Infrared Thermography to Mass-Screen Suspected Sars Patients with Fever

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Abstract

Fever greater than 38°C is a cardinal sign of patients with the severe acute respiratory syndromes (SARS). To reduce the risk of nosocomial cross infections, screening all patients and visitors who visit hospitals and clinics for fever at the entrance of every hospital building has become a standard protocol in Taiwan during the SARS epidemic from mid-April to mid-June 2003. We used a digital infrared thermal imaging (DITI) system (Telesis Spectrum 9000 MB) to conduct mass screening of patients and visitors who entered the hospital to identify those with fever. The DITI system has two components: a sensor head and a PC imaging workstation. The sensor head is an optic-mechanical device which consists of imagining optics for focusing the infrared source information on the infrared detector. The infrared images are further converted into electrical signals, which are then processed for real-time display on the monitor. During the period from April 13 to May 12 2003, 72,327 outpatients and visitors entered Taipei Medical University-Wan Fang Hospital, Taipei, Taiwan. A total of 305 febrile patients (0.42%) was detected by infrared thermography. Among them, three probable SARS patients were identified after thorough studies including contact history, laboratory tests and radiology examinations. The findings suggests that infrared thermography was an effective and reliable tool ideal for mass-screening patients with fever in the initial phase of screening for SARS patients at a busy hospital which sees approximately 3,000 outpatients every weekday during the SARS epidemic. ***Asia Pac J Public Health 2005: 17(1): 26-28.***

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Introduction

Since the first case of atypical pneumonia appeared in Guangdong Province, People's Republic of China in November 2002, outbreaks of the severe acute respiratory syndrome (SARS) have been reported in 29 countries[1-3]. In Taiwan, the SARS outbreak began in March 2003. By June 6 2003, 2,132 cases have been reported, including 677 probable, 1,374 suspected, with 81 deaths[4].

Fever is almost always present in SARS patients[5,6]. Detection of fever has become an essential step in identifying patients who may have contracted SARS for isolation and workup before they transmit the disease to other patients or hospital staff. Every hospital in Taiwan has been screening patients' body temperature since early April.

This report describes the first thermographic screening to detect possible SARS patients who entered a general hospital in Taipei, Taiwan between April 13 and May 12 2003.

Materials and Methods

The World Health Organization (WHO) announced the City of Taipei as one of the SARS "affected areas", which is defined as a region at the first administrative level where the country is reporting local transmission of SARS[7]. Taipei Medical University-Wan Fang Hospital (TMU-WFH) which is a Taipei municipal hospital managed by Taipei Medical University has 600 inpatient beds and four clinics with approximately 3,000 outpatients daily during the SARS epidemic. Being similar to other medical centers in Taiwan, the clinics are located inside TMU-WFH. To reduce the risk of nosocomial cross infections, we have been screening every patient and visitor to identify those with the body temperature of 38°C or greater.

Traditional tools to measure the body temperature are through the mouth and ear canal. These methods are time-consuming and had created long lines at TMU-WFH with more than 3,600 patients and visitors every weekday at the early phase of the SARS epidemic. Starting in early April 2003, TMU-WFH has been using infrared thermography (Telesis Spectrum 9000MB digital infrared thermal imaging [DITI] system)[8-10] as a mass-screening tool to identify febrile entrants. The DITI system has two components: a sensor head and a PC imaging workstation.

The sensor head is an optic-mechanical device to collect imaging optics by focusing its infrared source information on the infrared detector, which is packaged within a vacuum container (or Dewar) operating at room temperature and stabilized by a thermoelectric cooler. The infrared images are further converted into electrical signals, which are then processed for real-time display on the monitor.

The DITI system can measure between 10°C and 40°C at 60 frames per second. The minimum change in temperature that can be detected is 0.07°C. The captured image resolution is 320 X 240 pixel. Focus (manual) ranges from 3 inches to infinity. Based on the information of the human body core temperature[11], the DITI system can measure the skin temperature of the face, especially the frontal area, to screen febrile patients[12]. With Spectrum 9000 MB Fever Test Mode, the alarm system will go off when the thermographic temperature is greater than 37.5°C as expected in a febrile patient. Figure 1 shows a patient with an ear drum temperature of 38.7°C as he went through the thermographic detector.

To maintain the measured temperature close to the absolute temperature, the DITI system can be calibrated automatically based on a reference black body temperature. To evaluate the validity of the DITI system, we carried out a correlational study on 993 hospital visitors. Among 12 visitors whose eardrum temperatures were 37.5°C or greater, nine visitors were detected as thermographically febrile patients. The DITI system sensitivity was 75% (9/12). Three febrile patients undetected by the DITI system were re-examined with eardrum thermometer. All three cases were below 38°C, which was the criterion commonly used to define fever in SARS patients. Furthermore, these false negative patients were also proved to be non-SARS patients. Among 981 hospital visitors with ear drum temperature lower than 37.5°C, 977 visitors were found without thermographic fever, showing 99.6% of specificity (977/981).

When a patient was found to have a thermographic temperature greater than 37.5°C, thermometer measurement through the ear canal was performed to confirm whether the patient had a fever (38°C). When a patient's ear drum temperature was 38°C or higher, he or she was immediately isolated for further examination. The patient was examined to determine whether the patient (1) had any history of contact

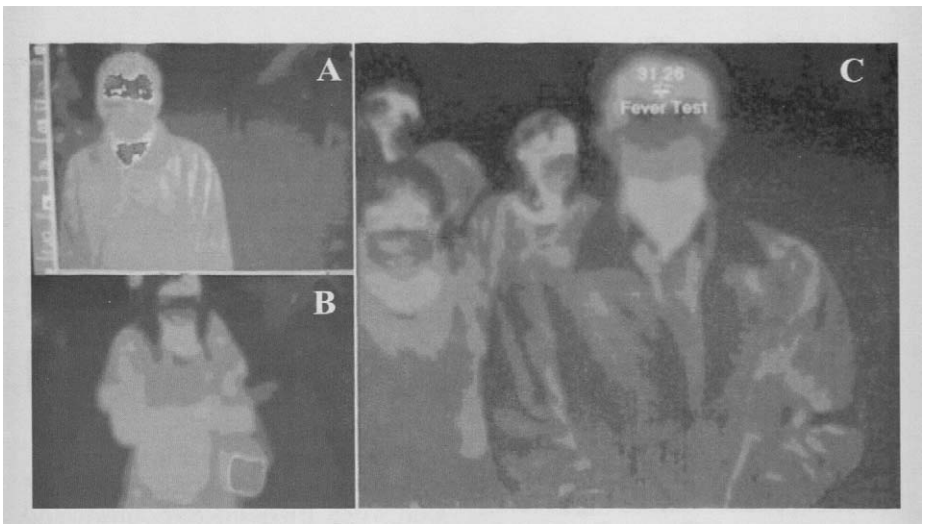

Figure 1. Images collected by the digital infrared thermal image system
(A: a febrile patient with an ear drum temperature of 38.7°C; B: a febrile visitor carrying a bag of hot food; C: A group of afebrile entrants)

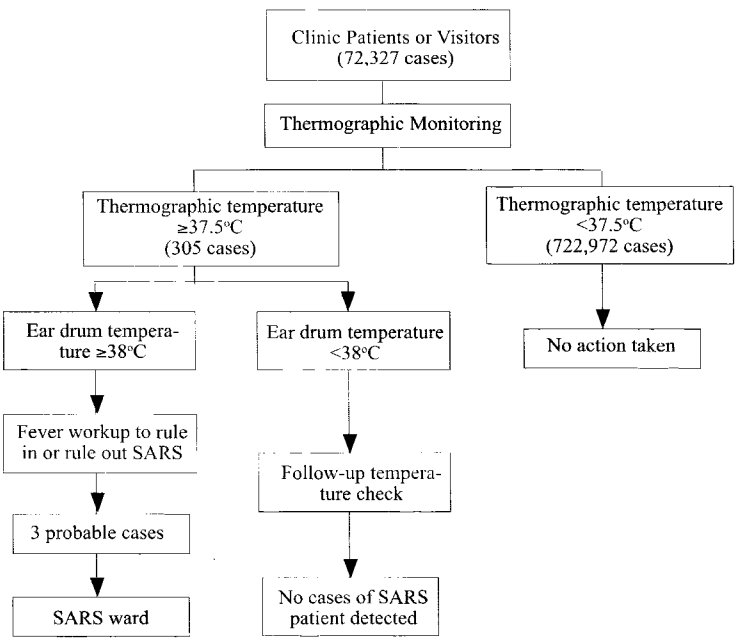

Figure 2. Flow chart for work-up of 305 cases of "Fever" by thermography

with SARS patients, (2) traveled to an epidemic region, or (3) presented with any SARS symptoms or signs. Fig.2 shows the workup flow chart for "fever" detected by infrared thermography.

Results

From April 13 to May 12, 2003, 72,327 patients or visitors passed through the only entrance allowed at TMU-WFH where a thermography station was in operation. A total of 305 patients or visitors (0.42%) were detected to have a thermographic "fever" (higher than 37.5°C). These "febrile" patients went through a fever workup protocol (Figure 2). Among 145 patients with an ear drum temperature lower than 38°C, none was noted to have SARS. Among 145 patients with an ear drum temperature greater than 38°C, three were eventually found to meet the criteria of probable cases.

Discussion

A number of methods are available to measure the body temperature to detect fever. These include conventional mercury thermometers for oral or rectal temperatures or infrared thermometers for the ear drum or frontal skin temperature. These methods are not convenient for mass-screening. Over a period of one month, 72,327 patients or visitors went through the infrared thermography station. Three hundred and five patients or visitors were detected to have a thermographic "fever". These "febrile" patients received further evaluation to confirm the fever based on the ear drum temperature. Of 305 cases, three patients were eventually diagnosed as probable SARS. We suggest that infrared thermography could become a device for mass-screening to detect febrile patients in a SARS affected area.

Based on the findings in our study, we found that the temperature error would become larger when those high fever patients were under sweating phase. The DITI system may produce false negative detection and have decreased sensitivity in fever screening. We set the temperature of the thermographic fever screening flow chart at 37.5°C, that is lower than the criteria of SARS (38°C), to make sure all high fever (>38°C) patients could be detected by the DITI system. To review sensitivity and specificity in the DITI system screening, we could find all false negative cases with body temperature lower than 38°C.

Fever is a cardinal sign of patients with SARS. It presents early in virtually all patients with SARS.[13] As reported by the first global conference on SARS at the WHO headquarters in Geneva on May 16-17 2003, no persons without fever can transmit SARS to others[14]. Therefore, every hospital in Taiwan has set up screening methods at its entrance. Because of the volume of patients and visitors who enter a hospital each day, a less time-consuming and reliable method to screen body temperature is highly desirable. In this study, we used the DITI system with a high-resolution to mass-screen large number of entrants in an efficient and non-intrusive manner as the first step of screening patients. This method requires no direct contact between patients and health care professionals. Because close personal contact is a major mode of transmitting SARS, the thermographic screening of body temperature is also safer than conventional methods. We suggest that the thermographic fever screening be further explored in the future as the initial phase of screening patients in regions with SARS epidemic.

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