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A Review of the History of Thermography in Breast Cancer Detection-Part II: Questions and Answers

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SUMMARY

The second part of this review on historical papers related to detection of breast cancer by infrared thermal imaging provides answers to five common questions arising from the available literature. These questions are:
1. Are There Specific Thermal Features that Define Cancer?
2. What Size Lesions are Detected by Thermography?
3. Can Thermography Differentiate Between Malignant Lesions and Other Conditions?
4. Are Specific Types of Malignant or Benign Lesions More Often Detected by Themography Over Others?
5: Is Thermography a Useful Risk-assessment Model for Breast Cancer Detection ?
The answers provided discuss in detail strengths and weaknesses of thermography as a breast cancer detection. Despite a seemingly high false-positive rate, an abnormal thermogram may actually be providing a priori information about the prognosis and long-term survival potential of women at risk of developing breast cancer.

KEY WORDS: breast cancer, review, infrared thermal imaging, prognosis, risk assessment

EINE ÜBERSICHT ZUR GESCHICHTE DES EINSATZES VON THERMOGRAPHY ZUR BRUSTKREBS-ERKENNUNG- TEIL 2: FRAGEN UND ANTWORTEN

Der zweite Teil der Übersicht über historische Publikationen zum Einsatz von Infrarotthermographie zur Entdeckung von Brustkrebs liefert auf Grund der vorhandenen Literatur Antworten auf folgende fünf häufig gestellte Fragen.
1. Gibt es spezifische thermische Charakteristiken für Brustkrebs ?
2. Wie große Veränderungen könen mit Thermographie erkannt werden?
3. Kann man mitttels Thermographie zwischen bösartigen und anderen Veränderungen unterscheiden?
4. Werden bestimmte Arten bösartiger oder gutartiger Läsionen öfter durch Thernographie endeckte als mit anderen Methoden?
5: Erlaubt die Thermographie eine brauchbare Risikobeurteilung bei der Brustkrebserkennung?
Die gelieferten Antworten diskutieren ausführlich die Stärken und Schwächen der Thermographie bei der Brustkrebsentdeckung. Trotz der offensichtlich hohen Rate an falsch positiven Befunden, stellt ein abnormales Thermogramm tatsächlich eine primäre Informationquelle dar, die über die Prognose und das Langzeit-Überlebenspotential von Frauen mit dem Risiko Brustkrebs zu entwickeln, Auskunft geben kann.

SCHLÜSSELWÖRTER: Brustkrebs, Übersicht, Infrarotthermographie, Prognose, Risiko-Beurteilung

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Introduction

Part I of this review [1] reported facts and statistics derived from the results of 20 trials published between 1961 and 2004 .Some commonly asked questions about the use of thermography in breast cancer detection and the answers suggested by the available literature follow below.

Question 1: Are There Specific Thermal Features that Define Cancer?

Answer 1: The available literature provides a variety of specific thermal patterns of high emission blood vessels as well as relative emission levels linked to breast cancer that may be a strong indicator of high risk patients, tumour growth rate, prognosis and survival. Thermal features described as abnormal have been associated with several measurable indicators of aggressive tumours. However, the specificity of these thermal patterns was never proven. Additionally, thermography can be a gauge for prognosis and survival rates, as cancers missed by thermography were slower growing, less aggressive tumours, with better treatment outcomes. Retrospective postmortem data showed that accuracy of thermography was higher in a deceased patient group vs. living patients. This suggests that thermography may be a powerful tool to help identify cancer in specialized, high risk patient groups, such as those referred for mammograms because of a suspicious lump.

As early as the 1960's (and, by today's standards, despite rudimentary equipment), Lawson *et al.* used thermography to show that the average temperature of breasts with cancerous lesions was increased compared to breasts with benign lesions (36.9°C vs. 35.4°C, a 1.5°C difference) [2]. More recent work reports similar findings. Ng *et al.* showed that on average breasts with cancerous lesions were 0.51°C warmer than tissue with benign lesions and 0.85°C warmer

Table 1
"Hot" vs. "Cold" Thermogram Results by Lesion Type

Author	Type of Lesion	Abnormal (hot) (%)	Normal (cold) (%)	Temperature Change (°C)
Lloyd-Williams (1961)	Abscess	100	0	2-4
	Carcinoma	95	5	2-7
	Fibroadenoma	60	40	0-2
	Cyst	6	94	2
	Adenosis	0	100	
	Fat Necrosis	0	100	-
	Duct stasis	0	100	-
Gershon-Cohen (1965)	Carcinoma	96	4	
	Adenosis	50	50	
	Fibroadenoma	39	61	
	Cyst	12.5	87.5	

Both studies used a >1°C change in temperature as criteria for an abnormal thermogram. Patient group for Lloyd-Williams *et al.* consisted of women with a lump in one breast. Carcinomas (n=57), abscesses (n=4), cysts (n=18), adenosis (n=6), fat necrosis (n=2), duct stasis (n=3), and fibroadenoma (n=10).
Gershon-Cohen *et al.*: Carcinoma (n=100), cysts (n=24), adenosis (n=4), and fibroadenoma (n=33).

than healthy breast tissue [3]. While there is no specific temperature "signature" that identifies and differentiates a carcinoma from a benign lesion or other condition, studies have demonstrated the value of grouping lesions into "hot" or "cold" clusters according to the results of thermograms (Table 1).

One study reported that carcinomas and abscesses were strongly correlated with an asymmetric breast temperature pattern of "hot" (abnormal thermogram). Fibroadenomas were fairly equally distributed between "hot" and "cold" (normal thermogram) groups. Cysts were predominantly seen as "cold". Adenosis, ductal stasis and fat necrosis (either enlarged ducts or degenerative-type lesions) were all seen as "cold" [4]. This is consistent with other studies that show a fairly even mixture of hot and cold scans for fibroadenomas and cold scans for cysts. However, whereas, one study showed adenosis in the normal category, another equally divided them between normal and abnormal [5]. This type of clustering can sometimes delineate a subgroup of patients and help determine tumour growth rate, prognosis, and survival.

Thermographic Results and tumour Growth Rates

Grouping lesions by thermogram results has also been shown to strongly correlate with tumour growth rate and, therefore, prognosis and survival. Fine needle biopsy of breast lesions followed by thermograms have revealed a positid ve correlation between temperature and tumour growth rate in small tumours (less than two cm) [6]. In addition to increased heat production, abnormal thermograms have been shown to correlate with several other prognostic indicators of fast growing tumours that can be consistently measured. These indicators include increased DNA synthesis, which shows that cell division is taking place. Higher quantities of ferritin are by-products of nitric oxide synthesis and is positively correlated with aggressive tumour growth rate. The expression of Ki-67, a proliferation-associated tumour antigen (a marker of an actively growing tumour), is increased in faster growing tumours as well (Table 2) [7, 8].

Thermographic Results and Survival Rates

Several studies have shown that the survival rate of women with lesions missed by thermograms, i.e. "cold" tumours, is decidedly better than those with "hot" tumours (Table 3). In these studies, all patients had cancer; however, those with abnormal or "hot" thermograms had diminished survival rates compared to cancer patients with normal or "cold" thermograms. One study retrospectively examined the survival rates of 340 women diagnosed with invasive breast cancer over a period of 2-137 months (median of 96 months). Women with abnormal thermograms (a change $\geq$0.9°C) had significantly decreased survival rates com-

Table 2
Thermographic Results are Related to tumour Growth Rates

Author		Abnormal	Normal
Gautherie (1980)	Heat Generated (mW/cm³)	70	12
Head (1993)	DNA Synthesis (% cells)	10.45	5.63
	Ferritin (ng/mg)	1512	762
	Ki-67	8	2
Sterns (1996)	Ki-67(% of cells)	15	10

In addition to asymmetric heat increases, increased DNA synthesis, concentrations of ferritin, and expression of proliferation-associated tumour antigen Ki-67 are all related to fast-growing, more aggressive tumours

Table 3
Thermographic Results are Related to Survival Rates

		Survival (%) "Hot" Tumours	Survival (%) "Cold" Tumours
Jones (1975)	3 Year Survival	75	92
Amalric (1982)	3 Year Survival	74	91
Isard (1988)	5 Year Survival	30	80
Sterns (1996)	5 Year Survival	58	79
Ohsumi (2002)	5 Year Survival	73	90

The data reflects overall survival rates in the studies by Jones et al. and Isard et al.
The three other studies report disease-free survival

pared to woman with cancers that went undetected by thermography [9].

Studies done by Isard et al. in the late 1970's as a part of the BCDDP at Albert Einstein Medical Center examined asymptomatic women between the ages of 35 and 74 years.

Table 4
TNM Classification for Breast Cancer

Classification	Definition
TX	Primary tumour cannot be assessed
T0	No evidence of primary tumour
Tis	Carcinoma *in situ*
Tis (DCIS)	Ductal carcinoma *in situ*
Tis (LCIS)	Lobular carcinoma *in situ*
Tis (Paget)	Pagets disease of the nipple with no tumour
T1	Tumour ≤ 2cm
T3	Tumour > 5cm
T4	Tumour of any size with direct extension to chest wall or skin

Adapted from the *AJCC Cancer Staging Manual*, 6th Edition.

Of 5,040 women enrolled in the study, 70 with a cancer diagnosis made by December 1980 were followed for 6-13 years. They found that the TNM Classification for Breast Cancer (Table 4), while giving comparable survival rates overall, could not accurately predict survival by cancer stage. For example, within a group of women with stage II cancer (n=10), there were survival rates ranging from 20-57%. However, within this group, women with thermograms described as "marked asymmetry with gross vascular distortion, dilated hot veins, considerable focal or global heat, and loss of the normal breast contour" had only a 20% survival rate compared to the rest of the group. The authors concluded that thermography is a valuable tool for predicting survival rates and may be useful for predicting several different types/stages of cancer, such as DCIS, medullary carcinoma and infiltrating ductal carcinoma [10]

In the previously mentioned clinical studies, as well as others, "cold" tumours that were not detected by thermography were classified as false negatives. While the high rate of false negatives in thermography is a valid criticism of the technique, the ability to predict faster growing, more aggressive cancer suggests that thermography is a fundamental and valuable addition to breast cancer detection.

Question 2: What Size Lesions are Detected by Thermography?

Answer: Thermography has been shown to identify the presence of lesions of all sizes, including tumours that are otherwise clinically undetectable. There is evidence that as tumour size and growth rate (aggressiveness) increases the accuracy of thermography detection also increases.

Following biopsy, tumours are typically described according to the TNM Classification for Breast Cancer (Figure 1). Using this system, tumours are categorized by the size of the mass and by how far it has spread within the tissue. Most studies show that the accuracy of thermography increases with tumour size [11, 12], as is the case with other breast cancer detection modalities, such as clinical exam and mammography. For example, in one study, tumours greater than five centimeters all had abnormal thermograms [7]. In this same study, 10 of 19 tumours less than two centimeters also had abnormal scans.

There were seven studies available in the literature that reported on the relationship between tumour size and thermography accuracy (Table 4). Grouping data from these studies according to TNM classification and averaging by sensitivity (%) shows that there is a positive relationship between tumour size and the detection rate of thermography (Figure 2). Despite this trend, there is evidence that thermography can accurately detect small lesions prior to any clinical signs. Several studies describe cases of in situ cancers that were detected by thermography [13 14, 15, 16, 17, 18].

At times, thermography has successfully detected smaller tumours than mammography. In one study, thermography found all four cases of DCIS present in the patient group

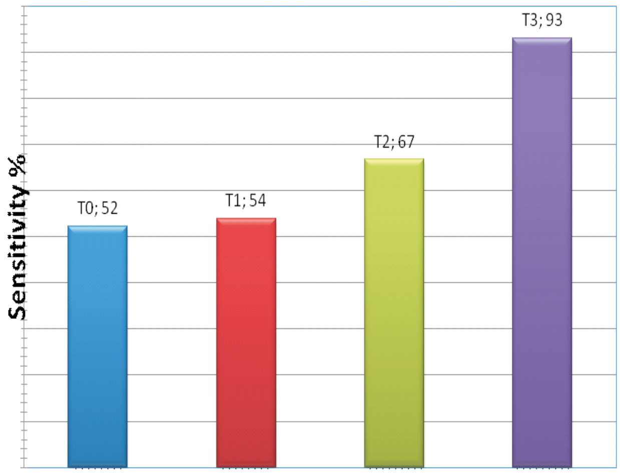


Figure 5
Data from the seven studies listed in Table 4 were grouped according to TNM classification and sensitivity was averaged. Average sensitivity: T0 52%, T1 54%, T2 67%, T3 93%.

and detected tumours with an average size of 1.28 cm, compared to tumours that were 1.66 cm found using mammography [8]. In another study, thermography identified nine of 10 non-palpable cancers at a better rate than did mammography [16]. These authors describe thermography as a "first alarm" in six of 10 non-palpable cancers that were missed by mammography. (Significantly, a more recent study with a modern dynamic computerized infrared imaging system with a 97% sensitivity rate and 95-99% negative predictive value (NPV) (subjects with a negative test that were correctly diagnosed) was not able to successfully recognize in situ cancers [19].)

As mentioned previously, the relationship between temperature change and tumour growth rate may be a better predictor of thermography accuracy rather than tumour size. Interpreting accuracy based on tumour size may explain the conflicting results from Parisky et al.

Question 3: Can Thermography Differentiate Between Malignant Lesions and Other Conditions?

Answer: Based on current available literature, thermography does not consistently differentiate between malignant lesions and other tissue conditions such as benign breast conditions or healthy tissue. Rather, it identifies heat asymmetries that indicate the need for follow-up exams.

There are studies that demonstrate instances where thermography accurately differentiated malignant and benign lesions (4 of 8) and malignant and healthy tissue (2 of 3 studies). However, the overall accuracy of thermography in these studies was still around the level of chance: correct in six of 13 studies. To quote Isard et al. [16]:

"*This point needs repeated emphasis for too often the question is asked whether a thermogram indicates a malignant condition, when in fact it*

Table 4
True Positive Rates of Thermography According to tumour Size

	Classification	Tumour Size	True Positive (%)	# of cases
Amalric (1983)	T0	< 1cm	59	122
	T1	≤ 2cm	69	unk
	T2	≥ 2cm	88	unk
	T3	> 5cm	97	unk
Head (1993)	T1	≤ 2cm	53	19
	T2	≥ 2cm	69	45
	T3	> 5cm	100	10
Keyserlingk (1998)	T0	< 1cm	25	4
	T1	1-2cm	86	7
	T2 +	> 2cm	75	4
Lloyd-Williams (1990)	T0	< 1cm	64	11
	T1	1-2cm	57	23
	T2 +	> 2cm	64	25
Ohashi (2000)	T0	< 1cm	33	3
	T1	≤ 2cm	31	73
	T2	≥ 2cm	49	152
	T3	> 5cm	82	85
Threatt (1980)	T0	< 1cm	47	unk
	T1	≥ 1cm	55	unk
	T2	≥ 2cm	56	26
Van Dam (1988)	T1	< 2cm	27	41
	T2 +	> 2cm	66	54

True positive (aka sensitivity) was derived as follows: true positive/(true positive + false negative). Some studies listed true positive rates, but did not report the number of cases (unk=unknown).

Table 5
Malignant vs. Benign

	Sensitivity (%)	Specificity (%)	Overall Accuracy (%)	Malignant vs. Benign	General . Population
Lloyd-Williams (1961)	95	74	86	Yes	-
Jones (1975)	68	63	64	-	-
Almaric (1983)	89	88	89	Yes	Yes
Van Dam (1988)	49	86	69	-	-
Head (1993)	65	72	69	-	Yes
Head (1993)	88	72	81	Yes	Yes
Keyserlingk (1998)	83	81	82	Yes	-
Parisky (2003)	97	14	32	-	-

Eight studies were compared for accuracy at differentiating between malignant and benign lesions. Four studies were determined to be able to make this distinction by the overall accuracy of >80%. Studies that were not representative of general population had groups that either had a lump in one breast (Lloyd-Williams, and Van Dam), were referred for biopsy (Jones and Parisky), or all had cancer (Keyserlingk).

should be asked whether it indicates an abnormality. The thermogram at this stage of development of the discipline of thermography can no more by itself differentiate a benign from malignant condition than can the temperature recording by the oral thermometer differentiate pneumonitis from a necrotizing neoplasm."

In order to establish whether thermography could differentiate between malignant and other breast conditions, a standard of accuracy had to be employed. Mammography is the prevailing standard of breast cancer detection. Yet the relative sensitivity and specificity of mammography can vary greatly and may be influenced by factors such as a woman's age, type of cancer being detected, breast density, computerized vs. human interpretations of mammograms, etc. Sensitivity can range from 45% for very dense breast tissue to the approximately 80% for intraductal carcinomas to 100% for other cancers [20-23]. Specificity, however, is 17% if defined by the relationship between positive findings and the results of biopsy [24]. Therefore, as a cutoff point that exceeds chance (i.e., >50%) but still falls within a reasonable range of mammography accuracy, the following comparisons were based on an overall accuracy of 80% to consider thermography results applicable.

Malignant and Benign Lesions

Eight studies that evaluated the use of thermography for identifying malignant and benign lesions were compared for accuracy, which was determined by adding the true positive and true negative values and then dividing by the total. Four studies of the eight examined had an overall accuracy of >80% (Table 5).

A prospective study by Lloyd-Williams et al. examined whether thermography could accurately detect malignant breast pathology within a high risk group of women. This study consisted of 100 patients all referred for thermography for a lump in one breast. The authors admit that there was a bias for cancer since any clinically obvious cysts were determined at an outpatient visit, so this patient group is not representative of the general population. Within the confirmed cases of cancer, 54 had abnormal scans and three were normal (sensitivity of 95%). There were 11 confirmed cases of benign pathology with abnormal thermograms and 32 that were normal (specificity of 74%). Among the benign lesions with abnormal thermo- grams, four (of four) were chronic abscesses, six (of 10) were fibroadenomas (benign tumour made of fibrous and/or glandular tissue), and one (of 18) were cysts. This study divided thermograms in to "hot" or "cold" (hot = 1oC change compared to reference spot on opposite breast). The "hot" group (those with abnormal thermograms) consisted of malignant tumours and inflammatory swellings. Those conditions that were "cold" included adenosis, fat necrosis, and duct stasis. Fibroadenomas were fairly equally divided between the hot and cold groups. The authors concluded that temperature increases of 1°C were a useful diagnostic indicator of malignancies.

Summary: Given, this study was done long ago, with equipment no longer used; but even so, it had a remarkable sensitivity rate of 95%. This was a special patient population, as they all had a lump; however, this study demonstrates that within this specialized group thermography still had an overall diagnostic accuracy of 86%. *Thus, thermography was highly, if not overwhelmingly, successful at differentiating malignant from benign lesions.*

A prospective study by Jones et al. examined thermography in terms of stages of disease and prognosis. More than 12,000 women representing the general population (wellness screening) were the subject of this report, including 8,000 asymptomatic patients. Within this group, 1,464 biopsies were performed uncovering 363 cases of cancer (25%) and 1,101 benign lesions. There were 248 confirmed cases of cancer with abnormal thermograms, 68 were equivocal and 68 were negative (sensitivity of 68%). When abnormal findings are combined with equivocal findings (as many studies will do), the sensitivity is increased to 81%. Within the abnormal scans, 57% were determined to be stage I, 62% stage II and 83% stage III tumours. There were 240 benign conditions that had abnormal scans, 171 were equivocal and 690 were negative (specificity of 63%) The authors recommend the use of thermography as an adjunct to mammography.

Summary: This study showed that thermography can be related to prognosis. Patients with stage II or III tumours that had normal thermograms (false negative) had a better survival rate than those with abnormal scans. Combining the true positive thermograms and equivocal scans increased sensitivity to 81%, however, overall accuracy remains below the cutoff of 80%. As such, in this study *thermography did not differentiate between malignant and benign lesions.*.

A prospective study by Amalric et al. reviewed the role of thermography in breast cancer management using data collected over a period of ten years. This study was comprised of 61,000 women receiving thermograms as part of a breast diagnosis program, and therefore this group is representative of the general population. It reports on 6,822 lesions that were diagnosed by biopsy and contains information on follow-up thermograms from 16,000 women. There were 3,429 confirmed cases of cancer that had abnormal thermograms and 418 that were normal (sensitivity of 89%). There were 344 cases of benign pathology that had abnormal thermograms and 2,631 that were normal (specificity of 88%). Thermography was shown to play a significant role in detecting small cancers: correctly identifying 91% of in situ carcinomas. Thermography was also found to play a role in prognosis, as women with cancer who had a normal thermogram (false negative) had significantly better survival rates than those with abnormal scans. Thermography correctly identified 74% of small breast cancers missed by clinical exam and 81% of those missed by mammography.

Summary: This study showed that when thermography is combined with other detection modalities, risk assessment and prognosis are improved. Using all three modalities, only 1% (2 of 220) of cancers was missed. With an overall accuracy of 89%, this study demonstrates that *thermography successfully differentiated between malignant and benign lesions*.

A blind retrospective study by Van Dam et al. assessed multi-modality testing of palpable masses in breast tissue. Since patients were referred for thermograms, sonograms and mammograms based on palpable breast masses, they were not representative of the general population. Of the 1,340 women examined, 201 had biopsies that confirmed a cancer diagnoses. Within this group, 47 confirmed cases of cancer had abnormal thermograms while 48 were normal (sensitivity of 49%). There were 62 confirmed benign lesions with abnormal scans and 139 with normal thermograms (specificity of 86%). Comparatively, clinical exam had 47% and 71% sensitivity and specificity while mammogram had 82% and 55%. The authors found that the limitations of individual modalities were compensated for by the others, but conclude that despite the low false positive rates in thermography, the low true positive rates lead them to believe it was not a helpful component of breast cancer screening.

Summary: In this study, thermography had better specificity than clinical exam and mammography. Further, the overall accuracy of thermography exceeded that of the other modalities (69% for thermography vs. 60% for exam and 68% for mammography). However, the authors combine the positive tests with the equivocal results for clinical exam and mammography (there were no equivocal results given for thermography). In this manner, the sensitivity and specificity of clinical exam are 88% and 71% and 94% and 55% for mammography. Regardless of the method of data analysis, this study did not meet the 80% accuracy; therefore, thermography did not differentiate between malignant and benign lesions.

Combined prospective and retrospective studies by Head et al. examined thermography as a tool for risk assessment and prognostic use. This study consisted of 126 randomly selected patients who had died of breast cancer (medical records were retrospectively analyzed), 100 randomly selected living women with breast cancer, and 100 women with various mastopathies, but no cancer diagnosis (benign group). All subjects had clinical examinations, thermography, mammography and biopsy. All groups (except those that were deceased due to breast cancer) were representative of the general population. Within the group of 100 living patients, thermograms were abnormal in 65 confirmed cases of cancer (sensitivity of 65%). tumours were found to be significantly larger in cancers with abnormal thermograms (all patients with tumours >5 cm in diameter had abnormal scans). However, 10 of 19 patients with tumours <2 cm also had abnormal scans. Thermograms were abnormal in 28 cases of confirmed benign breast pathology (specificity of 72%). The 93 patients with an abnormal thermogram (a purported 28% false positive rate) were not followed long-term to see if the abnormal thermogram was a predictive indicator of cancer. Within the group of 126 deceased patients, thermograms were abnormal in 111 confirmed cases of cancer (sensitivity of 88%). This study also examined several risk factors, such as age, menopausal status and estrogen and progesterone receptor status, as well as several indicators of tumour growth rates to see whether abnormal thermograms could be related to prognosis. Abnormal thermograms were not related to any risk factors, but did correspond to indicators of tumour growth rate, such as, levels of ferritin, Ki-67 (a proliferation-associated tumour antigen) and DNA synthesis. All of these factors were increased in patients with cancer who had abnormal thermograms. Note: this study also compared groups of normal and high risk patients (n=220) using two different thermographic equipment types (scanning and focal plane). There was ~18% increase in thermosensitivity between 1st and 2nd generation equipment.

Summary: This study shows that an abnormal thermo-. gram is a useful indicator of high risk groups for breast cancer and indicates the possibility of poorer prognosis (based on 88% accuracy in deceased patients). Additionally, this study suggests that faster growing tumours and, therefore, poor prognosis, are associated with abnormal scans. The overall accuracy in the living group was 69%; therefore, thermography did not differentiate between malignant and benign lesions. However, in the deceased group, the overall accuracy reached 81%. Therefore, in this subset of patients, thermography successfully differentiated between malignant and benign lesions.

In a retrospective study, Keyserlingk et al. compared the breast cancer detection accuracy of thermography to clinical breast exams and mammography. To evaluate the accuracy with which these three modalities detected breast cancer, 100 confirmed cases of cancer and 100 cases of confirmed benign breast pathology were retrospectively reviewed and compared. Each patient included in the study had received evaluations using all of the modalities, had the lesion biopsied, and had either DCIS (n=4), stage I (n=42), or stage II (n=54) invasive breast cancer. Nearly all of the patients had been referred by physicians and 61 had a palpable lump. Therefore, this group is not representative of the general population. Thermograms were abnormal in 83 cases of confirmed cancers and equivocal or negative in 17 (sensitivity of 83%). Of the patients with benign breast pathology, 19 had an abnormal thermogram (specificity of 81%). Clinical exam was abnormal in 61 cases of confirmed cancers, equivocal in 34 and normal in 5 (sensitivity of 61%). Mammography was abnormal in 66 cases of confirmed cancers, equivocal in 19 and normal in 15 (sensitivity of 66%) . Thirty confirmed cases of benign breast pathology had abnormal mammograms, (specificity of 67%). The researchers concluded that thermography has sufficient specificity to be used in combination with other detection modalities to improve the detection rate of breast cancer.

Summary: In this study, the authors falsely inflated the figures for mammography and clinical exams by combining equivocal and negative findings only for thermography. When all are calculated similarly, thermography (overall accuracy of 82%) outperforms both clinical exams (71%) and mammography (74%). Another noteworthy finding is that the average tumour size that was missed by mammography was 1.66 cm, and the average size missed by thermography was 1.28 cm. In this study, thermography successfully differentiated between malignant and benign lesions.

In a blind prospective study, Parisky et al. evaluated the efficacy of a dynamic computer infrared imaging system in detecting cancer and benign breast pathology. The authors describe this study as blind; meaning that the biopsy findings were not made available to investigators examining the thermography and mammography data. All patients included in this study were referred for biopsy based on an abnormal clinical exam, abnormal mammogram, or both, so they are not representative of the general population. Although there were 875 biopsies, the statistics are based on 1-3 interpretations by seven different examiners. Each assessment was weighted based on the number of interpretations. Using this system, thermography was abnormal in 482 confirmed cases of cancer and normal in 13 (sensitivity of 97%), and 1,544 patients with benign breast pathology had abnormal scans (specificity of 14%). The authors also analyzed the data after removing all cases of micro-calcification proven to be false negatives. Using these parameters, the sensitivity was 100% and specificity 18%. The authors determined that thermography is a useful adjunct to mammography to differentiate malignant lesions in a group with suspicious mammograms, but recommend that it should not be used as a screening tool. Furthermore, they propose placing importance on the high negative predictive value in this study rather than the low positive predictive value.

Summary: Private clinic websites that offer thermography as a breast cancer screening tool, often state that benign and malignant lesions can be differentiated using thermography. Frequently, this study by Parisky et al. is cited as evidence for this differentiation. Indeed this group demonstrated a high sensitivity (~97%), but the patient group consisted of women who had been referred for biopsies because of an abnormal clinical exam, an abnormal mammogram, or both. While this study was able to demonstrate that thermography could accurately identify cancer in a specialized, high risk group, it was unable to distinguish benign from malignant lesions and had a false positive rate of ~86% (593 of 688 benign lesions had abnormal thermograms). The overall accuracy is 32%; therefore, thermography did not differentiate between malignant and benign lesions.

Malignant and Healthy Tissue

Three studies that evaluated the use of thermography for differentiating malignant lesions and healthy tissue were. Accuracy was determined by adding the true positive and true negative and dividing by the total. Two studies were determined to be able to make this distinction by the overall accuracy of >80% (Table 6)

A prospective study by Davey et al. evaluated the use of thermography in wellness screening for the early detection of breast and cervical cancer. A total of 1,717 women were examined by clinical exam and thermography. Those with clinical abnormalities or dense breast tissue also received mammograms. This was a wellness screening, so patients are representative of the general public. There were 11 cases of confirmed cancer that had abnormal scans and

Table 6
Malignant vs. Healthy

	Sensitivity (%)	Specificity (%)	Overall Accuracy (%)	Malignant vs. Healthy	General Population
Davey (1970)	73	89	89	X	X
Stark (1985)	86	89	89	X	X
Lloyd-Williams (1990)	61	76	76	-	X

Three studies were compared for accuracy at differentiating between malignant and healthye tissue. Two studies were determined to be able to make this distinction by the overall accuracy of >80%. All three studies used in this analysis had patient group that were representative of the genral population.

four that were normal (sensitivity of 73%). There were 186 thermograms that were abnormal in the healthy group and 1516 that were normal (specificity of 89%). Thermography screening lead to follow-up visits for some patients who would not have normally been given a mammogram and two cancers were detected this way. The authors conclude that thermography is a useful tool for finding suspicious cases that should be followed-up with mammograms.

Summary: Thermograms performed during a wellness screening had an overall accuracy of 89%, therefore thermography successfully differentiated between malignant and healthy lesions in this study.

A prospective study by Stark et al. examined whether an abnormal thermogram was a valid risk factor in breast cancer detection. This study described a large scale (n=11,240) wellness screening. Women included in study were asymptomatic at the time of their first exam. Women were grouped by risk factors (+/- pregnancy, family history, previous breast pathology, and previous abnormal thermography exam) into 3 categories: 5,825 with no risks, 3,881 with one risk factor, and 1,534 with more than one risk factor. There were 346 abnormal scans for confirmed cases of cancer, and 58 normal scans (sensitivity of 86%). There were 1,153 abnormal scans for healthy women and 9,741 normal scans (specificity of 89%). Thermography detected 22 cases of cancer with no clinical symptoms. There was a group of 494 women whose only risk factor was an abnormal thermogram; within this group 99 cancers were found. Women with one or more risk factors were offered annual follow-up appointments for 10 years, others that requested follow-up examinations were seen on average at 30-36 month intervals. Follow-up exams spanned 10-16.5 years. The authors conclude that thermography should not be used as a diagnostic tool; rather it is a valuable indicator of risk factors.

Summary: The overall accuracy of this study was 89%, therefore, thermography successfully differentiated between malignant and healthy tissue.

A combined prospective and retrospective study by Lloyd-Williams et al. examined thermography as a breast cancer detection device and as a predictor of those at risk of developing breast cancer within a five year period following initial exams. A total of 10,229 women were included in this study. About half of the women were recruited by their personal doctors and the other half were volunteers from the general public. Only a small portion was symptomatic at the time of initial exam (~200), so this groups was representative of the general population. All participants received a physical exam and thermography; if either was abnormal they also had a mammogram. Of 59 women with cancer, 36 had abnormal thermograms (sensitivity of 61%). Of the remaining 10,170 women without cancer, 7,726 had normal thermograms (specificity of 76%). Thermography accurately identified seven of 11 tumours less than one cm. More than 96% of the patient group was followed retrospectively through clinical records. Within five years, 72% who originally had normal thermograms were diagnosed with cancer. Additionally, 73% who originally had abnormal thermograms, but no other symptoms, were also diagnosed with cancer. The authors concluded that thermography was neither sensitive enough to be used as a screening tool, nor was it a good indicator of high risk groups.

***Summary**:* While the authors' assessment seems reasonable, they did not indicate whether any of the women with abnormal thermograms without cancer had other benign breast tissue abnormalities that thermography was detecting. In this study, thermography was rarely better than chance at detecting cancer (sensitivity of 61% and specificity of 76%). Follow-up studies suggest that thermography is not an accurate risk predictor, as the same percentage of women were later diagnosed with cancer regardless of having had an abnormal scan or not. The overall accuracy of this study was less than 80%, therefore, thermography did not successfully differentiate between malignant and healthy tissue.

Malignant Tissue and a Combination of Benign and Healthy Tissue

Some studies combine groups with benign lesions and healthy breast tissue, counting them as one group to compare to cancerous lesions. Two studies evaluated the use of thermography for these combined groups. Accuracy was determined by adding the true positive and true negative and dividing by the total. Neither study was determined to be able to make this distinction by the overall accuracy of >80% (Table 7)

Dodd et al. published a preliminary report on the usefulness of thermography as a mass screening tool for breast cancer detection. This study reported on 597 women, who were a subgroup from a larger study involving 4,726 participants. Thermography and mammography were performed and analyzed separately for each patient. Thermograms were abnormal in 60 cases of confirmed cancer and normal in nine cases (sensitivity of 87%). Thermography was abnormal in 186 cases of benign pathology and normal in 342 (specificity of 65%). Over 300 patients were fol-

Table 7
Malignant vs. Benign + Healthy

	Sensitivity (%)	Specificity (%)	Overall Accuracy (%)	Malignant vs. Benign + Healthy	General Population
Dodd (1969)	87	65	67	-	X
Isard (1972)	71	71	71	-	-

There were two studies compared for accuracy at differentiating between malignant and a combination of benign + healthy tissue. Neither study was determined to be able to make this distinction by an overall accuracy of >80%. One study is representative of the general population, while the other is made up of women who were referred for mammograms..

Table 8
Comparing Exam, Thermography and Mammography in Two Patient Groups

	Symptomatic (n=270)	Asymptomatic (n=36)	Total (n=306)
Clinical Exam	222 (82%)	0	222 (73%)
Thermography	196 (72%)	22 (61%)	218 (71%)
Mammography	230 (85%)	30 (83%)	260 (85%)

Adapted from Isard et al.

lowed for one and a half to three years and 19 patients with abnormal thermograms and a diagnosis of benign breast lesions were later diagnosed with cancer. Thermography and mammography both had similar true positive rates of about 85%; however, they did not necessarily detect the same tumours. Further analysis was being processed for a larger group of 4,726. In this group there were 195 cancers detected with a true positive of ~85% (including 32 clinically undetectable tumours). In this larger group, the false positive rate was approximately 11%. The authors note that while thermography accurately detected 32 non-palpable tumours, the majority of false negatives were for tumours more than one cm in diameter. The authors conclude that despite high false positive rates, thermography is a useful screening tool when used in conjunction with mammography. Furthermore, they conclude that thermography may be useful for identifying pre-cancerous lesions.

Summary: In this study thermography and mammography had a similar true positive rate (~85%). Both of these modalities were able to detect some cancers that the other had missed; therefore, the authors concluded that thermography and mammography used jointly could be a useful screening tool. It is noteworthy that while 32 clinically occult cancers were detected by thermography in this study, the tumours that were missed were typically more than one centimeter in diameter. The authors did not have a clear explanation for this phenomenon; however, based on information from other studies, it is likely that these were not fast growing tumours and were seen as "cold" by thermography (see "Question 1: Are There Specific Temperature Patterns that Define Cancer"). Despite a relatively high sensitivity rate (85%), thermography was just above the level of chance (65%) for specificity. As a result, the overall accuracy did not reach 80%, and we must conclude, that thermography was not successful at differentiating malignant tumours from a patient group that were either healthy or had benign lesions.

A prospective study by Isard et al. examined whether pairing thermography and mammogram increased the accuracy of detecting breast cancer. A total of 10,055 women were examined by thermography and mammogram, 5,662 of whom were symptomatic (4393 asymptomatic). All patients were referred for mammogram, so this group was not representative of the general public. Of the total number examined, 3,072 had abnormal thermograms (6,983 normal). Within the group with abnormal thermograms, 36% (2,044) were symptomatic and 23% (1,028) were asymptomatic. Biopsy was performed on 1,111 patients with abnormal scans; of which about 16% (883) were symptomatic and about 5% (228) were asymptomatic. Cancer was confirmed in 306 cases (270 symptomatic and 36 asymptomatic), while 805 (613 symptomatic and 192 asymptomatic) were benign. On its own, thermography accurately predicted 218 of 306 cases of cancer (sensitivity of 71%) (Table 8). Thermograms were abnormal in 2,854 patients that were either healthy or had benign breast lesions (specificity of 71%). Overall, mammogram accurately predicted 75% (230 of 306) of cancer cases, including 10 that were missed by thermography. There were 14 cases that were missed by both thermography and mammogram. Within the symptomatic group, thermography detected 72% (n=196) cases of cancer, mammogram detected 85% (n=230), and combined modalities detected with 92% (n=248) accuracy. Clinical exam detected 82% (n=222) of cancers, but it should be noted that the majority of the women in the symptomatic group had palpable lesions. Within the asymptomatic group, thermography detected 61% (n=22) of instances of cancer, mammogram detected 83% (30), and the combined modalities detected 89% (n=32). Despite a high false negative rate (29%), thermography detected 61% of occult cancers in the asymptomatic group.

Overall, thermography plus clinical exam had 88% (237 of 306) accuracy, and mammogram plus thermography had 92% (248 of 306) accuracy. Patients with abnormal thermograms who were clinically normal were followed for several years. This resulted in nine cancer diagnoses. The authors conclude that pairing clinical exams, thermography and mammography improves the accuracy of diagnosis in symptomatic patients and helps to elucidate high risk patients within this group.

Summary: This study demonstrated that thermography was not as accurate as mammography at detecting cancer in women referred for mammograms. The sensitivity of thermography was 71% compared to 85% sensitivity in mammogram. When combined, the accuracy of these two modalities improved to 92%, suggesting that merging these techniques would be of clinical benefit. As in the previous study, we must conclude that thermography was not successful at differentiating malignant tumours from a patient group that were either healthy or had benign lesions.

Question 4: Are Specific Types of Malignant or Benign Lesions More Often Detected by Themography Over Others?

Answer: As to malignant lesions, results were inconclusive; there was only one study available from which to draw a conclusion. For benign lesions, rather, the answer is an emphatic yes: inflammatory conditions and abscesses frequently produce heat patterns leading to the interpretation of an abnormal thermogram.

Malignant Lesions

Only one study was found that listed the specific type of breast pathology detected by thermography. This was a blind, retrospective study done as a part of the BCDDP project in Ann Arbor, Michigan. Ten evaluators reported on 576 thermograms and found that invasive cancers most often had abnormal thermograms compared to slow growing localized cancers [25] (Table 9).

It should be noted that the overall accuracy in this study was barely above that of chance (59%). Furthermore, it was not included in the main analysis because authors did not include information on the criteria used to read thermograms and there was wide variation on thermogram interpretations among evaluators.

Benign Lesions

There are data available from four studies that express the relationship between different types of benign pathology and the accuracy of thermography (Table 10). The number of patients represented in some of these categories is rather small (abscess, fat necrosis, adenosis and inflammatory conditions), so only cursory conclusions can be drawn. However, there are sizeable patient groups for fibrocystic disease and fibroadenoma. When the percentages of normal thermograms from these benign conditions were averaged, it demonstrated that the two benign conditions that consistently had false positive thermograms were inflammatory conditions and abscesses (Figure 6). This is to be expected as both of these conditions are characterized by increased heat and swelling in the tissue.

Question 5: Is Thermography a Useful Risk-assessment Model for Breast Cancer Detection?

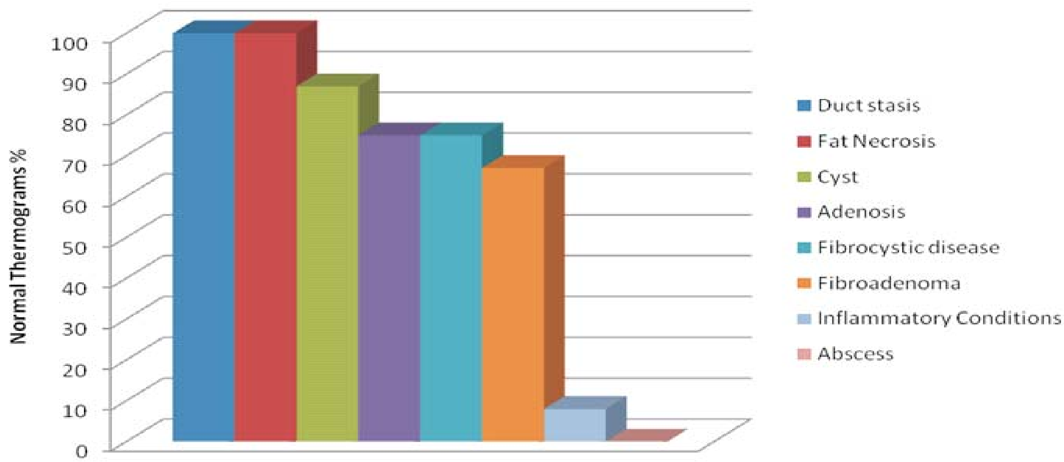
Answer: Yes, thermography provides information about subtle physiological changes to breast tissue

Table 9
Types of Malignant Conditions with Abnormal Thermograms

	Type of Lesion	True Positive (%)
Threatt (1980)	Lobular carcinoma *in situ*	45
	Intraductal papillary	50
	Intraductal solid	58
	Invasive ductal	53
	Invasive ductal with fibrosis	56
	Invasive lobular	69

Cancerous histology detected by thermograms. As cancer increases in size and/or aggressiveness, the accuracy of thermography improves.

Figure 3
Normal Thermograms (%) for Benign Conditions: An Average of Four Studies



Averaged data from four studies reveal the number of normal thermograms from several benign conditions. The total number of cases analyzed within each category (n) and the average number of normal thermograms (%) are as follows: duct stasis (n=3) (100%), fat necrosis (n=2) (100%), cyst (n=88) (87%), adenosis (n=10) (75%), fibrocystic disease (n=861) (75%), fibroadenoma (n= 224) (67%), inflammatory conditions (n=13) (8%), abscess (n=4) (0%). Data are from 4, 5, 17, 26.

Table 10
Types of Benign Conditions with Normal Thermograms

Type of Benign Lesion	Normal (%)	# of cases	Studies
Abscess	0	4	Lloyd-Williams (1961)
Adenosis	100	6	Lloyd-Williams (1961)
Adenosis	50	4	Gershon-Cohen (1965)
Cyst	94	18	Lloyd-Williams (1961)
	87.5	24	Gershon-Cohen (1965)
	80	46	Jones (1975)
Duct stasis	100	3	Lloyd-Williams (1961)
Fat Necrosis	100	2	Lloyd-Williams (1961)
Fibroadenoma	93	30	Van Dam (1988)
	72	151	Jones (1975)
	61	33	Gershon-Cohen (1965)
	40	10	Lloyd-Williams (1961)
Fibrocystic disease	87	70	Van Dam (1988)
	62	791	Jones (1975)
Inflammatory Conditions	8	13	Jones (1975)

Data for the % of normal thermograms are arranged according to benign conditions, followed by the number of cases within that subgroup. Data are from four studies [4, 5, 17, 26]

that can lead to more attentive monitoring. Thermography has been shown to enhance and, at times, surpass other breast cancer detection modalities that lack the ability to detect pre-cancerous conditions years prior to manifestation.

As thermography equipment and methods of analysis were improved, it demonstrated diagnostic power that rivaled that of other modalities, such as mammography, the "gold standard" of breast cancer detection. Pairing thermography and mammogram has been shown to significantly increase the accuracy of detecting breast cancer. In one study, combining clinical exam, thermography and mammography lead to 95% accuracy [10]. Perhaps more importantly, research suggests that even though thermography and mammography can be shown to have similar true positive rates (~85%), they do not necessarily detected the same tumors [21]. Several studies show that abnormal thermograms lead to a biopsy that detected instances of cancers that were missed by mammogram [30-32]. It has been suggested that thermography may be more useful than mammography in early detection of breast cancer. One study showed that the mean age of women with cancers found by thermography was 51 compared to 63 years in those found by mammogram [32]. In addition, studies demonstrate that thermography screening can lead to follow-up visits for some patients who are low-risk and therefore may not have normally been given a mammogram except for an abnormal thermogram [5, 33]. A report by Stark et al. illustrated that without an abnormal thermogram as a risk factor, 99 cancers would have been missed from their cohort [5].

Sometimes there are subtle features of tissue change before cancer develops. Actively looking for early indicators and having a record of these changes are key to early detection. A retrospective study by Gamagami et al. examined 530 women, who presented investigators with all previous mammogram films received prior to being diagnosed with breast cancer. In 95% of cancers there was a subtle sign in early mammograms (done prior to diagnosis). Thermograms done in 148 cases of non-palpable cancers showed hypervascularity and hyperthermia in 86% (~127) of cases. In 15% of subjects (~22) the abnormal thermograms lead to a biopsy that found cancer missed by mammography. This study also demonstrated that thermography can be a useful tool during treatment of cancer. The presence or absence of hypervascularity and hyperthermia directly related to the success of chemotherapy.

One of the criticisms of using thermography in breast cancer detection is the relatively high rate of false-positive results. However, several studies have demonstrated that an abnormal thermogram that is initially characterized as a false-positive result may actually be an early warning that warrants continued monitoring. These studies stress the importance of frequent follow-up exams for patients that, despite having no other clinical indications of cancer, had a thermogram that was classified as abnormal. Stark et al. report that false-positives or abnormal thermographic results with no other apparent abnormalities for 10 years, accounted for about 1.7% of the population studied in their 1985 report. Of 5,825 women considered to be at very low risk of breast cancer, 24 cancers were diagnosed using thermography, five of which were found more than 15 months after the abnormal scan. Further, they reported that, on average, cancer is found six years after an abnormal scan, with proof of it taking up to 11 years [5]. Spitalier et al. followed 1,416 cases of seemingly false positive (abnormal) thermographs for a period of one to eight years in patients with complaints of breast pain, but no other evidence of breast disease (no palpable lumps). Over an average time of 25 months, approximately 84 cancers were found [32]. Sterns et al. reported on two cases previously characterized as false positives that were diagnosed as cancer within 29-40 months [34].

Likewise, Gautherie and Gros examined thermography as a tool for risk assessment and the early detection of breast cancer. This study looked at 58,000 women, who were mostly symptomatic prior to exams. In this group of patients, 1,527 with abnormal thermograms were followed in a long-term study. Within a subgroup of 784 women with abnormal thermograms, with no other indications of cancer (normal clinical exam, ultrasound and mammogram), 298 were diagnosed with cancer within four years [13]. It is noteworthy that 44% of patients with benign findings (mostly cystic mastopathies), who originally had abnormal thermograms, were diagnosed with malignancies within this time period as well. This may suggest that detection of benign breast pathology with thermography can lead to earlier detection of breast cancer later.

Summary

As a stand-alone technique, thermography has limited value, mainly because it cannot consistently differentiate between benign and malignant conditions. Nor can it give information about the location and size of a tumor to guide biopsy. However, the strengths of thermography are multi-faceted (Table 11). Thermography is a fast, non-invasive, low cost and harmless process without radiation exposure. Thermography consistently identifies groups of women at risk for developing breast cancer. An abnormal thermogram in lieu of any other symptoms can be a first warning sign and provide the impetus for regular follow-up exams leading to earlier detection of breast tissue changes. Thermography reliably identifies faster growing, more aggressive cancers at an earlier stage than other detection modalities. There is even evidence that it can discriminate cancers that will respond well to chemotherapy. Despite a seemingly high false-positive rate, an abnormal thermogram may actually be providing a priori information about the prognosis and long-term survival potential of women at risk of developing breast cancer. The improved quality and preservation of life make the addition of thermography to existing breast cancer detection modalities of great clinical importance.

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Table 11
Strengths and Weaknesses of Thermography in Breast Cancer Detection

Strengths	Weaknesses
An abnormal thermogram is a good indicator of: high risk patients, tumor growth rate, prognosis, survival, success of chemotherapy.	High false-positive rates (Caveat: may be an early warning).
Can identify lesions of all sizes.	Cannot provide information on tumor location for biopsy.
Adding thermography to other detection modalities improves the accuracy of breast cancer detection.	Does not consistently differentiate benign from malignant conditions.
May be the first early warning sign of pre-cancerous lesions.	Slower growing tumors may be missed.

Some of the major strengths and weaknesses of thermography as a breast cancer detection device are summarized.

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Viscerocutaneous reflexes with abdominal wall pain: A study conducted in 1981 on pregnant women from a general practice

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SUMMARY

BACKGROUND: This is an article regarding an unpublished study that was designed and conducted in 1981, but publication in time was not possible due to the workload in the busy practice of the author. Temperature changes on the abdominal wall could be caused by nociceptive sensations in the viscera which are transfered to the surface via viscerocutaneous reflex pathways. Two aspects play a role in this: 1. An internal organ's proximity to the skin, 2. That organ's registration of function to the skin. This study addresses the registration of function of an organ on a specific site of the skin.

The aim of the study was to investigate if infrared thermography can measure temperature changes associated with the functional status of a pregnancy. The null hypothesis was: during the course of pregnancy, there is no difference in skin temperature between the skin areas selected.

METHODOLOGY: The occurrence of viscerocutaneous reflexes was investigated by means of infrared thermography in a group of pregnant women who were cared for in a general medical practice.This observational study started on the first visit for a pregnancy check-up and at every check-up visit, the temperature was measured. Because the check-ups were scheduled by the doctor based on indications or on woman's request, the number of measurement differs among women. We used a linear mixed-effects model to model the difference in temperature between the genital zone and navel zone, with week and complaint group as fixed effects.

INTERVENTION: On four areas of the abdominal wall, infrared thermography temperature measurements were taken on the abdominal skin.

RESULTS: During pregnancy, a significant temperature difference developed between the genital zone and the navel zone (t=-6.019), caused by lower temperature in the genital zone that became visible approximately in the 34th week of the pregnancy.

CONCLUSIONS: The null hypothesis should be rejected. Infrared thermography seems to be able to measure the viscero- cutaneous consequences of a visceral process on a physiological level. The investigation with pregnant women reported in this publication is relevant for two reasons, because the evidence based data show that: 1. Infrared thermography can play a role in the detection of processes in the viscerum. 2. Chronic pain of the abdominal wall cannot be an isolated entity. This confirms extensively documented literature published previously. Abdominal wall pain continues to be a major problem medically, economically, and socially. Abdominal problems must be ruled out explicitly when searching for the location of abdominal wall pain. Differential diagnostics are a prerequisite for determining a specific solution.

KEYWORD: abdominal wall, chronic pain, pelvis pain, thermography, viscerocutaneous reflex.

VISZERKUTANE REFLEXE BEI BAUCHSCHMERZEN - EINE STUDIE AN SCHWANGEREN FRAUEN AUS EINER ALLGEMEINPRAXIS IM JAHRE 1981

HINTERGRUND: Dies ist ein Artikel über eine bislang unveröffentlichte Studie, die im Jahre 1981 geplant und durchgeführt worden war, die aber auf Grund der Arbeitsbelastung in der ausgelasteten Praxis des Autors nicht zeitnahe publiziert werden konnte. Temperaturänderungen auf der Bauchdecke könnten durch nozizeptive Empfindungen in den Eingeweide verursacht werden, die auf die Oberfläche über viszerokutane Reflexbahnen übertragen werden. Zwei Aspekte spielen dabei eine Rolle: 1. Die Nähe eines inneren Organs zur Haut, 2. Die Repräsentation der Funktion eines inneren Organs auf der Haut. Diese Studie befasst sich mit der Repräsentation innerer Organe in bestimmten Regionen der Haut.

ZIEL: Ziel der Studie war es zu untersuchen, ob die Infrarot-Thermographie Temperaturänderungen messen kann, die im Zusammenhang mit dem funktionellen Status einer Schwangerschaft stehen. Die Nullhypothese war, dass im Verlauf der Schwangerschaft kein Unterschied in der Hauttemperatur zwischen den ausgewählten Hautflächen fest zu stellen ist.

METHODIK Das Auftreten von viszerokutanen Reflexen wurde mittels Infrarot-Thermographie in einer Gruppe von schwangeren Frauen untersucht, die in einer allgemein- medizinischen Praxis betreut worden waren. Diese Beobachtungsstudie begann beim ersten Besuch zur Schwangerschaftskontrolle. In der Folge wurde bei jeder Kontrolluntersuchung auch die Bauchhauttemperatur gemessen. Die Zahl der Messungen war unterschiedlich, da die Kontrolluntersuchungen entweder nach medizinischer Indikation oder auf Wunsch der Patientinnen durchgeführt wurden. Wegen der variablen Zeitabstände der Messungen wurde ein linear gemischtes Effektmodell verwendet, um den Temperaturunterschied zwischen der Genitalzone und der Nabelzone deutlich zu machen. Schwangerschaftswoche und die Beschwerdegruppen fungierten als Festpunkte.

INTERVENTION: In vier Bereichen der Bauchwand wurden Infrarot -Thermografische Messungen vorgenommen.

ERGEBNISSE: Im Laufe der Schwangerschaft entwickelte sich eine signifikante Temperaturdifferenz zwischen der Genital- und der Nabel- Zone (t = -6,019), die durch eine ab der 34. Schwangerschaftswoche nachweisbare, niedrigere Temperatur in der Genital-Zone verursacht war.

SCHLUSSFOLGERUNG: Die Nullhypothese sollte abgelehnt werden. Die Infrarot-Thermographie scheint in der Lage zu sein, die viszero kutanen Folgen eines viszeralen Prozesses auf einem physiologischen Niveau messen zu können. Unsere Untersuchung an schwangeren Frauen sind aus zwei Gründen relevant , da die Daten zeigen, dass
1. Die Infrarot-Thermografie eine Rolle bei der Erkennung von Prozessen in den inneren Organen spielen kann.
2. Chronische Schmerzen der Bauchwand keine isoliertes Entität darstellen. Unsere Ergebnisse bestätigen die bis jetzt veröffentlichte, ausführlich dokumentierte Literatur.

Schmerzen in der Bauchdecke sind nach wie vor ein ein großes medizinisches, wirtschaftliches und soziales Problem. Intra-abdominalen Beschwerden müssen explizit bei der Suche nach Ursache der Bauchdeckenschmerzen ausgeschlossen. Differentialdiagnostik ist die Voraussetzung für die Festlegung einer spezifischen Behandlung.

SCHLÜSSELWÖRTER: Bauchwand, chronischer Schmerz, Beckenschmerz, Thermographie, viscero-kutaner Reflex.

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Introduction

For almost a century, abdominal pain has been a diagnostic problem for clinicians, with chronic abdominal pain having its own specific domain. The term 'chronic' is used for pain that lasts longer than six months. Chronic abdominal pain is separated into two broad groups:

1. Chronic Pelvic Pain Syndrome (CPPS)

The term Chronic Pelvic Pain Syndrome dates back to 1926. Pelvic pain is a symptom that can affect both women and men. The pelvic pain that persists for a period of 6 months or more is considered chronic, while pain lasting less than this is considered acute. The pain may indicate the existence of poorly understood conditions that likely represent abnormal psychoneuromuscular function (1) The pain is located in the pelvic area of the abdominal wall, which makes it part of chronic pain in the abdominal wall.

2. Chronic Abdominal Wall Pain (CAWP)

CAWP is defined as pain located in and originating from the structures of the abdominal wall. According to a large number of authors, this means there is no relationship with visceral structures. In other words, CAWP could possibly exist as an isolated entity.

Differential diagnostics

The diagnostic problem still exists in 2012, regardless of the fact that in 1926, a method was reported which could make it possible to distinguish between pain in the abdominal wall proper, and pain originating from internal organs (2). In 1963, a clinical lesson was published about CAWP (3). Its conclusion was that abdominal wall pain could be established with manual examination and that all that was needed for this was to assuage the patient's concern. Nevertheless, the examination methods are not sufficiently satisfactory. A wave of publications continues: In 2012, PubMed listed 1066 publications about CPPS and 441 about CAWP. Total: 1507. The costs of these diagnoses are high due to:

1. frequently missed diagnoses of abdominal wall pain (4, 5, 6) that resulted in many expensive, unnecessary examinations.

2. the tendency towards overdiagnosis of abdominal wall pain by the ardent supports of it (4,6,7).

3. the absence of visceral diagnoses at a rate between 4% and 45%. One study reported finding 4% visceral diseases after the diagnosis of CAWP was made (8). Another reported finding 7% misdiagnoses upon careful examination and during aftercare. Two studies reported 45% misdiagnoses (9,10).

Much remains unclear, and a good diagnostic method is lacking. People continue to search for an easy diagnostic method due the high costs that accompany the syndrome (11). Currently, diagnostics involve this method: the pain pressure threshold (12), injections with local anaesthetics, allodynia tests, and the Carnett's test. The skin is partially involved in all the tests. Even with these tests, the literature report there is an expensive problem, which is difficult for doctors to deal with (13).

It is shown in the following diagnoses:

1. Ten studies concerned the diagnosis: cutaneous nerve entrapment (14,15,16,17,18,19,20,21,22,23).

  a. In four cases, the diagnosis was made after administration of local anaesthetics to the suspected cutaneous nerve.
  b. In six cases, the diagnosis was made after Carnett's test and the administration of local anaesthetics. If the pain disappeared, further examination was unnecessary.

2. Despite the unequivocal involvement of the skin, the emphasis is mainly placed on the myofascial aspects (24,25,26,27) with reference to pain related to a source in the abdomen or thorax (28).

3. Some of the literature places more emphasis on abdominal wall pain, allodynia and viscerocutaneous reflexes (26,29,30).

4. Only one publication that establishes a relation between viscerum and abdominal wall skin (31).

5. Even an investigation into pain thresholds with Urological Chronic Pelvic Pain Syndrome (UCPPS) only refers to central effects and not to the skin (32).

All of the above-mentioned techniques, following Carnett and Kloosterman, explicitly assume abdominal wall pain is an isolated entity not related to any internal organ. However, invasive therapy was nonetheless implemented in a large number of cases included reassurance as sufficient therapy in the above-mentioned studies. Merely a few attempted to introduce structure to the complexity of diagnostic methods used by indicating pain-inducing surface structures in the skin (33,34). However, even these authors do not address the fact that conditions related to the abdominal wall could also induce reactions via cutaneo-visceral pathways in the viscerum itself (35,36).

No investigations were found with evidence-based data regarding an isolated entity of pelvic pain and abdominal wall pain. Old as well as recent literature, partially based on evidence-based data, actually show the contrary: abdominal wall pain is not an isolated entity.

Extensively documented literature (35) indicates a fixed relation between viscerum, skin, and muscles of the abdominal wall. There would always be a relation between abdominal wall and viscerum via the viscerocutaneous and cutaneovisceral reflex pathways, which makes the existence of an isolated entity impossible. That would only be possible without the presence of viscerocutaneous reflexes on the one hand and cutaneovisceral reflexes on the other (35,36).

The implementation of infrared thermography

The old literature reports on vascular circulatory changes in the skin as a result of viscerocutaneous neural transmission. Diseases of the viscera induce reflectory reactions in the skin, skeleton, connective tissues, and muscles (35). The skin is an unappreciated organ, while there is actually a perfect diagnostic possibility for this organ, namely, infrared thermography.

Infrared thermography was present as a medically applicable device at the start of the 1980s in the form of a noncontactual infrared recording device. Diagnostic methods that differentiate between superficial pain and visceral diseases with pain are being sought after for CPPS as well as CAWP. It seemed fairly obvious that an infrared device should be integrated with the problem of diagnosing CAWP.

It should hence be made clear where information about this can be obtained: only in superficial processes in the abdominal wall or also information about processes in the viscera. To this purpose, the notion as to whether abdominal wall pain is an isolated entity needs to be shown first. To answer this question, it would be sufficient to demonstrate whether changes in functions in the viscera can be detected with infrared thermography. Hence, a function-specific investigation was designed.

Organ information, along with function information, must also be obtained in order for infrared thermography to have potential for visceral examinations. This requires another investigation. This investigation is limited to the function.

Fundamental assumption of the study

The hypothesis that abdominal wall pain is an isolated entity should be rejected as soon as a fixed relation can be established between visceral activity and changes on or in the abdominal wall. Otherwise, concluding that abdominal wall pain has nothing to do with an internal process cannot be justified.

Null hypothesis

Functional or pathological activity of the uterus is not observable in or on the skin. With regard to the adjusted measuring methodology, this means that there is no difference in skin temperature between the skin areas selected during the course of the pregnancy.

Literature discussion 1981–2012

The testing methods reported reveal painful sites in the abdominal wall, but do not substantiate abdominal wall pain as being an isolated entity. Based on the study from 1981, and on practical grounds, that is the reason why visceral problems with abdominal wall pain should not be ruled out (10,12,21,35,38). Therefore, the golden standard for easy diagnostics has not yet been discovered, which can also be said with regard to the solution for the high cost. The medical world is perplexed about the symptoms of CPPS and CAWP (39). Caregivers resort to "physical exclusions", "psychological inclusions" and referrals to specialists (13, 40). The existence of the possibility for pain transmission via viscerocutaneous reflex pathways was confirmed in 2007 (37).

Method and material

Implementation concept

Viscerocutaneous reflex pathways run via the autonomic nervous system. Vascular regulation is an important function of that. In 1981, infrared thermography increased the possibility to detect skin perfusion changes. If it were an isolated entity, a perfusion change of an internal organ would not accompany perfusion changes in a section of dermatome related to that organ. If infrared thermography does detect these changes, there would be a fixed relation between viscerum and abdominal wall, which puts the notion of an isolated entity entirely out of the question.

The study population had to meet the following requirements:

1. The target group had to have a comparable physiological or pathological process located in the viscera that influenced the state of perfusion of that viscera.

2. A sufficient number of participants had to be found.

3. The study could not put the participants at risk or be an extra burden to them.

4. The visceral stimulation had to be as minimal as possible. The sensitivity of the study medium will be less conclusive, the stronger the sensation is.

A group of pregnant women from one general practice met these requirements. Pregnancy increases the body temperature. Hence, the general vascular system is affected. Measuring a temperature increase therefore only says something about viscerocutaneous reflexes if the genital area (area of the skin that has segmentary connection to the uterus) changes significantly in temperature in comparison to other sites on the abdominal skin that are measured.

Population

The choice was for a prospective study on pregnant women who visited a general practice from October 1981 to September 1982. Due to the expected limited number of eligible candidates, there was no correction for potentially interfering variables.

The women were invited to participate in the study. The study would commence on the first visit for a pregnancy checkup and proceed until the day of delivery. The check-ups were scheduled by the doctor based on indications, or they were scheduled based on the woman's request. It was assumed that there would be unfavourable irregularity of data collection. The patients were told what they could expect if they were to participate in the study. In 1981, the use of written informed consent forms was not yet implemented. The check-ups took place on a voluntary basis and the study design was not a burden and did not involve risks to the participants.

In the analysis we will make a distinction between women who had complaints at the end of the measurement schedule (n=9) and women who did not have complaints (n=8) in order to see whether results were different for both groups.

This distinction took place because it was unclear if this anomalous group would influence the measurement results.Nine women had complaints; eight did not.

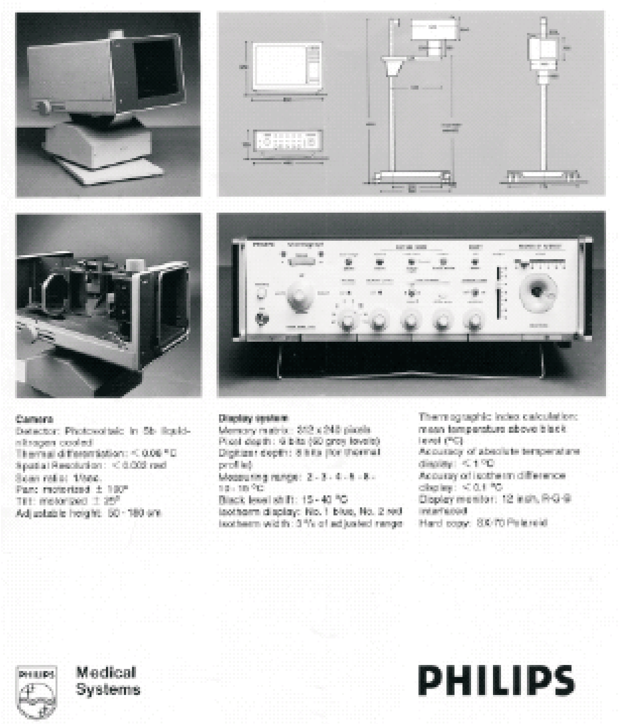
The pregnancy timeframe was divided into three categories:

1. before week 16
2. from week 16 until week 38
3. after week 38

Technique

A Philips Video Thermograph was used (modification 1980) (see Figure 1) For thermal camera specifications see table 1.

Figure 1
Philips Video Thermograph



A Canon A1 analogue single lens reflex camera with databack was used for hard copies instead of the standard SX-70 Polaroid. Recorded on 18 DIN slide positive film (Figure. 2.).

Measurements

The skin temperature measurements were carried out with the patient in the prone position on an examination table. The camera with infrared mirror was hovered 80 to 100 centimetres above the patient.

The ambient temperature was kept constant at 20-22 °C and the relative humidity was maintained between 35% and 40% with a Thies Clima Hygro-Thermograph, type 0177. The precision of the hygrometer was ±3% relative humidity; the precision of the thermometer was 0.5 °C. "Direct Dynamic Cooling" was used to avoid long-term (20 min) acclimatization times (41). For cooling, a wall fan placed at a distance of two metres was used for a period of 30 seconds, followed by three minutes of adaptation. A self-adhering metal masker of 1.5/1.5 cm produced by Avery was adhered to the navel for focussing (figure 2.). The measured temperature of this mask was at the "black level" temperature range. Half of this mask was located in the measured navel zone and segment Th 10. The intensity of the measure artefact by all patients was equal and contained no more than 0.9% of the total measurement surface of the segment Th 10. A puncture (28.3 mm², a quarter of the surface) was made in the centre of the masker. The rest of the mask compensated for an excessive temperature effect from the navel itself

Region of interest

The core area measured was 5×5 cm, in the middle of the abdomen, right above the pubic hairline (figure 3). That is the area where pain often reported in cases with gynaecolo-

Table 1
Specifications of thePhillips Video Thermograph

Camera	Display system
Detector: Photovoltaic in Sb liquid-nitrogen cooled	Memory matrix: 312×240 pixels
Thermal differentiation:<0.08 °C	Pixel depth: 6 bits (60 grey levels)
Spatial resolution:<0.002 rad	Digitizer depth: 8 bits (for thermal profile)
Scan ratio: 1/sec	Measuring range: 2-3-4-5-8-10-15
Pan: motorized ± 100	Black level shift: 15-40 °C
Tilt: motorized ± 25°	Thermographic index calculation: Mean temperature above black level
Adjustable height: 50-180 cm	Display monitor: 12 inch R-G-B interfaced

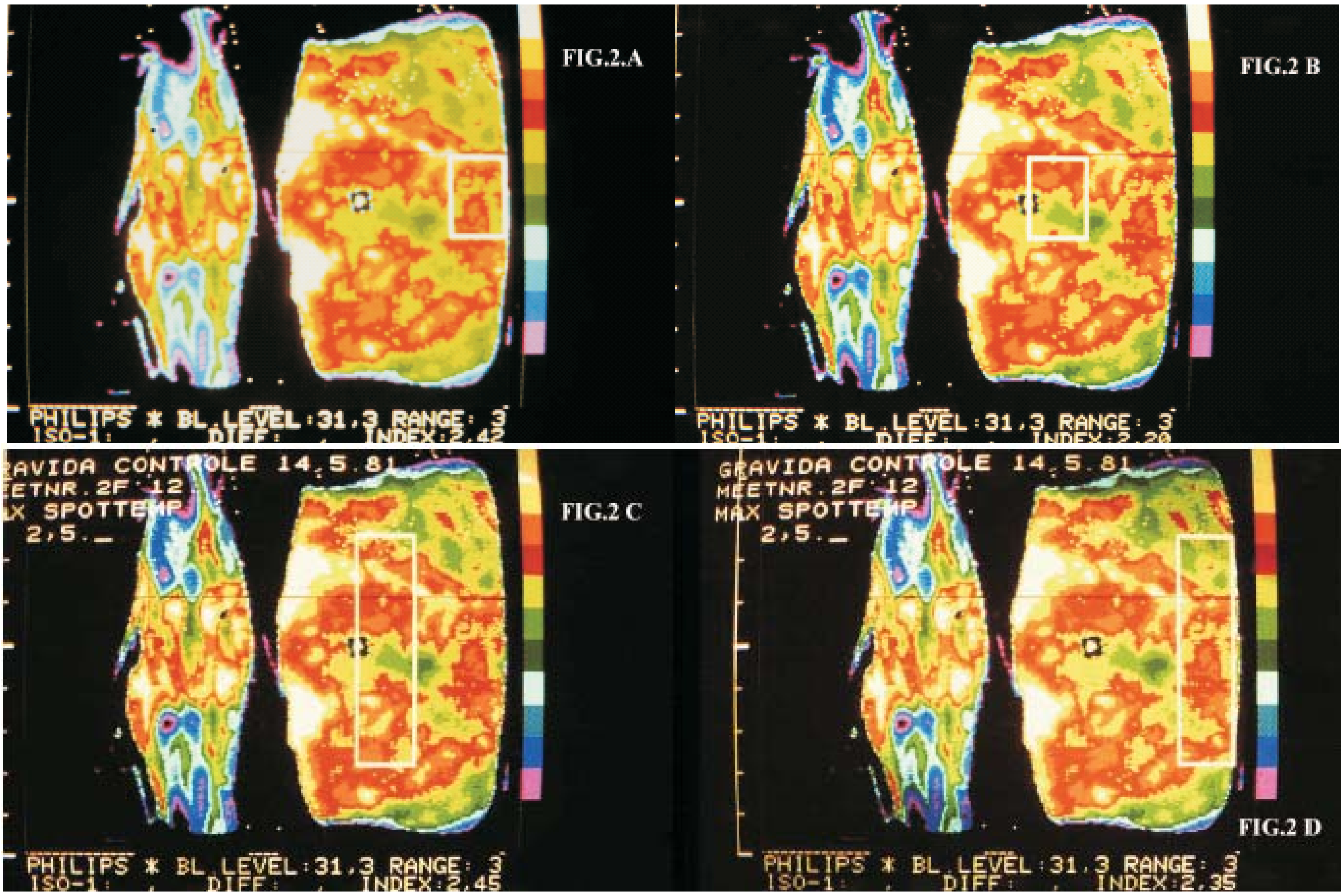


Figure 2. Image while lying down with the head turned to the left. The areas measured are the white outlined frames.The average temperature values above black level are right below behind "Index".
2A: gen. zone. 2B: umb. zone. 2C: segment Th 10. 2D: segment Th 12. The temperature range is 3 °C distributed over eleven equal scales. The colour purple is in 1 scale above the black level, and white is larger than black level + range.

gical disease. The literature refers to it as the "genital zone" (31). This was compared to the following: an area of the same size with its upper part at the navel – further referred to as the "umb. zone"; a larger area, 25×5 cm, located above the pubic hair of the same dermatome – further referred to as "segment Th12"; and an area comparable to this with its upper part at the navel called "segment Th10". It was assumed that the results of segment Th12 would be influenced by those of the genital zone (35)

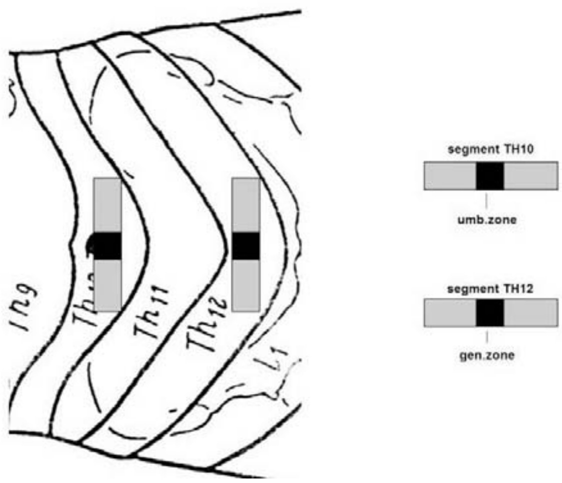


Figure 3.
The whole rectangle in the measured area is "segment Th10". The "umb. zone" in the text is the black part.

Results

The data obtained in 1981 was tested again by fitting a linear mixed-effects model. The difference in temperature between the genital zone and the navel zone (ΔT gen-umb) was used as the dependent variable, and pregnancy week and group (A versus B) were used as fixed factors. We used a random intercept to take into account the possible differences among the women. Thereby, a quadratic fit of pregnancy week and an interaction between group and week were tested. "The statistics program R, version 2.13.2 was used. The final model is given in Table 2.

In this model there is a significant effect of the quadratic component of pregnancy week. This means that the difference in temperature increases in the first weeks, but decreases in the last weeks ($t = -6.019$). On average, the temperature difference for group A was 0.31°C higher than for group B. This effect was slightly significantly different from zero [95% CI: 0.002, 0.618]. To see if different curves for group A and group B were present in the data, an interaction effect between week and group was tested. This ef-

Table 2
Results of the linear mixed-effects model explaining the difference in temperature between the genital zone and navel zone (ΔT gen-umb).

				95% Confidence Interval (CI) of the estimate	
Coefficient	Estimate	Std. Error	t value	Lower	Upper
Intercept	-0.327	0.203	-1.611	-0.726	0.071
Group (A=1)	0.310	0.157	1.974	0.002	0.618
Pregnancy week	0.081	0.017	4.699	0.047	0.114
Square of week	-0.002	0.0003	-6.019	-0.002	-0.001

fect seemed to be present, but was omitted from the model because it was not significant.

The average curves for groups A and B are presented in Figure 4a; in Figure 4b the actual data and a fitted curve of one typical result (ID=9, group A) are given. In both plots, the increase in temperature difference before week 20 and the decrease from week 20 onwards are quite visible.

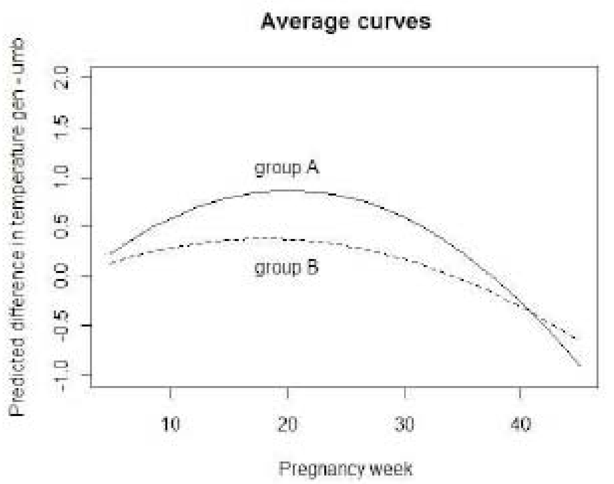


Figure 4a:
Average curve of the difference in temperature between the genital zone and the navel zone (DT gen-umb), for groups A and B separately. The horizontal axis indicates the number of pregnancy weeks. The vertical axis shows the difference in temperature in °C.

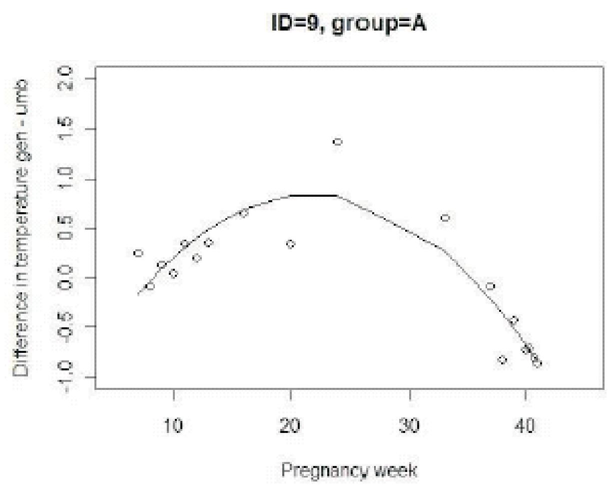


Figure 4b:
Data and estimated curve for a typical result (ID=9, group A) for the difference in temperature between the genital zone and the navel zone (ΔT gen-umb) The horizontal axis indicates the number of pregnancy weeks. The vertical axis shows the difference in temperature in °C.

Discussion

General

The study is function-specific, but not organ-specific. A relation has been demonstrated between a specific skin area and pregnancy. The literature suggests that this skin area has a relation with the uterus. In this study, this relation has not been proven. A follow-up study on the relationship of the genital zone with the uterus is required for that. That is possible by artificially stimulating the organ while controlling the stimulation effects on the skin to measure with infrared thermography. This study was carried out in 1982 in cooperation with Erasmus MC in Rotterdam. The results are now being processed for publication.

In addition, a non-significant difference was found in the course of temperature between group A and group B. The temperature decrease in the genital zone and in segment Th 12 in the last phase of pregnancy seemed to be somewhat stronger in group A than in group B. It is unclear to what this could possibly be attributed. For both groups, the general conclusion of the study holds.

Rejecting the null hypothesis implies that pain can be projected on the skin by the viscerocutaneous pathway. That could explain why a painful disease in the viscerum in which pain has a unlocalizable character is sensed as if it is on the abdominal wall (35,29)

Temperature change

No predictive value was found for the start of the delivery process(42). The temperature decrease at the end of pregnancy has been reported in animals(43), but that does not guarantee that these findings can be generalized to humans. Temperature increase of the skin during pregnancy might occur due to an overall warming of the body, physical factors such as convection, radiation, conduction, or because of reflex processes. Overall warming of the body, however, cannot be the source of the findings. If that were so, there would be no significant temperature differences between the genital zone and other measured areas.

Radiation, conduction en convection is not likely. Anatomically, the uterus is not situated against the abdominal wall. The uterus does indeed increase in size and presses against the abdominal wall, but the contact surface around the navel is larger than in the genital zone whereas that is the warmer cutaneous area. In addition, the specific temperature decrease in the genital zone at the end of the pregnancy cannot be explained by radiation or conduction. The medium for it is not homogeneous. It comprises connective tissue, muscle tissue, fatty tissue in different thicknesses and states of function. The body mass becomes active and alternating, flushed with fluid with a constant temperature and the temperature differences are very slight.

In addition to this, the emanating heat of an object determined by the Stefan–Boltzmann law. The following factors play a role in this:

Q = the energy flux density of the emitted radiance (W/m^2)

ε = the emission coefficient of the material surface

T = the absolute temperature (K)

σ = radiation constant or Boltzmann constant (W/m^2K)

Qz = the heat radiation of the "black body"

There is no coefficient for the spherical formation of a heat-radiating object. The abdominal spherical formation over the course of a pregnancy results in a larger radiation surface per measurement unit in the flat surface. That should induce higher heat production in the spherical formation of the abdomen during certain phases of pregnancy. That does not turn out to be the case. The most spherical portion around the navel is cooler than the genital zone and segment Th 12.

This also means that physical heat transfer cannot be the cause of the differences. The specific temperature change measured all through the pregnancy that significantly deviates with respect to the reference areas indicates a reflectory mechanism by viscerocutaneous pathways.

Sensitivity

A pregnancy is a physiological process. Therefore, the outcome of the study means that infrared thermography is able to detect that process at the physiological level. The expectation is that video thermography is a medium with high sensitivity. The inextricable and unfavourable expectation to that is also a limitation of the specificity. The following values for sensitivity and specificity were found for Complex Regional Pain Syndrome (CRPS) in 2004: sensitivity 92%, specificity 94% (44). The latter is surprising and possibly because CRPS as a serious pathological situation far from the normal physiology.

1. Infrared thermography can play a role in the detection of processes in the viscerum.

2. Chronic pain of the abdominal wall cannot be an isolated entity. This confirms extensively documented literature published earlier.

Infrared thermography in 2012

When the imited calculation vigour, image resolution and image storage capacity from 1981 are compared with those of 2012, we see that the modern technical possibilities of thermography are essentially unlimited. Maximum and minimum spots can now be determined effortlessly in comparison to what was possible in1981. Extensive areas with significant temperature increases and decreases in comparison with a complete image could possibly be determined effortlessly. The precision of the measuring device used in 2012 has not improved, but it has also not worsened. It has become easier to use.

The reported investigation can be replicated without a problem by using modern detection devices. Modern statistical calculations are even possible with the data collected in the past. This could be carried out effortlessly with new data sequencing.

Conclusion

1. Changes take place in the genital zone during pregnancy, which differed significantly from other zones measured.

2. The null hypothesis should therefore be rejected.

Final conclusions

The findings and conclusions of this study do not contradict recent publications about chronic pelvic pain and CAWP. The results are still relevant and nothing was published after 1981 that did indeed confirm the null hypothesis. There is one recent publication which confirms that pain originally developing in the viscera via viscerocutaneous reflexes can generate pain in the abdominal wall. Thermography can detect its location. That does not rule out the possibility of the abdominal wall being the source of the pain. However, because of the tightly interwoven nature of pain generated in the abdominal wall resulting from processes in the viscera, a visceral source should be explicitly ruled out. The current test methods implemented are insufficient. This study shows that infrared thermography could possibly play a role in providing a safe and inexpensive contribution to alleviate that.

Conflict of interest

No third parties have been involved in this study.

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17th Congress of the Polish Association of Thermology and Certifying course: "Practical application of thermography in medical diagnostics"

Zakopane, March 15th - 17th, 2013

Scientific Committee

Prof. Jung Anna MD,PhD (Poland)

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Zakopane, Pilsudskiego str 20

Organizers

Paediatric,Nephrology and Alergology Clinic

Military Institute of Medicine, Warsaw, Poland

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Scientific Programme

Saturday, March 15th 2013

09:50 - 11:00 Session I
Chairmen: Prof. Francis Ring, Prof. Anna Jung

1. Ring F. (*UK*)- The Herschel legacy of infrared imaging.

2. Mercer JB., Lokebo JE, de Weerd L(*Norway*) - Thermography as an adjunct with other imaging modalities to evaluate the perfusion of freezing cold injuries.

3. Vardasca R, Silva A, Seixas A, Gabriel J. (*Portugal*)- Medical thermal imaging technological assited lab.

4. Ammer K. (*Austria)* - Publications on Thermology between 1989 and 2012.

11:00 - 11:30 Coffee break

11:30 - 13:00 Session II
Chairmen: Prof. James Mercer , Prof. Boguslaw Wiecek

1. Strakowski R, Wiecek B. (*Poland*)- Review on multispectral thermography and its applications in biomedicine.

2. Rustecki B, Jung A, Kalicki B, Murawski P, Rustecka A, Zuber J. (*Poland*) - Esophagus measured central temperature compared with infrared camera temperature in patient under general anesthesia - preliminary study.

3. Badaro J, Lima M, Araujo J, Marcondes A, Brioschi M, Teixeira M, Vardasca R (*Brazil*) - Thermographic evaluation of migraine.

4. Strakowska M, De Mey G, Wiecek B, Wittchen W, Marzec S. (*Poland*) - Thermal transient thermography for human skin modelling and screening.

5. Urakow AI, Urakowa NA. (*Russia*) - Thermography of the skin as a method of increasing local injection safety

13:00 - 14:00 Lunch

14:30 - 16:00 Session III
Chairmen: Prof. Kurt Ammer , Dr Kevin Hovell

1. Kasatkin AA.(*Russia*)- Effect of drugs temperature on infrared spectrum of human tissue.

2. Brioschi M, Teixeira M, Yeng L, Franco G, Araujo J, Lima M, Marcondes A, Freitas P, Badaro J. (*Brazil*)- Comparison clinical, ultrasound and thermography points in identifying myofascial.triggers in patients with fibromyalgia

3. Boguszewski D, Adamczyk J, Slupik A, Mosiolek A, Bialoszewski D. (*Poland*) - Usage of thermovision in evaluation of influence of sports massage on selected biomechanical and physiological parameters of lower limbs.

4. Adamczyk J, Boguszewski D, Siewierski M., Bialoszewski D. (*Poland*) .- Relations between thermal portrait and aerobic capacity - evaluation of thermoregulation efficiency throughout thermovision.

5. Soroko M, Henklewski R, Filipowski H, Jodkowska E.(*Poland*) - The effectiveness of thermographic analysis in equine orthopaedics.

16:00 - 16:15 Coffee break

16:15 - 17:00 Training course

Chairmen: Dr med. Boleslaw Kalicki

1. Ring F., Ammer K .(*UK/Austria*) - Errors and artefacts in infrared imaging.
2. Wiecek B. (*Poland*) - The useness of thermal impedance concept in medical thermography.
3. Firm presentation.

17:00 - 18:30 EAT Committee Meeting

Sunday, March 17th 2013

09:30 - 11:00 Session IV
Chairmen: Dr Ricardo Vardasca, Dr med. Janusz Zuber

1. Urakowa NA.(*Russia*) - Decrease of the temperature of the head of the fetus during birth as a symptom of hypoxia

2. Naseer S, Keresztes KG., Coats TJ .(*UK*) - Developing a thermal imaging protocol for use in emergency care environment.

3. Seixas A, Silva A, Mendes JG, Vardasca R. (*Portugal*)- The effects of whole-body vibration on thermal symmetry of the lower legs in healthy subjects.

4. Murawski P, Jung A, Kalicki B, Rustecki B. (*Poland*) - Usefullness of Linear Predictive Coding coefficients for the qualification healthy people and patients with sinusitis based on facial thermograms.

5. Cholewka A., Stanek A., Kwiatek S., Siero? A., Drzazga Z. (*Poland*) - Does the temperature correlate with photodynamic diagnosis parameter numerical colour value (NCV)?

Abstracts

THE HERSCHEL LEGACY OF INFRARED IMAGING

Francis Ring

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There are many references to the fact that Infrared radiation was identified by William Herschel in England in 1800. In the Philosophical Transactions of The Royal Society London in 1800 a series of papers can be found that relate to the properties of sunlight. In the famous experiment to discover the source of heat sometimes recognised by Herschel using his own optical systems for telescopes he attempted to measure the temperature of each colour of the optical spectrum using a prism in a darkened room, and placing thermometers in the path of each displayed colour. To his surprise he found the only increase in temperature occurred outside the visible colours, beyond the red. He called this dark heat, now known to us as infrared radiation. There are many more observations beside that fundamental discovery, and Herschel compared the properties of both light and heat. He noted that heat rays could be reflected and focussed and that a number of substances in solution acted as filters reducing the energy when heat rays were passed through them, similar to those of visible light. It was also important that in 1840 shortly after his father's death that his son John Herschel made an experiment to record heat from the son by an evaporation process with alcohol and carbon particles in suspension. This created an image over a period of several hours that he called a thermogram. Today in the 21 century we are using infrared images in a wide range of applications both medical and industrial. Significant advances have been made in recent years in infrared astronomy. Here the very subject that brought William Herschel to investigate heat, remarkable technology is now used to study the cosmos using infrared imaging and spectroscopy. This paper will overview some of the more recent findings using satellite spacecraft to carry multispectral imaging telescopes beyond the earth's atmosphere to study the very origins of the Universe.

THERMOGRAPHY AS AN ADJUNCT WITH OTHER IMAGING MODALITIES TO EVALUATE THE PERFUSION OF FREEZING COLD INJURIES

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There is little international consensus on the management of freezing cold injuries (FCI) and treatment procedures vary from being aggressive (rapid amputation) to conservative (wait and see). The different approaches to treating such injuries can partly be explained by the complexity surrounding the injury. For example, with frostbite tissue freezing occurs which may involve only superficial tissues or may extend to the bone. The onset and severity of frostbite may be affected by a multitude of factors such as air temperature, wind speed, duration of exposure, amount of exposed area, and predisposing conditions such as poor or inadequate insulation from the cold or wind, immersion, altitude, impaired circulation from tight clothing or shoes, fatigue, injuries, circulatory disease, poor nutrition, dehydration, hypothermia, alcohol or drug use, and use of tobacco products. Damage to the frostbitten tissues is caused by crystallization of water within the tissues, typically between the cells, and by resulting changes in electrolyte concentration within the cells. Damage occurs during the freezing process. Further damage occurs during reperfusion of frostbitten tissue. Whatever the situation one of the key factors in recovery is adequate tissue blood perfusion. So whether one is interested in mapping the extent of such an injury in the acute phase or monitoring the effect of a treatment regime or assessing the final outcome, some form of blood perfusion measurement is desirable. An example of a multimodal imaging approach using CT angiography, MR, scintigraphy and thermography for investigating blood perfusion in a severe case of frost bite of the feet will be presented. It will be shown that thermography as a non-invasive method without the use of ionizing radiation was helpful in confirming the diagnosis, assessing the severity of the injury, and finally monitoring the outcome of FCI.

MEDICAL THERMAL IMAGING TECHNOLOGICAL ASSISTED LAB

Ricardo Vardasca[1,2], António Silva[1], Adérito Seixas[3,4], Joaquim Gabriel[1]

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Medical thermography has evolved since its first application in 1956 either with technological and protocol developments. Ammer in 2003 pointed to the need for standardisation in the medical thermal imaging to cope with the other medical imaging modalities used in daily clinical practice. Recommendations and guidelines for preparing the room environment, equipment and subject before and during the examination have been produced and used to increase and warranty the quality and the acceptance of the technique as valuable.

Some technological issues are still open for development such as dedicated software package making use of the most recent image processing algorithms and predefined views and other intrinsic aspects of Medical Thermography is missing, the development of the defined DICOM modality to accommodate the specific data from a simple or functional examination. Consequently there is a lack of a medical thermal imaging database to be used worldwide as a reference.

Currently there are assistive technologies that can help to improve the use of Medical Thermography contributing to a considerable decrease of the human error and operator dependency, which can be used to improve the quality and reliability of the method. Examples of those assistive improvements are the usage of environment variables sensors (air flow, humidity and temperature) in the stand where the IR camera is placed for examination. Sensors of distance, emissivity and angular position, with a touchscreen interface would assist the operator in using the technique correctly and to record the whole environmental relevant data at the moment of capture into the DICOM medical thermography modality definition. Having that information available in a PACS system, image analysis and reporting tools can be developed to be used by the current and future mobile systems as tablets and smartphones, which will contribute to a better satisfaction and convenience from the health professionals and patients.

A fully implementation of these concepts would put Medical Thermography at the same level of development of other medical imaging modalities and would significantly contribute to its credibility assurance leading to global widespread usage among health care professionals, filling the gap of six decades.

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PUBLICATIONS ON THERMOLOGY BETWEEN 1989 AND 2012

Kurt Ammer [1,2]

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[2] Medical Imaging Research Unit, Faculty of Advanced Technology, University of Glamorgan, Pontypridd, UK

In 1997, a CD ROM [1,2] was compiled at the University of Glamorgan containing all issues of the journal "Thermology" published by the American Academy of Thermology and almost all issues of "Acta thermographica" edited by Prof. G.F. Pistolesi. Both discontinued publications years ago. The journal "Thermology international" which started as "Thermologie Österreich" and changed its name "European Journal of Thermology" between 1997 and 1998, evolved as the main organ for publication of the thermological community.

Together with the proceedings of the 6th European Congress of Thermology, held in Bath in October1994, Thermology international is an important source of references which is supported by the fact that Reutters Web of Science lists 90 papers from Thermology international resulting in a total of 130 citations. Embase accepted to include full papers from Thermology international in 2002 and started to list conference abstracts in 2012. For the period from 2002 on, 369 citations were found in Embase/Scopus. Using Harzing´s Publish or Perish, a bibliography search tool based on Google Scholar, a total of 368 citations were obtained for 89 papers published in Thermology international. Searching for European Journal of Thermology in Google Scholar resulted in 65 citations for 19 papers. In my own archive, 229 cited papers - 95 published in Thermologie Österreich, 34 in the European Journal of Thermology and, 100 in Thermology international - received about 1050 citations.

In December 2012 a DVD-ROM became available including PDF-files of all issues of "Thermologie Österreich" (May 1991 to April 1997), "European Journal of Thermology" (July 1997to October 1998) and "Thermology international" (January 1998 to October 2012). Some papers such as "The Technique of Infra red Imaging in Medicine by E.F.J. Ring and K Ammer, Thermology international 2000; 10(1) 7-14." have been supplemented with a list of citations received. The DVD contains also the book The Thermal Image in Medicine and Biology edited by K.Ammer and E.F.J Ring (1995) plus 3 volumes of an index of "Published Papers on Thermology and Temperature Measurement (Volume 1: 1989 to 2004, Volume 2 2005 to 2006, Volume 3 2007 to 2011). Finally, early thermological publications of the Austrian Society are included (Proceedings of the First Thermological Symposium of the Austrian Society of Thermology: Thermographie, evozierte Potentiale edited by O.Rathkolb and K.Ammer, Proceedings of the Second Thermological Symposium of the Austrian Society of Thermology: Kontaktthermometrie und Thermographie edited by K.Ammer and O.Rathkolb, Thermo graphie 90 - Eine computergestützte Literatursuche by K.Ammer).

A simple navigation system, that guides the reader through the content of each pdf-document, is included and its function will be demonstrated at the meeting.

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2.Jones BF, Ring EF. A Searchable Archive of Thermal Imaging for Medicine Papers on CD-ROM. Thermol intern 2000 , 10(4):205-8

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REVIEW OF MULTISPECTRAL THERMOGRAPHY AND ITS APPLICATIONS IN BIOMEDICINE

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There are many reasons of using multispectral thermovision systems. First of all, the division of the total spectral range into two shorter windows corresponds to the atmosphere transmissivity which is different for different spectrum ranges. According to this fact, thermographic cameras can work either in MWIR (Mid-Wavelength Infra Red) or LWIR (Long-Wavelenght Infra-Red) ranges [1]. The atmosphere transmissivity depends on the distance of the camera and the object, as well as the relative air humidity. The most important is that it strongly varies with the radiation wavelengths. For this reason multispectral infrared cameras are often used in long range imaging systems. In addition, presence of some toxic and explosive gases affects the atmosphere transmissivity, what results in the ability of gas detection and the concentration measurement [2]. Secondly, the value of one of the most important parameter in thermovision measurements, the object emissivity depends on the wavelength as well. That fact makes possible not only the detection of objects in the observation applications but also emissivity correction for accurate measurements in the more advanced systems. Moreover, referring to Planck's curves, the maximum value of monochromatic power density radiated from the body surface depends on both the object temperature and the wavelength.

The implementation of multispectral thermographic system can be done in several modes. The simplest one is to use the minimum two cameras for different electromagnetic wavelength ranges. The acquired data is processed and combined together for better imaging and interpretation. More sophisticated systems measure radiation power for different wavelength on the detector level. These types of cameras use detectors cooled down to 50-70 K. There are different approaches in building such multiband cameras. It can be done by using indium antimonite interlace detectors, where e.g. odd and even lines measure MWIR and LWIR radiation power, respectively. Another approach uses Quantum Well Infrared Photodetectors. QWIP detectors are based on forming the quantum well using multilayer nanoscale structures. By varying the thickness of given layers one can adjust the absorption characteristics. Some QWIPs are made in form of a stacked structure where every pixel of FPA (Focal Plane Array) contains two detectors. Another group of multispectral systems are ones based on modified MWIR or LWIR cooled cameras. First approach uses spinning filter wheel in front of the detector. Its movement is synchronized with the acquisition and frame rate. The filter wheel consists of a few IR band-pass filters. It allows to get thermograms for subbands of MWIR or LWIR range. Second solution known under the name of hyperspectral camera, uses the diffraction grids or interference filters in order to "select" desirable wavelength and project it onto the detector.

Higher capabilities of multispectral thermal system causes the interest of their use in the medical applications. The IR systems consisting of MWIR and LWIR cameras for breast screening have been already reported [3,4]. The efforts are also being made to use NIR (Near Infra Red) spectrum (wavelength at ~ m) for diagnostic purposes. A NIR tomograph is now using for breast cancer screening [5]. It operates with NIR LEDs which generate the IR harmless radiation to be propagated in the breast. The scattered and the reflected light is measured using tens of sensitive small detectors in order to evaluate the total hemoglobin and in consequence the oxygen saturation of blood vessels [5].

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ESOPHAGUS MEASURED CENTRAL TEMPERATURE COMPARED WITH INFRARED CAMERA TEMPERATURE IN PATIENT UNDER GENERAL ANESTHESIA.

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Patients under general anesthesia are endangered with cooling. Thermal regulation center is in hypothalamus, all anesthetics disturb its function and move thermal regulation point. When gradient between central temperature and skin of the forearm temperature is greater than 4°C, usually peripheral vases contract. Anesthetic drugs move that value to higher level. Without anti heat loosing treatment all patients undergoing general anesthesia are endangered with cooling. Laminar flow devices speed up this process noticeably.

Post surgery cooling implicates negatively patients comfort, it also worsens patients pain killer drugs reactions and improves oxygen patients need, and in effect cooling increases peri-operative respiratory risk and perioperative risk at all. Concerning mostly elder patients under longer surgical procedures.

Human without his clothes in environment temperature lower than thermal comfort temperature, cools down quickly for first 15 min, afterward slowly for next 45 min, reaching balance with environment temperature. Patient under general anesthesia may reach balance with environment temperature even later. During all major surgery procedures temperature should be monitored. From many various temperature monitoring methods central temperature measure achieved with esophageal probe is the most preferable and reliable.

Installing an esophageal probe can be sometimes technically difficult and despite necessity of temperature monitoring avoided while general anesthesia. Moreover it is traumatic for conscious patient and not possible to use during procedures with usage of regional anesthesia techniques. Infrared camera temperature monitoring can be interesting alternative for monitoring temperature while general anesthesia. Especially those internal corners of skin surrounding eyes are supported with branches of ophthalmic artery and this region temperature should respond to central temperature measure.

It takes much effort to prevent patient cooling during general anesthesia. In prevention of cooling during anesthesia all patients under anesthesia for general surgery receive warm i.v. fluids. Anesthesiology and Intensive Care Clinic of Military Institute of Warsaw toked measures to limit cooling with special mattress allowing partly heating up operating table under lying patient. Its efficiency is not known.

This study was designed to exam if central temperature can be monitored in noninvasive way during general anesthesia with usage of infrared camera while examining efficiency of heat up mattresses.

After obtaining consent for participation on study patients over 50 years old, under 30 BMI, planned to general anesthesia for major surgical procedures with predicted lasting time over 2 hours were qualified. Every 15 min infrared camera photo was performed pointing nose base from around 0,5 distance, beginning just before intubation. Room's temperature (laminar flow device set), temperature around patients head, central temperature measure from esophageal probe and mattress temperature were registered. Patients were divided for two groups of patients, first without additional warming during general anesthesia, and latter warmed additionally with warming mattress set to 39°C.

We have managed to include 21 patients witch were randomized in to two groups. First group (n=11) were patients without additional warming up with mattress and second group (n=10) additionally warmed up to 39ºC. Groups statistically did not differ within age, weight, height and BMI (body mass index), and thus second group had slightly lower median BMI (26, 7 vs. 23).

Esophagus measured central temperature for both groups showed similar trend of cooling patient till 1 hour 45 minutes after intubation, respectively from 36,7ºC to 35,9ºC in the first group and from 36,4ºC to 35,7ºC in the second group. It changed afterwards, while patients which were not additionally warmed up continued to cool down to 35,8ºC 2 hours and 15 minutes after intubation, the latter group stared to recapture heat and warmed up to 36,4ºC 2 hours and 15 minutes after intubation. Data shown in diagram 1 (First group central temperature Dt gr1, and second Dt gr2).

Infrared photos were analyzed in two different measure areas. First was an average from two infrared temperature count marked from medial skin of aye corners. This count shows similar trend like in central temperature count, from 35,9ºC after intubation to 35,2ºC 1 hour 45 minutes after and 34,6ºC 2 hours 15 minutes after intubation in first group (It gr1 in diagram 1), and respectively 35,5ºC, 35ºC and 35,6º in the second group (It gr2 in diagram 1). The latter measure was taken from nasal basement and it showed essentially lower temperatures. 34,5ºC, 33,8ºC and 32,9ºC respectively in the first group (Nit gr1 in diagram 1) and 33,3ºC, 33,7ºC and 34,6ºC in group 2 (Nit gr2 in diagram 1). Central temperature cannot be measured after extubation due to previous removing of esophageal temperature probe. Infrared aye corners skin median temperature after awakening and extubation of patient shows sudden drop of temperature to averagely 33,2ºC in group 1 and 34,3ºC in group 2. Nasal basis infrared measure after extubation show even deeper temperature drop to averagely 32,1ºC in first group and 32,7ºC in the latter.

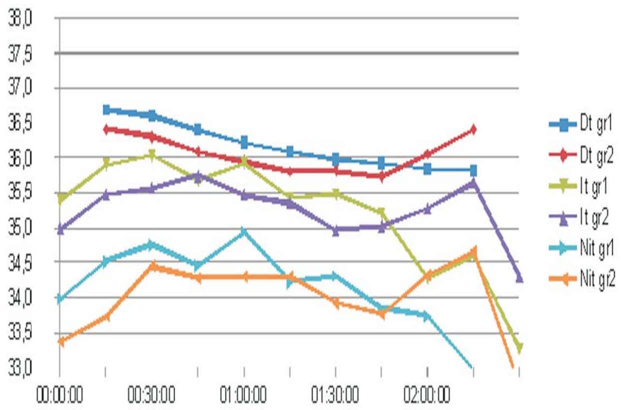

Diagram 1

Onset results of group 1 measurements are higher than one from group 2. It can be related with slightly lower BMI in this group. However, trend for quicker cooling in unwarmed group with tendency of rewarming after 1 hour 45 minutes of anesthesia in the second group, shows that this method of cooling prevention can be useful.

Similar trend in medial aye corners skin infrared for both groups measurements can point out usefulness of this method in attempts of finding noninvasive method of central temperature monitoring during general anesthesia. Lack of identical measurements between esophagus measurement and infrared measurements is probably related with imperfection of method and influence of breathing cycle on measurements count. Larger exam group should partly eliminate this problem. Further study is necessary on that issue.

Nasal basis infrared temperature count cannot be used to deep temperature monitoring during general anesthesia due to large difference in temperature measurements compared with central temperature count.

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THERMOGRAPHIC EVALUATIOAnestezjologia" 2005, 719-721N OF MIGRAINE

Juliana Badaro[1], Monica Lima[1,] Joaci Araújo[1], Adolfo Marcondes[1], Mark Brioschi[1], Manoel Jacobsen Teixeira[1], Ricardo Vardasca[2,3]

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Headache is a very common symptom in clinical practice, but unber valued in skills due to lack of objective documentation. Migraine is a type of primary headache caused by a cranial inherited neurovascular dysfunction. Characterized by recurrent attacks of headache hemicranial and pulsatile with or without aura, nausea, vomiting, photophobia, phonophobia and fatigue sensation. In a crisis situation all stages are not always necessary. Can lead to decreased productivity, loss of quality of life of patients and if not treated promptly it can result on amplification of pain, abnormal brain neuroplasticity and chronicity of pain. Migraine decreases the blood flow of the internal carotid artery (ICA) and consequently cause ischemia on the occipital spot, which explains the scotomas. The image obtained by the infrared thermal thermography through a functional examination can detect temperature changes in skin territory corresponding to cerebral circulation extra ICA. This change which causes temperature decrease in frontal supraorbital region is called "cold patch" (hyporadiation) and aids in the differential diagnosis of other causes of facial and skull pains in clinical and forensic. Thermography is an excellent marker for assessing migraine and guidance regarding the etiology and forensic documentation.

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THERMAL TRANSIENT THERMOGRAPHY FOR HUMAN SKIN MODELING AND SCREENING

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The aim of the research was to verify whether the power of radiation used in the provocation thermal test has any influence on the skin reaction, especially on the thermal time constant corresponding to the rate of heat removal by blood flow and thermoregulation. The temperature on the hand palm has been measured using the thermovision camera after thermal excitation (provocation). The halogen lamp with the radiation power density in the range of P = 500W/m2 - 3000W/m2 was used in the experiment as an external infrared radiation source. After the hundreds of image recorded, the temperature evolution vs time was plotted (Fig. 1).

All the measurement temperature curves have been approximated by the exponential functions and two parameters were taken into consideration - amplitude and the thermal time constant. A simple one layer thermal model was created in order to extract thermal parameters of the skin [3]. The thermal model includes the thermoregulation effect by blood flow and convection by the air (Fig. 2).

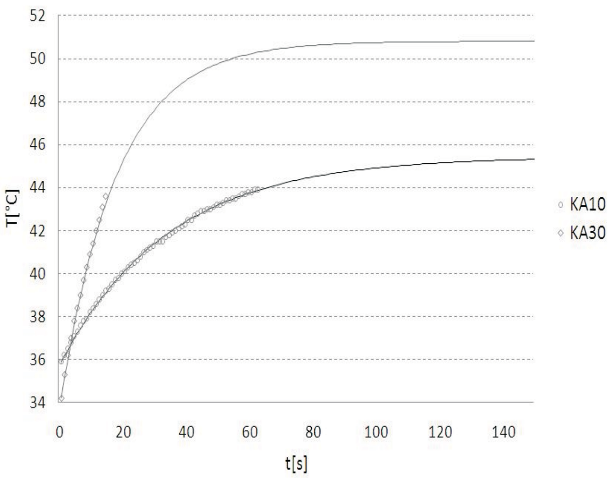

Figure 1
Example of single time constant approximation of the measured temperature rise during the heating

Using the temperature rise and time constant from experimental data, the thermal parameters from the model was extracted. The results correspond to the values getting from literature [3]. The results of the modeling confirmed that the perfusion has a crucial role in thermoregulation effect in the skin [1-3]. The simulation together with the experimental data proved that the cooling the skin by the blood flow was about five times higher than by the natural convection [3]. In addition, it was found out that thermal model of the skin is non-linear (temperature rise is not proportional to the power) and that the temperature of the skin depends on the power of infrared source. This fact is very important, and has to be taken into account in every thermal provocation test applied especially in the medicine.

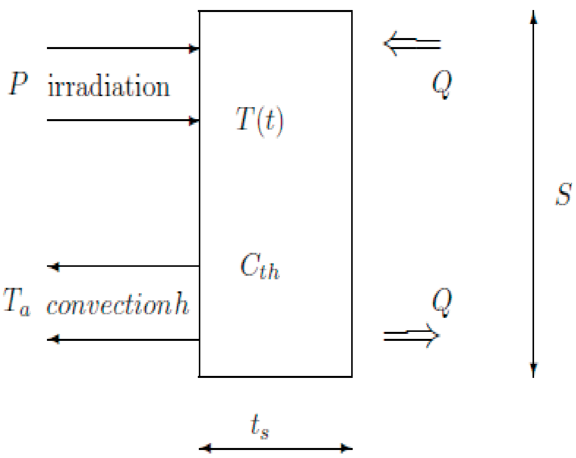

Figure 2
Thermal model of the skin with thermoregulation,
S – area of the skin considered in the model, t_s – skin thickness,
h – convection heat transfer coefficient, T_a – ambient temperature,
C_{th} – thermal capacitance of the skin

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THERMOGRAPHY OFThese results provide additional support for the continued study on the equine thermography. THE SKIN AS A METHOD OF INCREASING LOCAL INJECTION SAFETY

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INTRODUCTION: For a long time the process of introduction of drugs in the organism of patients not controlled by the reaction of tissues, interacting with drugs as their absorption and penetration of the blood, because there were no methods of safe and informative visualization methods [1,2]. In connection with this remained unknown features of the local drug interactions with various tissues and causes of their injuries caused by the introduction of certain medicines into the organism. Moreover, these complications associated with the violation of the technologies of introduction of drugs, so the perpetrators of complications were medical workers, violated the technology of introduction of drugs [3]. However, in recent years, there is evidence that the cause local damage can be themselves drugs, because modern standards of their quality admit that they have de- naturalizing action [4,5,6].

In these circumstances, the identification of universal indicators of the local pharmaceutical aggressiveness of drugs is an urgent task.

METHODS: A retrospective analysis of the areas of local application of solid and liquid medicines in 1000 patients in the hospital and out-patient treatment during the 2000 - 2012. The study of the condition of the places of injections in the visual, ultrasonic and infrared study of 100 patients are female and have 100 patients of male sex during their hospital treatment in the various branches of several city hospitals of the city of Izhevsk in 2012. The study was approved by the Ethics committee at Izhevsk State Medical Academy and complied with the Declaration of Helsinki. All patients gave informed consent.

Experiments were carried out on 20 keepers of pigs, which have carried out monitoring of a condition of the tissues of the oral cavity and congestion after local application of tablets and eye drops (respectively) and the condition of the skin and subcutaneous fat after subcutaneous injection of solutions 40 drugs before and after reconstitution with water.

Clinical and experimental studies of the pharmaceutical aggressiveness of medicines carried out with the account of factories-manufacturers, rooms series, pharmaceutical formulations, the values of the controlled physico-chemical quality indicators and some other characteristics.

Dynamics of a tissue with the introduction of these drugs was estimated in different years on the eye, with the help of the ultrasonic brand Aloka SSD-900 and through determination of the Dynamics of temperature and infrared radiation of bodies by ThermoTracer TH9100XX (NEC, USA). The obtained data were processed using software Thermography Explorer and Image Processor.

RESULTS: Our results indicate that every patient in the hospital and out-patient treatment is being daily from 1 to 12 oral tableted medicines and from 1 to 25 of hypodermic, intramuscular and intravenous injection of solutions of medicines. Therefore, today the absolute majority of the drug is introduced into the organism of patients through intravenous injection.

However, the medical records do not contain any information about the state of tissues on the introduction of the pills, eye drops and solutions for injections. Including the absence of information about the appearance of inflammation, bruises, hematomas and abscesses in the field of local action of eye drops, tablets and solutions for injections. At the same time, the observation of the state of organs of vision in adult patients with conjunctivitis and the babies with the introduction of these solution 25% sodium sulfacyl, conducted by the inspection of the skin of the buttocks and the elbow of the basins in pregnant women after multiple intramuscular and intravenous injections of plasma substitutional solutions and hemostatic products, as well as conducted by the observation of the state of mucous membranes of the mouth, gums and cheeks for women in the resorption of tablets acetylsalicylic acid, showed the presence of local inflammation at all 100% of patients.

Then we conducted an analysis of the legal list of controlled indicators of the quality of solutions for injection and the ranges of their possible values. It turned out that dispensatory requirements do not regulate the production of solutions for injection with a pH of 7.4, with an indicator of osmotic activity 280 mOsmol/l of water, as well as with the lack of local inflammatory (annoying) and denaturation (caustic) of action on the tissues in the ways the introduction of drugs. Therefore, solutions for injections that are considered today quality, can provide a cauterizing an (denaturation of action) action.

After this we decided to use the tissue temperature in the role of indicator urgent rapid assessment of their reaction to drugs. As the most secure, accurate, urgent and documented way of measuring the surface temperature of a thermal imager, to solve this problem we used a monitoring with the help of thermal imager of heat emission. Our results show that urgent monitoring with the help of thermal imager the local temperature of the mucous membranes of the lips when resorption of tablets acetylsalicylic acid, ketorol, or ascorbic acid, as well as the mucous membranes of the conjunctiva in instillation in the eye of the eye drops containing a solution of 25% sodium sulfacyl, or the skin of the buttocks when the intramuscular injection and/or the skin of the antecubital fossa with injections in cubital Vienna 5 ml solution 25% magnesium sulfate really allows you to receive early information on the fate of tissue on the introduction of drugs. Moreover, we have obtained data testify to the fact, that for the forecast of the local drug interactions is sufficient to determine the dynamics of local tissue temperature for 10 minutes after the start of their interaction with the drugs.

As an example, the image of the person of the newborn on the screen thermal imager at the time of and after 2 minutes after the introduction of drops of solution 25% sodium sulfacyl at a temperature of +24 C in the cavity of the conjunctiva of the left eye (Figure 1).

It is established that the drugs have annoying and/or cauterizing an action, cause, and medication, deprived of pharmaceutical aggression, not a cause in this period of time the local hyperthermia in places of local interactions. Therefore, the registration of the dynamics of the local temperature tissue in places of local interactions of medicines, implemented for the first 10 minutes after injection of medications, can claim the role of a universal indicator of Express-diagnostics of the pharmaceutical tissue damage to the introduction of drugs.

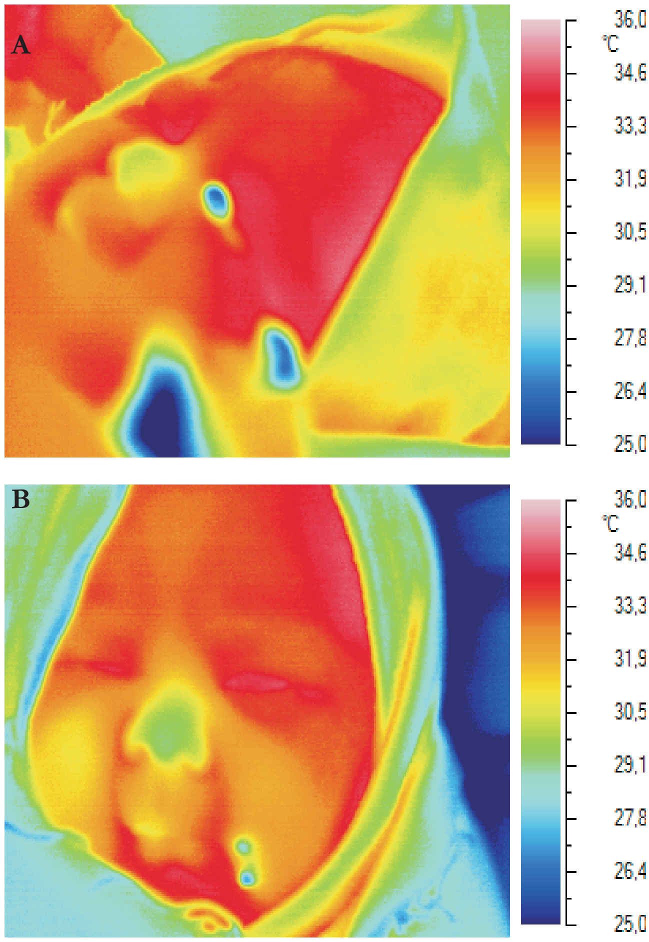

Figure 1.
Image of the face of a newborn (15.02.12) on the thermal imager at the time of the introduction of (A) and after 2 minutes (B) after the introduction of drops of solution 25% sodium sulfacyl at a temperature of +24° C in the cavity of the conjunctiva of the left eye

CONCLUSION: Changing the heat radiation of tissue during their interaction with the drugs proposed to consider as a universal criterion of the local drug safety when administered to the mother, her fetus and newborn. It is shown that the temperature of the tissue at the site of safe drug may decrease for a short time, but then normalized. Medicine, with irritant or cauterizing action, cause long-lasting local hyperthermia.

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EFFECT OF DRUGS TEMPERATURE ON INFRARED SPECTRUM OF HUMAN TISSUE

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Introduction: It is known that a change in the local or general temperature of the human body can cause biological effects, which are currently not achievable in clinical practice in any other way, even with the use of pharmacological agents. In addition, the pharmacokinetic and pharmacodynamic effects of all medicines were temperature dependent (1). Occurrence in clinical practice Digital Infrared Thermal Imaging (DITI) allowed to expand understanding of the interaction of drugs and organs (tissues) of the target based on their temperature (2,3). It is shown that the artificial lowering or raising the temperature of drugs compared to the temperature of the patient gives them thermocontrasting properties and provides visualization at the thermal imaging monitoring of the "invisible" on the surface of the body structures, such as saphenous veins. (4). Identified thermo-phar macological effects of drugs allowed to develop a safe and non-invasive way to visualize subcutaneous veins in the infrared spectrum of radiation with a thermal (5). As "thermocontrasting" substance recommended to use warm and cold solution of drug or blood (6,7).

METHODS: Observations were carried out in 70 patients of anesthesiology and intensive care department of clinical hospital No 9 (Izhevsk, Russia) in 2008-2009. Dynamics of temperature and infrared radiation of patients' bodies in intravenous drug injection investigated by ThermoTracer TH9100XX (NEC, USA). The obtained data were processed using software Thermography Explorer and Image Processor The study was approved by the Ethics committee at Izhevsk State Medical Academy and complied with the Declaration of Helsinki. All patients gave informed consent.

RESULTS: In the course of the research revealed that health workers are ignored and not recorded temperature readings of drugs solutions and injection sites. Determined that the temperatures of solutions for intravenous use, correspond to the temperature of storage +24,3 ± 1,2 ° C (n = 70). At the same time, the temperatures of patients skin in the place of intravenous injections were +35,1 ± 1,4 ° C (n = 70). Digital Infrared Thermal Imaging of the patients' bodies at the range +25,0 - +36,0 ° C revealed that "cold" solutions of drugs are depicted in blue, and the skin in the place of intravenous injections of red-orange-yellow. By intravenous administration of "cold" solution is reversible cooling veins and change their spectrum of infrared radiation over its surface to blue. The possibility of infrared imaging of subcutaneous veins in giving them a cold drug solution prompted us practical significance of this relationship as a possible alternative to the X-ray diagnosis of venous. Study confirmed this assumption - namely, the ability to identify saphenous veins with a Digital Infrared Thermal Imaging without any exposure of the patient and without the introduction of contrast media (Figure 1).

CONCLUSION: The difference (contrast) solution temperature, inside the saphenous veins, and tissues surrounding the veins, provides high-quality and secure visualization of veins in the Digital Infrared Thermal Imaging.

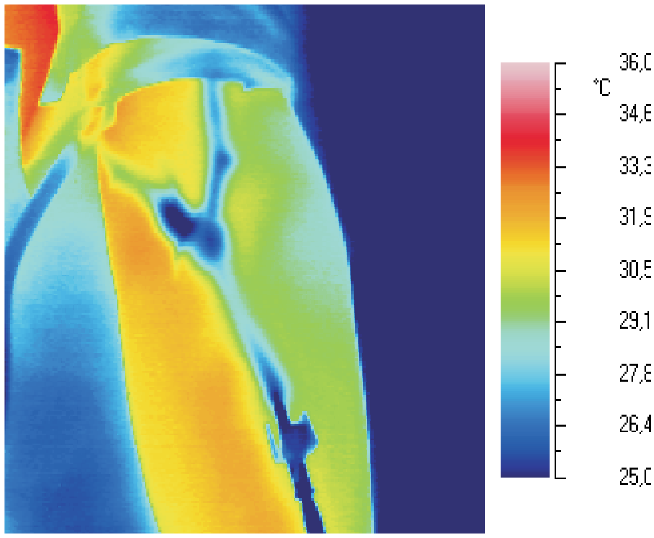

Figure 1
Infrared image of the left forearm of patient T, at age 34, recorded 1 minute after intravenous injection of a 0.9% solution of sodium chloride at room temperature at a rate of 120 drops per minute.

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COMPARISON CLINICAL, ULTRASOUND AND THERMOGRAPHY POINTS IN IDENTIFYING MYOFASCIAL TRIGGERS IN PATIENTS WITH FIBROMYALGIA

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The myofascial pain syndrome and fibromyalgia syndrome are common painful musculoskeletal conditions that often coexist in the same patient. OBJECTIVE: This study aimed to evaluate the parameters of sensitivity (S) and specificity (E) Thermography and Clinical palpation in the diagnosis of myofascial trigger points in patients with fibromyalgia syndrome. METHODS: Sensitivity (S) is the probability that a test result is positive when the disease and specificity (E) is likely to give a test negative in the absence of disease. We examined 40 patients with trigger points in myofascial pain syndrome associated with fibromyalgia by three different methods: clinical palpation, thermography and ultrasound as reference. For thermography, one of the criteria for positive diagnosis was a difference of 1° C from the contralateral region.

RESULTS: Thermography showed S = E = 79.31% and 50.00%. Already presented clinical palpation S = 65.52%, E = 18.18% when ultrasound was taken as reference. Joining thermography with palpation sensitivity was 93.1%.

CONCLUSION: Clinical assessment when integrated thermography showed higher diagnostic sensitivity in screening trigger points in patients with fibromyalgia, but not replace ultrasound confirmation. However ultrasound does not identify trigger points alone without guidance of palpation and thermography.

USAGE OF THERMOVISION IN EVALUATION OF THE INFLUENCE OF SPORTS MASSAGE ON SELECTED BIOMECHANICAL AND PHYSIOLOGICAL PARAMETERS OF LOWER LIMBS

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INTRODUCTION. Dynamic development of sport make the necessity to look for new indicators to achieve information of effectiveness of training and sport contests.

AIM. The aim of the study was to establish an of relationship between temperature of muscle quadriceps femoris and strength, power and, bioelectric potential.

MATERIAL AND METHODS. 23 women (aged 19-23) participated of the research. Camera Flir A325 was used for thermographic picture. Power was measured by OptoJump Next system while maximal torque was measured on the dynamometric Sumer UPR-02 arm-chair. Measurement of the surface electromyography was done with the utilization of the telemetric system Trigno 16ch . All tests were used twice - before and after the massage of muscles quadriceps femoris. Classic, sports, warm-up massage were applied.

RESULTS. After the massage temperature of massaged muscles (quadriceps femoris) significantly increased ($p<0,05$). We observed also ipsilateral effect of massage because - temperature of unmassaged shank muscles and the back of the thigh also rised. There were not significant differences in power level measured by counter movement jump ($p>0,05$).

CONCLUSION. Classic, sports massage has influence on temperature of muscles, but it is not enough to prepare to physical activity without warm-up activity.

RELATIONS BETWEEN THERMAL PORTRAIT AND AEROBIC CAPACITY - EVALUATION OF THERMOREGULATION EFFICIENCY THROUGHOUT THERMOVISION

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INTRODUCTION. As has been proven, thermal portrait can be connected both with VO2max as well as aerobic and anaerobic thresholds. One of reasons of such dependence is strong correlation between physical fitness and thermoregulation mechanisms which allow to give back excess heat.

AIM. Establishing relations between thermal portrait and physical fitness level measured by maximal oxygen consumption (VO2max).

MATERIAL AND METHODS. Totally 21 subjects were conducted in the study, including 13 rowers an 8 untrained males. For maximal oxygen consumption we used treadmill and incremental test protocol to the volitional exhaustion. Starting speed was set 8 km/h and after each 3 min was increased by 2 km/h. To VO2max analysis breath-by-breath MetaLyzer II system was used. Thermovison scanning was performer with using Flir A325 thermocam. Examined area of body was divided for 11 parts.

RESULTS. Average values Vo2max for examined rowers were slightly higher than 55 ml/kg/min. In untrained subgroup VO2max values were significantly lower ($p=0.000$) and was 43 ml/kg/min. No significant correlations between BMI and %FAT in comparison to VO2max and temperature changes after test effort were found. In whole examined group, statistically essential relation between VO2max level and lowering surface temperature of front side of trunk were found ($p= -0.44$; $p<0.05$). For the group with higher Vo2max - lower surface temperature of front forearm and back of thigh were strongly correlated with maximal oxygen consumption ($r= -0.93$).

CONCLUSIONS. Relations between maximal oxygen con sumption and thermal reaction on progressive effort to volitional exhaustion found in the research suggests, that thermography can be effective method of indirect evaluation of aerobic capacity. Better physical fitness is connected with efficient thermo- regulation mechanisms, responsible for giving back excess heat. This effect was spotted in better trained males.

THE EFFECTIVENESS OF THERMOGRAPHIC ANALYSIS IN EQUINE ORTHOPEDICS

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One of the main advantages of equine thermography is the detection of subclinical inflammation. The present study was undertaken to determine a specific threshold value of temperature change indicative of subclinical inflammation of the lower parts of the horse's limb.

The study involved monitoring 20 racehorses over a period of 10 months. Temperature measurements of IIIed metacarpal region were taken every 3 weeks allowing the average temperature differences to be ascertained between the same areas of forelimbs from the dorsal and palmar aspects in each session. Additionally, ultrasonographic and radiographic standard examinations of lower part of forelimbs were conducted to diagnose any pathological conditions of lower forelimbs. To determine the threshold value of temperature difference the Receiver Operating Characteristic (ROC) curve method was used, based on thermo- graphic examinations of the same measured area in 20 horses.

The threshold value of temperature difference indicative of subclinical inflammation was found to be 1.25 °C. In conclusion, thermography can be used as a quick and practical diagnostic tool of subclinical inflammation. These results provide additional support for the continued study on the equine thermo- graphy.

ERRORS AND ARTEFACTS IN INFRARED IMAGING

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Most medical imaging procedures share the common problems of errors and artefacts that can disguise or confuse the clinician. The sources of error begin with the patient, the environment used for imaging, the camera system, the image itself and the image analysis. In thermography which is an image procedure for body surface temperature, the environment can be especially important. In high ambient temperatures the human begins to sweat, as part of the heat balance process, and at cold temperatures shivering becomes a form of thermogenesis. Both of these mechanisms will adversely affect the themogram. There is now good evidence that careful positioning of the patient is important especially to improve repeatability, anf the method by which regions of interest are selected for measurement must be made using protocols that improve repeatability. Even with these provisos, the camera system may be subject to errors, due to faulty calibration, drifting and loss of resolution if too large an area of the body is being imaged.These important issues have been published and taught for the last decade or longer. However they are so important to good practice that it is useful to examine how these issues are being resolved with improved technology, or not, and how constant observations in clinical practice will benefit the long term reliability of thermal imaging in medicine.

DECREASE OF THE TEMPERATURE OF THE HEAD OF THE FETUS DURING BIRTH AS A SYMPTOM OF HYPOXIA

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INTRODUCTION: Despite the fact that fetuses and newborns continue to die during pregnancy and physiological delivery of sudden intrauterine hypoxia existing standards do not include delivery methods for monitoring and immediate detection of this pathology. Therefore, hypoxic damage of the cerebral cortex of the fetus is still not perceived to laboring women and "not visible" for obstetricians. Proposed in 2010 a radical removal of intrauterine hypoxia with respiratory masks to the fetus (intrauterine aqualung) and gas exchange in a way to ensure his body by artificial breathing (ventilation fetal lung breathing gas) inside the uterus was not supported by obstetricians and does not apply in practice [1,2].

In these circumstances, in 2012, we have developed a method of express-diagnostics of hypoxic damage of the cerebral cortex of the fetus and obstetrical benefits in vain attempts with a thermal imager [3,4]. The method is based on the following pattern revealed by us: hypoxia and ischemia tissue reduce the intensity of radiant heat.

METHODS: Thermography conducted in a maternity hospital in the physiological delivery in 35 pregnant women admitted for urgent delivery The control group included 20 women, with the re-birth, having healthy children, born in time. In addition, the criteria for selection of the control group pregnant women is high stability of their fruit to intrauterine hypoxia, confirmed in 30 - 32 weeks of pregnancy results Gauskneht functional test (more than 30 seconds). Another group of women studied consisted of 15 pregnant women who have previously had a successful physiological birth with the birth of live fetuses in the project schedule. Additional selection criterion in this group was the low stability of births of their fruit to intrauterine hypoxia, confirmed in 30 - 32 weeks of pregnancy test results Gauskneht (less than 10 seconds). Other than that, there was a pregnant woman entwined cord around the neck and chest of the fetus.

Infrared thermometry was performed using thermal imager ThermoTracer TH9100XX (NEC, USA) in the temperature range +26 - +36° C. The temperature of the air in the delivery room is in the range +24 - +26° C. The obtained data were processed using software Thermography Explorer and Image Processor.

RESULTS:Our results showed that monitoring Thermal imaging in the infrared spectrum of the radiation provides the definition temperature of the parietal part of the head of the fetus throughout the second period of labor and after the birth of the baby until the umbilical cord cut off and wraps baby in a diaper.The range of the individual indicators of the local temperature in the skin of the parietal part of scalp of live fetuses in the process of birth and the newborn immediately after birth in our study was between +31,6 °C and +36,1 °C. Found that in normal pregnancy and normal physiological delivery image of the head of living fetuses is depicted on our Thermal imager predominantly yellow-orange-red colors.

In addition, the fetuses who had the high values of prenatal test Gauskneht for resistant for hipoxia , during the childbirth had a stable pattern of heat radiation. In addition, the fetuses who had the high values of prenatal test Gauskneht (defining the resistant for hypoxia), during the childbirth had a stable pattern of heat radiation. The fetuses who suffered of prenatal hypoxia and having meconium in amniotic fluid, in childbirth demonstrated periods with reduction of thermal radiation. Moreover, in the norm on the surface of the parietal part of the head of the fetus can be detected identified portion of the local hyperthermia, in which temperature can be 0.5 - 4 ° C above the temperature of the surface of the head. This plot has an elongated shape and is located in the projection of not fused bones the Central seam of the cranium. But the other five fetuses in second period of physiological childbirth demonstrated short periods of reduced temperature of scalp of the projection of not fused bones the Central seam of the cranium. (figure 1). The duration of these periods ranged from 30 to 120 seconds.

We carried out an analysis of the circumstances surrounding the emergence of local hypothermia. The results showed that the immobility of fetuses in the period between attempts lead to the conservation and the progress of the local hypothermia fetal presenting part of the head, and the promotion of the baby on ancestral ways the efforts of the mother has restored radiation is already in 2-3 seconds from 5 fetuses of a monitoring group.

Thus, these results suggest that the dynamics of the temperature of the fetal scalp in the projection of not fused bones the Central seam of the cranium allows to evaluate the provision of oxygen cortex of brain of the fetus during labor , because the lack of oxygen leads to temperature reduction in the process of oxidative metabolism in the mitochondria of the brain, which promotes cooling the scalp fetus during labor in the presence of air at room temperature.

In this regard, the absence of periods setback temperature scalp during in moving fetus through the birth canal indicates the possibility of a healthy child in the process of physiological birth, and the emergence of local hypothermia in the projection of not fused bones the Central seam of the cranium indicates the beginning hypoxic and ischemic damage of cerebral cortex of the fetus and requires immediate hyper-oxygenation blood of the fetus.

In the absence of prenatal scuba gear to rescue the fetus immediately give his body continued progress with the initiation of the extraordinary attempts. This is necessary for the early birth and early lung ventilation air, or to reduce the period and/ or depth of hypoxia and ischemia of the brain, as their cause may be the "wrong" location of the fetus in the birth canal. That's why if you can not birth the fetus requires immediate move it forward through the birth canal until the restoration of the skin temperature of the slit of his skull.

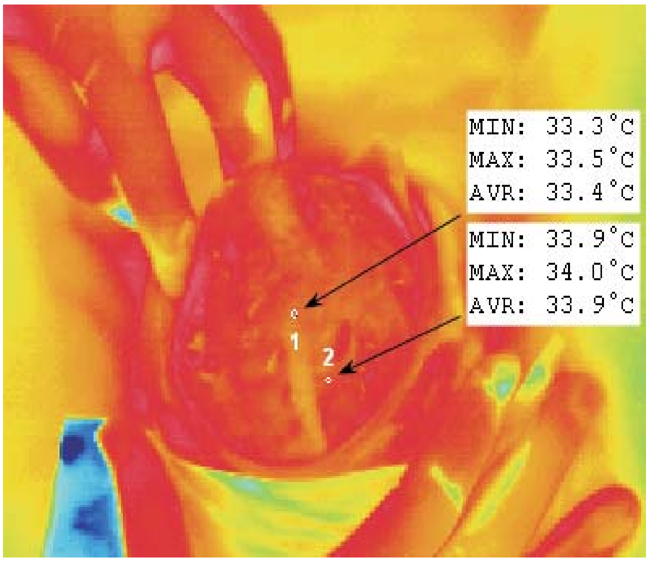

Figure. 1.
Image of the surface of the head of the fetus at its exit from the birth cana.l in S mothers after 30 attempts and after the stop of the fetus in the birth canal in the infrared spectrum of the radiation diapazone indicating the values of the local temperature of the skin over the center seam (1) and over the bones of the skull (2)

The experience of clinical application of the method allows to conclude that it is easy accurately reproduce in the conditions of any of the maternity hospital.

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ERRORS AND ARTEFACTS IN INFRARED IMAGING

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Most medical imaging procedures share the common problems of errors and artefacts that can disguise or confuse the clinician. The sources of error begin with the patient, the environment used for imaging, the camera system, the image itself and the image analysis. In thermography which is an image procedure for body surface temperature, the environment can be especially important. In high ambient temperatures the human begins to sweat, as part of the heat balance process, and at cold temperatures shivering becomes a form of thermogenesis. Both of these mechanisms will adversely affect the themogram. There is now good evidence that careful positioning of the patient is important especially to improve repeatability, anf the method by which regions of interest are selected for measurement must be made using protocols that improve repeatability. Even with these provisos, the camera system may be subject to errors, due to faulty calibration, drifting and loss of resolution if too large an area of the body is being imaged.These important issues have been published and taught for the last decade or longer. However they are so important to good practice that it is useful to examine how these issues are being resolved with improved technology, or not, and how constant observations in clinical practice will benefit the long term reliability of thermal imaging in medicine.

DEVELOPING A THERMAL IMAGING PROTOCOL FOR USE IN EMERGENCY CARE ENVIRONMENT

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Thermal imaging is a relatively new investigative tool in the field of medicine, with potential to play a crucial role in the monitoring of existing disease as well as the diagnosis of new. To date, a few protocols have been devised introducing a standardised way to use this technology within medicine, as seen by work carried out by Professor Francis Ring and Professor Kurt Ammer at the University of Glamorgan. The aim of this study is to further this work and develop a standardised protocol which can be used to consider whether a role for thermal imaging exists within an emergency care environment.

20 volunteers were invited to a laboratory at the Leicester Royal Infirmary. The laboratory was a constant to allow standardises environmental conditions. The volunteers were asked to change into a hospital gown, to allow exposure of the upper limb, and begin the start of a 15 minute acclimatisation period. Both arms were then imaged, in 3 different positions, from both the anterior and posterior aspect.

We aim to ascertain whether the position of the arm impacts on the thermal data recorded. This information would provide the foundation for the protocol to be used when applying the thermal imager within the Emergency Department (ED). Currently we do not have information with regards to whether the dominant or non-dominant arm provides significantly different data or whether imaging the anterior compared to the posterior aspect of the arm will give conflicting data and therefore we will aim to answer these questions within this study.

We will also explore the impact of holding the arm in a fixed position for a short period of time and identify if this is something that may influence how pictures are obtained in the ED Finally we are researching into an alternative method for identifying regions of interest along the upper limb. We will determine if there is a role for physical markers at anatomical landmarks (at the acromio-clavicular joint, across the ante-cubital fossa and the wrist) to identify new regions of interest which correspond to underlying vascular anatomy

THE EFFECT OF WHOLE-BODY VIBRATION ON THERMAL SYMMETRY OF THE LOWER LEGS IN HEALTHY SUBJECTS

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INTRODUCTION: Vibration exercise has become an alternate modality for proprioceptive, strength and balance training. It is practiced mostly while standing in vibration platforms and due to the widespread of vibrating plates distribution, its popularity is increasing. Few studies have addressed the effect of this exercise modality using skin temperature as an outcome measure and fewer have studied the effect of whole-body vibration on thermal symmetry. Thermal symmetry can be useful in the process of differential diagnose in a certain clinical context. The aim of this study is to evaluate the impact of acute exposure to vibration exercise on thermal symmetry of the lower legs in healthy subjects.

METHODS: Skin temperature of thirty six healthy and non trained male and female subjects (randomly distributed to the experimental and control group) was recorded using thermography, before and after the exposure to vibration exercise or control setting. A calibrated thermographic camera (FLIR A325) was used to record skin temperature. All subjects were instructed to undress, remain still in the examination room for 15 minutes in order to achieve thermal stabilization. The room was stabilized at 22º Celsius, with absence of air flow and humidity was less than 50%. Thermograms were obtained from the views: Leg, right (lateral view); Leg left (lateral view); Leg, right (medial view); Leg left (medial view); Lower legs (anterior view); Lower legs (dorsal view) and Both ankles (anterior view) before and after exposure to vibration. The Power Plate® provided a mechanical stimulation with parameters set at a frequency of 35Hz, high amplitude (5-6mm), resulting in maximum acceleration of 121-145 m/s2, for 5 minutes.

RESULTS: Thermal symmetry was higher in the anterior aspect of the lower leg (0.17±0.13ºC) and lower in the lateral aspect of the ankle (0.27±0.20ºC) and medial aspect of the ankle (0.26± 0.21ºC). The acute bout of exposure to whole-body vibration significantly increased thermal symmetry in both ankles (anterior view) and decreased thermal symmetry in the lateral aspect of the ankle (p?0.05). Significant differences on thermal symmetry before the exposure to the experimental setting between male and female participants were not found.

DISCUSSION: The results suggest that the exposure to an acute bout of vibration exercise (35Hz) has an effect on thermal symmetry of the ankles, though the mechanism underlying these changes will require future studies to be fully understood either in healthy and patient subjects. Caution should be taken by health and exercise professionals before prescribing this exercise modality since future research is still needed to clarify the potential mechanisms influencing microcirculation.

ACKNOWLEDGMENTS:: The authors would like to acknowledge to Project AAL4ALL, n. 13852, co-financed by the European Community Fund through COMPETE - Programa Operacional Factores de Competitividade.

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USEFULNESS OF LINEAR PREDICTIVE CODING COEFFICIENTS FOR THE QUALIFICATION HEALTHY PEOPLE AND PATIENTS WITH SINUSITIS BASED ON FACIAL THERMOGRAMS.

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Military Institute of Medicine, Warsaw, Szaserów 128 st., Poland

Standard technique of temperature measurement is simple and cheap but does not allow to determinate human surface temperature distribution, It is necessary to perform an analysis of temperature values distribution for marking of spots with intensified heat on human body surface, which can be observed in states of inflammation (e.g. Paranasal sinusitis). With usage of infrared camera and specialistic software it can be done [1,2,3,4]. Classification of patients to previously defined groups (e.g. healthy and sick) can be performed by converting received data. Method typically used for speech analysis, LPC (linear predictive coding) coefficients were used to analyze received signal [5, 6].

Possibility of patient qualification as paranasal sinusitis sick basing on value of signal received from face thermogram was goal of this exam.

MATERIAL: 93 thermograms of healthy and 70 sick with paranasal sinusitis, recognized in advance with physician's examination, were used to design the method of patients qualification.

METHOD: Pattern for healthy and sick person were appointed as thermogram of mean value of temperature form therm ograms transferred from standard rectangle structure to bipolar structure (a_r, α) where $\alpha = 0°..359°$ and ar = 0.01..1 with a 0.01 step. Ar value responds to proportion of length vector counting from middle of ellipsis to examined point of thermogram in head area up to ellipsis radius length for requested angle α (figure1).

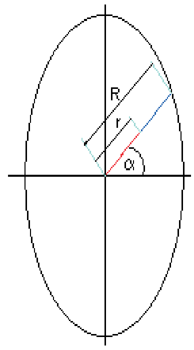

Figure 1:

Transduction from rectangle structure to bipolar elliptic face contour.

Finally value $a_r(\alpha)$ is described with pattern

$$a_r(\alpha) = \frac{r(\alpha)}{R(\alpha)}$$, where α ==...359

Conversion generates 360 x 100 values of temperature for every thermogram within area of interest. A converted picture for healthy and sick mean was made and medial thermogram was marked.

Pattern basis of healthy and sick were appointed on base of marked thermograms encrypted in the structure $a_r(\alpha)$

Marked LPC covariates were estimated in qualification process. Measure of probability was assessed as length of LPC covariates base from pattern of sick person

$$D_{si} = \sum_{i=1}^{p} \left\| LPC_i^x - LPC_i^{si} \right\|$$

and from pattern of healthy person

$$D_{he} = \sum_{i01}^{p} \left\| LPC_i^x - LPC_i^{he} \right\|$$

where: p - number of LPC covariates. Qualification process for marked numeric values relayed on establishing values of correlation:

$$Group = \left\{ \begin{array}{ll} Healthy.\ for & D_{he} < D_{si} \\ Sick.\ for & D_{he} \geq D_{si} \end{array} \right\}$$

Next step was to establish minimal amount of covariates allowing qualification of patient to proper group with minimal classification error. Calculation in range from 1 to 30 covariates was performed due to marking proper group in function of number of LPC covariates for every case. In effect every case was qualified to groups:

a)healthy - healthy

b)healthy - sick

c)sick - healthy

d)sick - sick

in dependence from known physicians examination diagnosis and marked, as a result, comparison of LPC covariates. Probability in function of number of LPC covariates was marked for qualified patients in this manner.

DISCUSSION: Values probability analysis shows optimal classification for 14 (n_{LPC})of LPC covariates number. For this number there are no false negative classifications and only 1,1% false positive classifications witch can be verified and excluded by proper clinical examination. Increasing number of LPC covariates does not lead to relevant increasing in classification precision, with large simultaneous increase of data needed to be converted.

CONCLUSION:

1.Application of LPC covariates in signals analysis marked from facial thermograms, allows qualification of patient to proper group healthy or sick.

2.Values of proper qualification probability are dependent on number of covariates and they are acceptable when $n_{LPC} = 14$.

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Table 1.
Probability of proper group qualification, depending on number of LPC covariates function

Number ofLPC covariates	Probability			
	healthy – healthy	healthy – sick	sick – healthy	sick – sick
1	0.6154	0.3846	0.3429	0.6571
2	0.7582	0.2418	0.4714	0.5286
3	0.8462	0.1538	0.3143	0.6857
4	0.9341	0.0659	0.2429	0.7571
5	0.9231	0.0769	0.2000	0.8000
6	0.8901	0.1099	0.1429	0.8571
7	0.9121	0.0879	0.0571	0.9429
8	0.9231	0.0769	0.0286	0.9714
9	0.9231	0.0769	0.0000	1.0000
10	0.9231	0.0769	0.0000	1.0000
11	0.9341	0.0659	0.0286	0.9714
12	0.9341	0.0659	0.0143	0.9857
13	0.9451	0.0549	0.0143	0.9857
14	0.9890	0.0110	0.0000	1.0000
15	0.9890	0.0110	0.0000	1.0000
16	0.9890	0.0110	0.0000	1.0000
17	0.9560	0.0440	0.0000	1.0000
18	0.9670	0.0330	0.0000	1.0000
19	0.9780	0.0220	0.0000	1.0000
20	0.9670	0.0330	0.0000	1.0000
21	0.9780	0.0220	0.0000	1.0000
22	0.9780	0.0220	0.0000	1.0000
23	0.9890	0.0110	0.0000	1.0000
24	0.9890	0.0110	0.0000	1.0000
25	0.9780	0.0220	0.0000	1.0000
26	1.0000	0.0000	0.0000	1.0000
27	1.0000	0.0000	0.0000	1.0000
28	1.0000	0.0000	0.0000	1.0000
29	1.0000	0.0000	0.0000	1.0000
30	1.0000	0.0000	0.0000	1.0000

Meetings

30thJune - 3thth July 2013.
International Centre of Biocybernetics (ICB)-
132nd Seminar "ADVANCES OF IR-THERMAL IMAGING IN MEDICINE" in Warsaw

Programme

Sunday 30 June

Arrival of participants

19:00 Get-together party at the IBBE PAS

Monday 1 July

9:00 Opening Ceremony, A. Nowakowski, J. Mercer, J. M. Wójcicki

9:15 **Plenary Lecture** – Chair: J. Mercer

Francis Ring, Pioneers and progress in InfraRed thermal imaging

10:00 – 10:30 Coffee Break

Session I "NDT" methods –Chairs: A. Seixas, B. Wiecek

10:30 Daniel Balageas, The Thermographic Signal Reconstruction method (TSR): a powerful tool for the enhancement of transient thermographic images

11:15 Antoni Nowakowski, Active Dynamic Thermography and Thermal Tomography in medical diagnostics – advantages and limitations

12:00 European Association of Thermology

12:45 – 13:45 Lunch Break

Session II Clinical applications I -Chairs: F. Ring, Z. Drzazga

13:45 Piotr Murawski, Boleslaw Kalicki, Anna Jung, Janusz Zuber, Usefulness of face thermograms for a sinus patient classification by use of linear predictive coding

14:30 James Mercer, Computed tomographic angiography (CTA) confirms that dynamic infrared thermography (DIRT) can be used for accurate mapping of perforators in breast reconstruction surgery

15:15 Mateusz Moderhak, Problems in evaluation of breast reconstruction surgery

15:45 – 16:15 Coffee Break

Session III Clinical applications II - Chairs: K. Ammer, A. Jung

16:15 Adérito Seixas, Thermographic evaluation in Tendinopathies

17:00 Mariusz Kaczmarek, IR-thermal imaging in cardiosurgery

19:00 – 22:00 Jablonna – Gala Dinner

Tuesday 2 July

Session IV Thermography in medicine I - Chairs: D. Balageas, A. Nowakowski

9:00 Arcangelo Merla, Thermal imaging in neuropsychology€

9:45 Halina Podbielska, Joanna Bauer, Iwona Holowacz, Ewa Boerner,
Assessment of physiotherapeutic procedures by means of thermovision

10:30 Ricardo Vardasca, A method to standardize medical thermal images of the human body based in templates

11:15 – 11:45 Coffee Break

Session V Transient thermography -Chairs: Manuel Sillero, H. Podbielska

11:45 Boguslaw Wiecek, Maria Strakowska, Gilbert De Mey, Transient thermography application for thermal modelling of a human skin

12:30 Mateusz Moderhak, M. Kaczmarek, A. Nowakowski, ADT in mammography

13:15 – 14:15 Lunch Break

Wednesday 3 July Session VI Thermography in medicine II -

Chairs: A. Merla, R. Vardasca

9:00 Kurt Ammer, Temperature of the finger tips in subjects with suspected Reynaud's phenomenon

9:45 Alexander Urakov, Temperature of the pads of the fingers of the patients in the clinical death and intensive care as an indicator of the stage of hypoxic damage and probability of resuscitation

10:30 Zygmunt Wróbel, Biometric applications of IR-thermal imaging

11:15 – 11:45 Coffee Break

Session VII Thermography in physical medicine -

Chairs: A. Urakov, Z. Wróbel

11:45 Zofia Drzazga, Thermovision application in physical medicine

12:30 Manuel Sillero, Infrared thermography as a means to quantify the effects of the training load

13:15 Closing remarks – A. Nowakowski, J. Mercer
13:45 – 14.45 Lunch Break

*For further information please conta*ct

Prof. Antoni Nowakowski, antowak@biomed.eti.pg.gda.pl (Chairman of the Seminar)
or
Dr Mariusz Kaczmerek, mariusz@biomed.eti.pg.gda.pl (Secretary of the Seminar)

3-5 July, 2013
18th International Conference on Thermal Engineering and Thermogrammetry (THERMO)
Budapest University of Technology and Economics(BME) Budapest, XI.,Mûegyetem rkpt.3.,Hungary

THE CONFERENCE ORGANIZER:
Branch of Thermal Engineering and Thermogrammetry (TE and TGM),
Hungarian Society of Thermology (HST) at MATE,
European Association of Thermology (EAT),

SPONSORED BY:
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MAIN TOPICS

The structure of the sessions will be fixed after receiving the papers, but the topics will cover the following fields:

General thermal engineering; theory of measurements; thermal informatics, thermo-CAD and its applications; advanced thermodinamics and the new tendencies associated: industrial energy management and process control systems; practice of thermal engineering; infra-red imaging science & technology: thermogrammetry, micro- and nanoscale thermal phenomena and sensing techniques, thermal defectometry; applied thermo-optics; thermophysical properties; heat and mass transfer; cooling of electronic components; heat exchangers; combustion; thermophysics of the environment; building services; environmental aspects of energy use; thermo-ergonomy and thermo-psychology; thermo diagnostics; system analysis in thermo-biology; IR-imaging in biomedical and bioengineering applications; remote sensing through IR- imaging, multidisciplinary topics.Solar hybrid & photovoltaic systems. Waste management research,hazardous materials, recycling & reuse.

VENUE

The conference is hosted by the Budapest University of Technology and Economics (BME, Budapest, XI. Budafoki út 4., Hungary) located near the Hotel 'Gellért' and the Danube. More information about the conference place and hotel accommodation will be sent after the arrival of the Registration Form: www.mate-net.hu/03menu/03index.htm

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25-27 October 2013,
American Academy of Thermology
Annual Meeting in Greenville, South Carolina

Venue: Bon Secours St. Francis Hospital, Greenville, SC,

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AITA 2013

12th International Workshop on Advanced Infrared Technology and Applications

FIRST CALL FOR PAPERS

1st *under* 35 PAPER AWARD

September 10 - 13, 2013
Castello del Valentino
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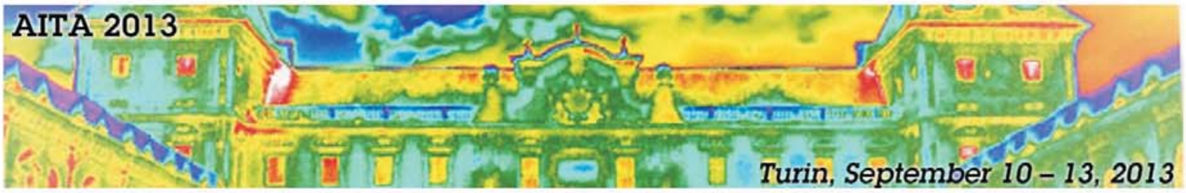

Workshop objectives

After the 11th International Workshop held in L'Aquila (Italy) in September 2011, it has been decided to organize the 12th AITA 2013 in Turin (Italy) with the main objectives to assess the state of the art of the technology in the Infrared bands and to present its most interesting applications.

Main topics

- Advanced technology and materials
- Smart and fiber-optic sensors
- Thermo-fluid dynamics
- Biomedical applications
- Environmental monitoring
- Aerospace and Industrial applications
- Astronomy and Earth observation
- Non-destructive tests and evaluation
- Systems for cultural heritage
- Image processing and data analysis
- Near-, mid-, and long wavelength systems

1st *under* 35 paper Award

A best paper award will be assigned by the chairman and the cochairmen in honor of Ermanno Grinzato, for a long time AITA cochairman and known scientist in the thermography community.
The award aims at encouraging innovative studies of young researchers in some of the topics of interest for the workshop.
The prize, reserved to under 35 main authors, shall be € 400,00 and an official certificate. The prize will be delivered to the winner during the social dinner.

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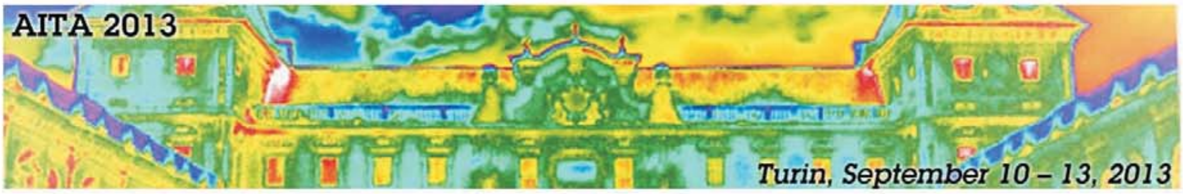

Language

The papers are to be written and presented in English.

Deadlines

Extended Abstract (2-4 pages)	17th May 2013
Notification of acceptance	14th June 2013
Program of the workshop will be sent	1st July 2013
Full paper submission (8 to 10 pages)	1st August 2013

Submission

Papers should be submitted to aita@isti.cnr.it within 17th May 2013, according to the template provided on the website (http://ronchi.isti.cnr.it/AITA2013).

Publication

Selected papers will be published in a Special Issue of an International Journal (Journal of Modern Optics and Advances in Optical Technologies published a special issue for the 10th and 11th AITA edition respectively).

Papers will be selected by the Scientific Committee. The Proceedings of the Workshop will consist of the 4-page summaries of all papers, included those selected for the Special Issue, and will be distributed electronically. Full papers not selected for the Special Issue will be published in an issue of "Atti della Fondazione Giorgio Ronchi".

Registration fee

The early registration fee is € 400,00 and includes: social dinner, coffee breaks, lunches, abstract booklet and Proceedings of the Workshop. A finite number of qualified students may apply at the reduced price of € 200,00, social dinner and Special Issue excluded.

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XVIII NATIONAL CONGRESS OF THE POLISH ASSOCIATION OF THERMOLOGY

ZAKOPANE 4th-6th April 2014

GENERAL INFORMATION

REGISTRATION FEE: 250.- €

ABSTRACT DEADLINE February 15th 2014

ajung@wim.mil.pl or a.jung@spencer.com.pl

Abstract form will be published in Thermology International and in Acta Bio-Optica et Informatica Medica and registration on line

Professor Jung and the Organizing Committee invite you to this annual conference in the beautiful mountain resort of Zakopane in South Poland, which is 2hours journey by bus from Krakow Internationalairport and the city of Krakow. The conference is in HYRNY Hotel with its wonderful viewsof theTatra mountains, and short walk fromthe town centre.

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Prof Wiecek Boguslaw PhD(Poland)
Dr. Kalicki Boleslaw MD,PhD (Poland)
Murawski Piotr MSc,Bsc. (Poland)
Dr Zuber Janusz MD,PhD (Poland)
Dr: Vardasca Ricardo PhD (Portugal)
Dr. Howell Kevin, PhD (UK)
ProfManuel SilleroQuintana PhD. (Spain)
ProfAdriana Nica MD,PhD (Romania)

Registration fee for non Polish participants will be paid in cash on arrival at the conference.
Registration by e-mail is required before March 1st to ensure hotel reservation.
After registration number is issued, delegates are committed to payment of the fee.

Registration includes welcome dinner Friday 15th
Lunch and accomodation.
Extra night + breakfast + 70 €
Accompaning person – 200 €