Fever screening and infrared thermal imaging: concerns and guidelines

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SUMMARY

The aim of the document is inform those either using or considering using infrared thermal imaging mass screening systems for fever detection of recent developments surrounding this concept. The recent publicity surrounding the Swine influenza outbreak (H1N1 strain of influenza type A) has spurred interest in the use of this technology. However, the publicity has also sparked a debate concerning the effectiveness of using infrared thermal imaging for this purpose. It is important to note that this document is not intended to answer the question as to the reliability of infrared thermal imaging for fever screening. Clearly opinions will vary depending on the interests and experience of the reader. Nevertheless, the European Association of Thermology (EAT) feel that there are some basic facts that need to be taken into account when either using and/or designing specialized infrared thermal imaging installations for mass screening of human subjects.

FIEBERSUCHE UND INFRAROT-THERMOGRAPHIE: PROBLEME UND LEITLINIEN

Ziel diese Beitrages ist es alle, die bereits die Infrarot Thermographiezur Massensuche nach Fieber einsetzen oder planen, dies zu tun, über neuere Entwicklung im Zusammenhang mit diesem Konzept zu informieren. Das öffentliche Interesse am Ausbruch der Schweingrippe (H1N1 Stamm des Influenza type A) hat zusätzlich die Diskussion des Einsatzes dieser Technologie gefördert. Allerdings wurde dadurch auch eine Debatte über die Sinnhaftigkeit des Einsatzes der Infrarrotthermographie für diesen Zweck entfacht. Es wird darauf hingewiesen, dass die Beantwortung der Zuverlässigkeit der Infrarotthermographie zur Fiebererkennung nicht die Intention dieses Beitrags darstellt. Verständlicher Weise werden die Meinungen dazu in Abhängigkeit von den Interessen und der Erfahrung des Lesers variieren. Trotzdem ist die Europäische Assoziation für Thermologie (EAT) der Meinung, dass einige grundlegende Fakten berücksichtigt werden müssen, wenn der Einsatz bzw. die Installation spezieller Infrarotkameras zum Zweck der Massensuche nach Personen mit Fieber geplant wird.

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Introduction

In light of the recent events surrounding the Swine flu pandemic interest in the use of infrared thermal imaging for fever screening has been widely publicised and many authorities have implemented or are considering implementing thermal imaging installations for mass screening purposes. For example, airport screening for fever is often illustrated with infrared thermal cameras mounted on a wall or ceiling to record thermograms of the face. The intention is to stop people with a high body temperature from travelling during periods of high infection risk. Manufacturers of thermal cameras are finding heightened demand as airport authorities are preparing for screening should a pandemic fever be announced by the World Health Organisation.

The concept of using infrared thermal imaging in fever detection arose in connection with the outbreak of severe Acute Respiratory Syndrome SARS in China in 2002-3, where infrared imaging was used in some airports as a means of screening passengers who may endanger others by travelling whilst suffering from a fever. Some papers have reported the value of infrared imaging for fever screening in an hospital environment [1, 2]. In 2004 the Singapore Standards authority SPRING produced two documents as technical references [3,4]. These were the first documents to focus on the required information for the application of this technology for fever screening.

The content of the Singapore documents were recently updated and expanded and used as the basis for a new working group for the International Standards Organization (ISO). This has resulted in a new standard for the correct deployment of thermal imaging for fever detection (see section 3 below).

The recent publicity has also spurred debate concerning the effectiveness of using infrared thermal imaging for this purpose. Basically the debate is concerned with 3 main points.

1. The exactness of the relationship between deep body temperature and infrared thermal images of selected skin areas on the head.

In medicine, invasive methods of measuring body core temperature such as rectal temperature and oesophageal temperature are considered two of the most reliable and easily accessible sites for measuring body core temperature. Oral (sub-lingual), axillary and inguinal temperatures are perhaps the most common alternative measuring sites and in recent years a large variety of infrared thermometers for measuring auditory canal and forehead temperature have become available. All of these latter mentioned measuring sites will normally underestimate the true body core temperature, and in the case of modern infrared thermometers various algorithms have to be employed to calculate the supposed true body core temperature. Furthermore, all of the above require that the thermometry device have direct contact with the subject which is undesirable in a mass screening situation due to fear of spreading infection. For a recent comparison of different body temperature measuring sites see Pascoe & Fisher. [5].

As there is no completely reliable method for measuring body core temperature non-invasively the possibility of using non-contact infrared thermal images of the head (face) to determine body core temperature is clearly very attractive. A major problem in using infrared thermal imaging to determine whether a person is in a febrile state (has an elevated body core temperature) is that until recently there was practically no available scientific data on the relationship between body core (for example rectal temperature) and thermal images of the head (especially the facial area) in either non-febrile or febrile subjects. Indeed the question as to which skin site on the head one should be measuring has also been debated, although the general consensuses of opinion, also supported by recent data, indicate that the temperature of the inner canthus of the eye is consistently warmest area on the head and the most suitable site for use in fever detection [6]. There are several recent reports in the scientific literature from scientists trying to address this lack of information [5,7].

From the outset, it is important to keep in mind that the temperature of the inner canthus, or any other skin site, is not the same as deep body temperature and will always be somewhat less and, unfortunately, not always by a constant amount. To further complicate the issue it has recently been shown that infrared based temperature measurements at the inner canthi of the eye are also affected by climatic conditions. For example it has been shown that increasing air temperatures from 15.5ºC to 26.6ºC caused the inner canthi surface to increase from 35.7ºC to 37.6ºC, even though deep body temperature remained unchanged [5]. The same authors have also demonstrated that changes in relative humidity may also affect temperature measurements at this site. Such problems clearly illustrate that it is important that the room environment for imaging must be controlled.

In subjects with a high fever the increase in the temperature of the inner canthus of the eye is relatively easy to detect. However, the relationship between the temperature of the inner canthus of the eye and body temperature is not a clear cut linear relationship and the lower the fever the more difficult it is to detect a significant increased of the inner canthus due to data scatter. As a result it is necessary to select relatively high "threshold skin temperatures" in mass screening camera installations to avoid too many false positives. In a recent study on febrile children a threshold of 37.5ºC was suggested based on simultaneous measurements of forehead and axilla temperatures [7]. Most existing camera installations seem to have arbitrarily chosen threshold temperatures that are relatively high, with the risk that one only detects those persons with the highest fevers.

2. The inability to detect infected persons during the early/late stages of fever development.

There will be always be situations when infectious persons may not have an elevated body core temperature and will therefore not be picked up by a screening system. For example it may take several days for a newly infected person to develop an increase in body temperature (fever), the so called incubation period. Likewise there will be persons who have regained normal body temperature following a bout of fever yet who may still be infectious or who have suppressed their elevated body temperatures with pharmaceutical agents such as acetylsalicylic acid (asprin) or paracetamol. These situations are well known to all public health authorities. Despite this some authorities, for example the USA, maintain that fever screening may reduce spread statistics by up to 50%.

3. Camera quality and camera usage in fever screening installations.

The incorrect use of IR-cameras and flaws in camera installations and failure to follow recent international (ISO) guidelines for camera use are also causes for concern. From recent televised events it is clear that most camera installations are incorrect due to problems such as too long distance from the subject, poor focus, and poor camera resolution.

Strict protocols, as in medical thermography, are the key to reliable and reproducible use of the technique. Proper understanding of the conditions for installation and use are essential, as are the regular testing of camera performance and training of personnel involved. The new ISO standard is called "Particular requirements for the basic safety and essential performance of screening thermographs for human febrile temperature screening" IEC80601-2-59and ISO subcommittee SC3 and was published after an international vote in September 2008. It provides many performance and calibration requirements for devices used in this application.

A second document based on the SPRING document Part 2, was published in March 2009. This is not an international standard as such, but a technical guide to the "deployment, Implementation and operational guidelines for identifying humans using a screening thermograph". ISO/IEC TC 121/SC 3 N. It bears directly on this use, and while not perfect, does represent a major milestone completed since SPRING Singapore began their effort to create workable standards in 2003.

The standards may be purchased and downloaded online (see figure 1).

The ISO standard sets out the technical minimal performance required for a thermographic system used for fever screening. It refers to a number of existing standards relating to calibration of cameras, use of black body radiators

Figure 1 URL for the download of ISO-Standards:

www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_ detail.htm?csnumber=51236 or www, webstore.ansi.org RecordDetail.aspx? Sku= IEC+8060 1-2-59 + Ed.+1.0+b%3a2008

etc. and the optimal performance needed to image to face and measure as accurately as possible.

The inner canthi area of the eyes is a preferred and recommended site to represent core temperature. However, it is very important that there must be an adequate number of pixels in that area to register temperature, and indicate the small difference between a normal healthy person and someone with a fever. The procedure requires correct positioning so that the face fills the majority area of the image. It also requires a minimal number of pixels in the measured area. As with any camera or imaging system, attention to detail, focus and in this case close up frontal; face imaging is required. This is in contrast to many of the pictures recently shown in the media where cameras have been, for example, directed at groups of people, and where the maximum temperature displayed in a thermogram may be based on a single pixel. Many images shown in thermograms drawn from image libraries by the media are of low resolution, probably out of focus, and the subject is too far away to measure temperature.

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