	Ring and little fingers
T4	Level of nipples
T10	Level of umbilicus
T12	Inguinal or groin regions
L1, 2, 3, 4	Anterior and inner surfaces of lower limbs
L4, 5, S1	Foot
L4	Medial side of great toe
S1, 2, L5	Posterior and outer surfaces of lower limbs
S1	Lateral margin of foot and little toe
S2, 3, 4	Perineum

Figure 2 - The segmental innervation of the skin – dermatomes

An electronic search of the medical and scientific literature that included Medline and the Cochrane databases for articles and reviews published between 1966 and 2001 was conducted. The key words that were used included: *thermoregulation, contact*

thermography, contact thermography and chronic diseases, contact thermography and premature births, contact regulation thermography, contact thermography and breast cancer.

In this report all relevant studies were reviewed on two aspects that included methodology and intervention results. When reviewing research methodologies, the patient selection criteria and procedure, the study design and the variability and reliability of the instrumentation were investigated. The quality of studies was rated according to a four point rating system. This rating system is recommended by the Quality of Care and Health Outcomes Committee and has been adapted from the system developed by the US Preventive ServicesTask Force, which has also been adopted by the National Health and Medical Research Council of Australia. The rating system consists of the following:

- **Level I Evidence** is obtained from a systematic review of all relevant randomised controlled trials – meta analyses.
- **Level II Evidence** is obtained from at least one properly designed randomised controlled clinical trial.
- **Level III Evidence** is obtained from well designed controlled trials without randomisation or from well designed cohort or case control analytic design studies, preferably from more than one centre or research group or from multiple time series with or without an intervention.
- **Level IV Evidence** represents the opinions of respected authorities based on clinical experience, descriptive studies or reports of expert committees.

Recently and following the development and advent of precision temperature measuring instruments known as contact thermometers contact thermography has evolved as a significant and reliable diagnostic method.[3] The scientific published evidence has shown that thermography is a very instructive method of showing the interaction between direct changes in heat radiation of the surface of the skin and its relation to reflex processes.[4]

We have identified from the medical/scientific literature 29 studies comprising either a level III or level IV evidence. These studies show significant methodological detail to afford the authors with a critical appraisal of their validity and reliability.[5-33]

In neonatal medicine, recent studies have shown that measuring lateral skin temperature profile of premature infants in incubators with thermography has enabled skin measurements to be carried out without stress caused by direct contact of probes to the skin. The results verified the greater accuracy and specificity for the use of thermography for measuring skin temperature of preterm infants in incubators.[5] Whereas in a further study of skin temperature measurements in premature infants a comparison of infrared telethermography and electric contact thermometry concluded that in clinical practice, infrared thermography and conductive thermometry can be successfully used for determinations of body surface temperature of premature infants, also under the condition of high temperatures and high humidity within an incubator.[15]

Numerous investigators from different geographical regions that include Denmark, France, Germany, Italy, Japan, United Kingdom and the United State have investigated the effects of contact thermography and more recently liquid crystal contact thermography in chronic diseases such as cancer.

Thermography has been shown to have a useful role as an adjuvant diagnostic tool. The reason for the thermal abnormality associated with some breast cancers is unclear, yet published studies show that an abnormal thermogram can be associated with large tumour size, high grade, and lymph node positivity.[9]

Numerous studies investigating breast abnormalities have shown that contact thermography was effective as a diagnostic tool with high sensitivity for detecting breast abnormalities.[7 11 18 21-23 31 33] Breast abnormalities in breast cancer patients were associated with increases in local regional hyperthermia as related to the tumour as well as a useful adjuvant tool for diagnosing suspected breast neoplasms.

Further contact thermography has also been useful in evaluating chemotherapeutic effectiveness by combining CT as an adjuvant diagnostic procedure.[13] In a preliminary report from Japan the significance of nipple hyperthermia in a contact thermogram aided in the prediction of breast cancer extension to the nipple. The results showed that contact thermography could enhance the detection of breast abnormalities.[34] In a case study of a woman with inflammatory breast cancer from Japan that was reported by Usuki and colleagues showed that CT was useful in evaluating preoperative chemotherapy.[21]

In an Italian study of contact thermography and breast development it was reported that CT was useful in evaluating pubertal breast development and in differentiating between premature thelarche and true precocious puberty.[28] Also in Italy in a study sample consisting of 12,000 patients it was shown that CT proved reliable in those patients aged under 30 in detecting benign pathologies or palpable nodules of the breast.[18]

Geshelin and colleagues have reported that CT is extremely useful as a supplementary diagnostic modality that can significantly distinguish between cancer of the breast and benign tumours.[23] Gautherie and Gros who have evaluated a cohort sample of 58,000 women in the USA over 12 years have reported that CT had made a significant contribution to the evaluation of patients suspected of having breast cancer.[33]

In a study from Japan with various cancer patients it was observed and reported that patients with abnormal CT profiles had cancer recurrences at more than one site.[26]

Contact thermography has also been extensively used in numerous other patient types and conditions that include deep vein thrombosis,[6 25 29 30 32] surgical patients that have examined wound healing,[8] skin damage due to chemical irritants,[27] diabetics with foot ulcers,[12 16] orthopaedic patients and those with temporomandibular dysfunction,[19 20] pregnant women with respiratory infections,[10] children with migraine,[14] facial pain and fifth cranial nerve neuralgia,[24] as well as lung cancer patients[17]

Published studies

Reference	Level	Source	Patient type	Method and outcome
Frankenberger RT et al, 1998[5]	IV	Total sample – not stated Sample – Germany	Premature infants	CT CT was useful in measuring skin temperature of preterm infants in incubators
Kohler A et al, 1998[6]	IV	Total sample – 112 Sample – USA	Deep vein thrombosis after proximal femur fractures	Liquid Crystal Contact Thermography (LCCT) LCCT has proved to be a suitable, cheap, non-invasive examination with a negative prediction value of 94%
Haga S et al, 1996[7]	IV	Total sample – 43 Sample – Japan	Breast cancer	CT 68% local regional hyperthermic area related to the tumour
Horzic M et al, 1996[8]	IV	Total sample – 30 Sample – USA	Surgical patients	CT The persistence of a wider zone of increased temperature after day 4 predicts the possibility of wound infection and disturbed healing
Sterns EE et al, 1996[9]	IV	Total sample – 420 Assessed – 181 Sample – Canada	Invasive ductal breast carcinoma	Doppler ultrasound (US) Microvessel density (MVD) Contact thermography (CT) Abnormal CT was associated with large tumour size, high grade and lymph node positivity
Fisher I et al, 1995[10]	IV	Total sample – not stated Sample – USSR	Pregnant women with tuberculosis	CT CT was an effective method for the detection of respiratory diseases in pregnant women
Abe R et al, 1994[11]	IV	Total sample – not stated Sample – Japan	Breast cancer	CT Clinically useful adjuvant diagnostic method for the early detection of breast cancer in some patients
Benbow SJ et al, 1994[12]	IV	Total sample – 30 Sample – USA	Diabetic patients with foot ulcers	LCCT Patients with high plantar foot temperatures are at increased risk of neuropathic foot ulceration
Kurihara T et al, 1993[13]	IV	Total sample – 6 Sample – Japan	Breast cancer	CT Chemotherapeutic effectiveness could be better evaluated by combining CT as an adjuvant diagnostic procedure
Wolstein JR et al, 1993[14]	III	Total sample – 64 54 cases 10 controls [Age matched] Sample – Canada	Children with migraine	CT Cases: 36% abnormal CT Controls: 10% abnormal CT
Hanssler I et al, 1992[15]	IV	Total sample – 6 Sample – Germany	Premature infants	CT CT was concluded as a useful determinant of body surface temperature of premature infants
Chan AW et al, 1991[16]	III	Total sample – 68 Cases – 35 Controls – 33 [Age, gender matched] Sample – USA	Diabetic patients with foot ulcers	CT Mean foot temperatures were significantly higher in cases than in controls

Reference	Level	Source	Disease stage and time since diagnosis and/or treatment	Method and outcome
Loviagin EV et al, 1991[17]	IV	Total sample – 42 Lung cancer – 40 Acute pneumonia – 2 Sample – USSR	Lung cancers and acute pneumonia	CT Local hyperthermia did not depend on a stage of lung cancer
Sforza M et al, 1991[18]	IV	Total sample – 12000 Sample – Italy	Breast abnormalities	CT CT proved reliable in patients aged under 30 with benign pathologies or palpable nodules
Specchiulli F et al, 1991[19]	IV	Total sample – 36 Sample – Italy	Orthopaedic patients	CT CT was an important diagnostic modality in these patients with low cost
Steed PA, 1991[20]	IV	Total sample – 109 Sample – USA	Temporomandibular dysfunction	CT CT proved to be a reliable indicator of pretreatment duration of dysfunction (chronicity pattern) in approximately 78% of the cases
Usuki H et al, 1991[21]	-	Total sample – 1 [Case report] Sample – Japan	Breast cancer	CT CT was found useful for an evaluation of pre-chemotherapy for inflammatory breast cancer
Yokoe T et al, 1990[22]	IV	Total sample – 162 Sample – Japan	Breast cancer	CT CT sensitivity for detecting breast abnormalities was 81.5% and 83.5% for specificity
Geshelin SA et al, 1989[23]	IV	Total sample – 162 Benign breast – 87 Malignant breast – 75 Sample – USSR	Breast abnormalities	CT CT may be considered as a supplementary diagnostic sign distinguishing cancer of the breast from benign tumours.
Hardy PA et al, 1989[24]	IV	Total sample – not stated Sample – UK	Facial pain and fifth cranial nerve neuralgia	CT CT was useful in detecting idiopathic trigeminal neuralgia
Hoffmann R et al, 1989[25]	IV	Total sample – 316 Sample – USA	Deep vein thrombosis	LCCT LCCT is well suited as screening method for DVTs
Ikeda T et al, 1989[26]	IV	Total sample – 97 Sample – Japan	Various cancer	CT Patients with abnormal CTs had recurrences at more than one site
Agner T et al, 1988[27]	IV	Total sample – 16 Sample – Denmark	Skin damage due to chemical irritants	CT CT for assessment of skin damage due to experimental irritants showed positive results
Frejaville E et al, 1988[28]	III	Total sample – 127 Cases – 22 Controls – 105 Sample – Italy	Breast development study	CT CT was useful in evaluating pubertal breast development and in differentiating between premature thelarche and true precocious puberty
Kjaer L et al, 1988[29]	IV	Total sample – 56 Sample – Denmark	DVT following major hip surgery	CT CT was not of value as a screening test for DVT following major hip surgery

Reference	Level	Source	Disease stage and time since diagnosis and/or treatment	Method and outcome
Nikulin MA et al, 1987[30]	IV	Total sample – 430 Sample – USSR	Vascular disease of the lower extremity	CT Useful objective assessment in alterations in blood circulation in the lower extremities resulting from a pathological process
Font Sastre et al, 1984[31]	IV	Total sample – 2523 Sample – France	Breast screening	CT A higher rate of positive global detections with our present analytic criteria for thermography
Jensen C et al, 1983[32]	IV	Total sample – 69 Sample – Denmark	DVT	CT CT is useful as a screening method
Gautherie M et al, 1980[33]	III	Total sample – 58000 [Over 12 years] Sample – USA	Breast cancer	CT CT made a significant contribution to the evaluation of patients suspected of having breast cancer

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