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Challenges to Global Implementation of Infrared Thermography Technology: Current Perspective

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Abstract

Medical infrared thermography (IT) produces an image of the infrared waves emitted by the human body as part of the thermoregulation process that can vary in intensity based on the health of the person. This review analyzes recent developments in the use of infrared thermography as a screening and diagnostic tool in clinical and nonclinical settings, and identifies possible future routes for improvement of the method. Currently, infrared thermography is not considered to be a fully reliable diagnostic method. If standard infrared protocol is established and a normative database is available, infrared thermography may become a reliable method for detecting inflammatory processes.

Keywords: *Infrared Thermography; Mass Screening; Epidemics*

Challenges to Global Implementation of Infrared Thermography Technology: Current Perspective

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Research

Medical infrared thermography (IT) produces an image of the infrared waves emitted by the human body as part of the thermoregulation process that can vary in intensity based on the health of the patient.[1] While the technology was originally developed in the 1950s, its development was much slower than ultrasonography, despite the fact that both methods are potentially highly informative, non invasive, and radiation free. On PubMed, there are 1,820 articles on the term “infrared thermography” dating from May 1963 to 2017, while 398,932 articles on “ultrasound” were published during the same period. The IT finally gained more attention in the 2000s with the emergence of avian, swine, and H1N1- influenza outbreaks, and other similar pandemics. The first articles describing IT implementation for mass blind fever screening in international airports appeared in 2004.[2,3] Detection of febrile passengers by IT scanning in airports became a common trend and several more reports supporting the use of this technology were published.[4-6] However, other published reports questioned reliability of the IT technology as a fever screening procedure, specifically citing technical errors leading to low sensitivity of the screening procedure.[7,8]

Recent progress in improvement of infrared camera technology sensitivity, excellent time resolution, as well as calibration according to heat emissivity, room temperature, humidity, and distance to the object of interest, caught practitioners unprepared to take full advantage of the IT capacities that exist today.

Currently published research papers on IT do not provide complete and detailed descriptions of how the camera and/or the software were calibrated and what settings have been used. In 2013, Choi et al. detected the mean temperature of healthy cheeks to be 26-27°C,[11] which is about 4°C lower than normal. The article does not report room humidity or the distance between the camera and the investigated face.

Another study reported the surface skin temperature of a healthy knee as median 36°C and maximum of 38.1°C. [12] This reading is about 6-7°C higher than normal and the article provides minimal detail about the data acquisition process (including room temperature, humidity, distance to object, and heat emissivity preset).[13] While some papers clearly report laboratory room temperature and a relative air humidity, they may omit other important variables.[13,14] For

example, an article describing the IT assessment of joints with active arthritis reported ambient room temperature and skin emissivity, but did not indicate the precise distance to the object ("the camera was positioned directly over the hands") and the room humidity.[15]

Out of 200 recently published (May 2013-May 2017) PubMed research on IT implementation as a screening and diagnostic tool for various clinical conditions, only 13 articles (6.5 percent of total articles) have complete data acquisition methodology (correct calibration of the IT device and/or software for skin heat emissivity, distance to object, air humidity, air temperature, etc.).

General thermography guidelines, standards, and protocols, were introduced in 2002 and were followed by specific guidelines for neuromusculoskeletal, dental-oral, and systemic disorders in 2015 and 2016.[16-18] These guidelines articulate that the room temperature range should be maintained between 18 and 23°C during the investigation and that a minimum equilibration period of 15 minutes should be observed for patient acclimation to the room. Given varying temperatures at airports and inability to achieve 15 minutes acclimation periods for every passenger, the guidelines may suggest that IT cannot be used as an accurate screening method at the airports. The guidelines do not indicate that an IT technician or a practitioner must calibrate the camera for human skin heat emissivity (0.98), existing room temperature and humidity, and distance between the camera and the region of interest. Most modern IT cameras have the program for this preset in their menu.[19-21] Even without proper camera calibration, the data for these variables can be put into software program directly before image analysis. The time of day during investigation should be indicated as well to accommodate human temperature changes due to circadian rhythm.[22-25] With normal circadian rhythm, the human body has its lowest temperature at 4 AM and its highest temperature at 6 PM. This variation needs to be adjusted for with proper correction index in order to correctly interpret measurement results.

An individual approach to each subject is warranted if IT is used for screening. The necessary primary step in any proper IT investigation is to establish a normative range of surface skin temperature changes of a given person because of interpersonal vasoconstriction/vasodilatation variations. This scale will provide an IT practitioner with an understanding of what is normal and what is abnormal for a given patient. Sympathetic skin response and the vasomotor reflex vary in different cases and these variations can be detected by the IT.[26]

Review articles on IT provide either favorable[27,28] or unfavorable[29,30] feedback about its applicability for mass screening. The favorable reviews suggest that for certain applications, thermal imaging is shown to provide objective measurement of temperature changes that are clinically significant for the detection of local inflammatory processes, skin lesions, benign and malignant tumors, vasoactivity, and vascular diseases. With properly calibrated IT cameras and improved knowledge of normative skin temperatures on various body surfaces, practitioners will be able to assess cutaneous vasoactivity. Thus, the IT method might be reliable in the clinical settings but not recommended as a screening procedure at the airports. A portable, radiation-free, inexpensive, non-contact, and non-invasive IT device could become a welcomed addition to the hospital armamentarium in many developing countries assuming the development and implementation of proper standard guidelines.

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