Concise Communications

Limitations of Forehead Infrared Body Temperature Detection for Fever Screening for Severe Acute Respiratory Syndrome

Chuan-Chuan Liu, MS; Ray-E Chang, PhD;
Wen-Cheng Chang, MS

ABSTRACT

We investigated alternative measurement methodology for infrared body thermometry to increase accuracy for outdoor fever screening during the 2003 SARS epidemic. Our results indicate that the auditory meatus temperature is a superior alternative compared with the forehead body surface temperature due to its close approximation to the tympanic temperature (*Infect Control Hosp Epidemiol* 2004;25:1109-1111).

Many countries were affected by the severe acute respiratory syndrome (SARS) epidemic of 2003. Several countries employed screening for fever as part of a SARS prevention plan to halt the spread of the disease. The government of Taiwan implemented a requirement to measure body temperature for individuals entering and exiting the country and also started measuring body temperature at screening stations set up at public facilities such as airports, hospitals, schools, government installations, and large confined spaces. This became a requirement for entering such facilities, but many different methods and devices were used to measure body temperature. During the height of the epidemic, screening was taking place outdoors to prevent the entrance of infected individuals into some buildings. Therefore, to take the body temperatures of a large number of individuals rapidly, the most common method used in Taiwan was infrared body thermometry measuring the forehead body surface temperature to detect fever. Because body surface temperature could be affected by many variables, forehead body temperature may not be an accurate predictor.^{1,2} How to use infrared body thermometry in a large population accurately under outdoor conditions thus became an issue worth investigating. We report the results of a study comparing the findings of infrared thermometry at two body sites with those of a tympanic thermometer.

METHODS

Study Subjects

The subjects were patients seeking outpatient services in a medical center who consented to participate in this study. Selection criteria were as follows: (1) having no ear disease or ear damage, (2) not wearing earrings, and

(3) being able to walk. Five hundred subjects were selected from May 12 through June 2, 2003.

Equipment and Measurement Methodology

Two measuring devices were employed. A tympanic thermometer (Welch Allyn 9000, Welch Allyn, San Diego, CA) was used to measure tympanic temperature. An infrared body thermometer (Thermofocus Thermometer, Tecnimed, Italy) was used to measure forehead body surface temperature and auditory meatus temperature. Both measurement devices were calibrated following the instructions given in their respective manuals. The screening station was a shelter located at the hospital's front entrance. All temperature measurements were taken by a single individual for measurement consistency and were completed in 5 minutes. Standard operating procedures were followed for both devices based on the respective manuals, and readings were then recorded.

Analyses

With the use of SPSS statistical software (SPSS, Inc., Chicago, IL), the means and standard deviations were calculated for the three measurements. We then compared both measurements obtained from the infrared body thermometer with that from the tympanic thermometer in terms of the correlation, accuracy, sensitivity, and specificity. Receiver operating characteristic curves were also derived to compare the two measurements from the infrared body thermometer.

RESULTS

The means and standard deviations were 36.44°C and 0.37°C for tympanic temperature, 35.63°C and 0.36°C for forehead body surface temperature, and 36.20°C and 0.30°C for auditory meatus temperature. Whereas the tympanic temperature and the auditory meatus temperature were significantly positively correlated, the tympanic temperature and the forehead body surface temperature were not (Table). Regarding the accuracy, using the tympanic temperature $\pm 0.37^\circ\text{C}$ (standard deviation, 1) as the acceptable temperature measurement range, 110 of the 500 subjects had tympanic and forehead body surface temperatures within the standard deviation, with an accuracy rate of 24%. On the other hand, 276 subjects had tympanic and auditory meatus temperatures within 0.37°C , with an accuracy rate of 55.2%. Therefore, the relative accuracy of the auditory meatus temperature was 31.2% higher than that of the forehead body surface temperature. Following the fever-detecting policy mandated by

TABLE
COMPARISON OF THE MEASUREMENTS OBTAINED BY INFRARED
BODY THERMOMETRY WITH THOSE OBTAINED BY TYMPANIC
THERMOMETER

	Forehead	Auditory Meatus
Pearson correlation	0.25 ($P = .19$)	0.56 ($P < .01$)
Accuracy*	24%	55.2%
Sensitivity†	17.3%	82.7%
Specificity†	98.2%	98.7%
False negative†	82.7%	17.3%
False positive†	1.8%	1.3%

*Percentage of measurements within the difference of 0.37°C from that measured by the tympanic thermometer.

†Using 37.5°C as the cutoff point.

the hospital, 37.5°C was employed as the threshold for fever screening. The auditory meatus temperature more closely approximated the tympanic temperature (Table, Figure).

DISCUSSION

The results of this study suggest that measuring the auditory meatus temperature is a more reliable screen for fever than measuring the forehead body surface temperature using the same infrared body thermometer in outdoor conditions. This could be due to more prominent effects of outdoor environmental factors on forehead body surface temperature.

Transmission of SARS can be prevented by rapid case detection.³ Because fever is one of the common symptoms of SARS infection, fever screening became a widely used detection tool in affected countries. However, given the requirement to screen many individuals in public facilities as quickly as possible, there was a paucity of practical measurement methods. With such limitations, many airports and public facilities around the globe used infrared body thermometry as the preferred screening method. However, the design of infrared body thermometry was based on measuring the body surface temperature assuming a stable ambient temperature. Therefore, accurate fever screening using an infrared body thermometer warranted further investigation.

To prevent another situation in which SARS patients entered the hospital and caused a hospital-wide outbreak such as that at Hoping Hospital, Taiwan's health authorities implemented strict ingress controls at all hospitals. Screening stations at the entrance of healthcare facilities were used to identify fever. Individuals with fever were taken to secondary screening facilities outdoors where they underwent blood tests and x-rays as well as a detailed questionnaire concerning contacts during the 2 preceding weeks. This study was conducted at a medical center with approximately 2,100 beds and more than 7,000 outpatient visits per day. The hospital defined fever as a temperature of at least 37.5°C, and infrared thermometers

FIGURE. Receiver operating characteristic curves for forehead and auditory meatus temperatures with a cutoff point of 37.5°C and tympanic temperature as the reference.

were used as the measurement devices. It was thus imperative to ascertain the best methodology using such an instrument to either lower false-negative readings or increase accuracy. Because of practicality, oral and rectal temperature measurements were not considered and tympanic thermometer measurements were used as the most convenient reference. Although some studies have questioned the accuracy of tympanic temperature measurements,⁴⁻⁷ others have reported their accuracy.⁸⁻¹¹ Sloan¹² pointed out that if the effect of ambient temperature could be eliminated, tympanic temperature would provide a good measurement for body temperature. This study accounted for shifting environmental temperatures. When outdoor temperature and the screening station temperature differed by more than 5°C, the subject was required to rest for 5 minutes in the station before any measurement was taken. Given some doubt about the accuracy of tympanic temperatures as a gold standard method, future studies could use other gold standard methods. A small percentage of SARS cases did not exhibit fever; therefore, the screening process for SARS should perhaps screen for other symptoms such as cough, dyspnea, or diarrhea. Particular attention should be paid to individuals who have had close, sustained contact with SARS cases or have been in outbreak settings.

Ms. Liu is from the Department of Clinical Physiology, Mackay Memorial Hospital, Taipei; and the Department of Medical Technology, Yuanpei University of Science and Technology, Hsin-Chu, Taiwan. Dr. Chang is from the Graduate Institute of Health Care Organization Administration, College of Public Health, National Taiwan University, Taipei, Taiwan. Mr. Chang is from the Office of Deputy Superintendent, Mackay Memorial Hospital, Taipei, Taiwan.

Address reprint requests to Ray-E Chang, Graduate Institute of Health Care Organization Administration, College of Public Health, National Taiwan University, No. 19, Su-Chow Rd., #306, Taipei, Taiwan.

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Factors Affecting Perceived Risk of Contracting Severe Acute Respiratory Syndrome Among Academic Physicians

Sherry L. Grace, PhD; Karen Hershenfield, BSc;
Emma Robertson, PhD; Donna E. Stewart, MD,
FRCPC

ABSTRACT

SARS disproportionately affects healthcare providers. A physician survey was administered within three hospitals providing care to SARS patients. Knowing a colleague who contracted SARS and previous occupational exposure to infectious agents were significantly predictive of greater perceived risk, whereas perceived effectiveness of precautions and provision of direct care were not (*Infect Control Hosp Epidemiol* 2004;25:1111-1113).

Severe acute respiratory syndrome (SARS) disproportionately affects healthcare providers, who account for upward of 50% of those affected in Toronto.¹ Most physicians feel they have a "duty" to treat infectious patients²; however, factors such as perceived susceptibility or risk may affect physicians' compliance with infection control precautions³ and willingness to provide clinical services to affected patients.^{2,4} The objective of this study was to assess the degree of perceived occupational risk and the demographic, logistic, and attitudinal factors affecting perceived risk of contracting SARS among physicians.

METHODS

The University Health Network is composed of three large teaching hospitals in downtown Toronto where

SARS patients are treated. After the second SARS outbreak in the city in May 2003,⁵ there was spread to several healthcare workers (HCWs) at the University Health Network, who then received care on site. It was at this juncture that all physicians with a University Health Network address (n = 577) were selected for inclusion in this study from an online version of the Canadian Medical Directory. This sample consisted of 405 (70.19%) male and 172 (29.81%) female physicians. The institutional research ethics board approved the protocol for this study.

The cross-sectional survey was mailed to all physicians. Each package included an information letter, a survey, and a return envelope. As outlined in the information letter, the completion and return of the survey constituted the participant's informed consent for this study. To facilitate disclosure, the survey was completely anonymous, without any means to recontact nonresponding physicians through a numerical identifier. Of the 577 physicians who were mailed the survey, 23 (4%) were ineligible: 22 had moved and 1 was deceased. Of the remaining 554 physicians, 193 returned completed surveys (response rate, 34.8%).

Based on the literature regarding risk perception among HCWs,^{3,4,6-10} relevant sociodemographic, logistic, and attitudinal factors were incorporated into the survey. Sociodemographic characteristics consisted of gender, age, specialty, number and ages of children, number of years in practice, health status, and ethnocultural background. Logistic and attitudinal factors consisted of information and knowledge, previous exposure to infectious agents, infection control practices, and direct occupational exposure to SARS. Specifically, provision of direct care to SARS patients, knowing someone who contracted SARS, previous occupational exposure to an infectious agent, new SARS symptomatology, satisfaction with information provision, and perceived effectiveness of infection control precautions (5-point Likert scale from 1 ["not effective"] to 5 ["extremely effective"]) were measured. The dependent variable of perceived risk asked physicians to rate how likely they thought they were to contract SARS on a scale from 1 ("not likely") to 5 ("extremely likely").

RESULTS

Participant characteristics are presented in Table 1. Regarding specialty, 72 (48.0%) practiced medicine, 31 (20.7%) were surgeons, 20 (13.3%) worked in radiology, 13 (8.7%) practiced anesthesia, 11 (7.3%) worked in psychiatry, 3 (2.0%) worked in pathology, and 43 did not list their specialty (likely to ensure anonymity). When asked their ethnocultural background, 131 (70.8%) responded caucasian-English-Anglo-Saxon, 28 (15.1%) were Asian, 11 (5.9%) were Jewish, 6 (3.2%) were Indian, and others reported Mediterranean, Arabic, Hispanic, and Persian backgrounds. A dichotomous variable was created consisting of caucasian-Canadian versus all other self-reported backgrounds. Forty-five (23.3%) of the participants provided direct care to one or more SARS patients.

Ninety-nine (54.4%) of the physicians self-reported occupational exposure to at least one other infectious

TABLE 1
CHARACTERISTICS OF THE PARTICIPANTS (N = 193)

Characteristic	Mean (SD)	No. (%)
Gender		
Male		131 (67.9)
Female		62 (32.1)
Age, y	48.2 (11.0)	
Years in practice*	23.4 (11.0)	
Children		
Yes		141 (73.1)
No		52 (26.9)
No. of children	2.5 (0.9)	
Ethnocultural background		
Caucasian-white		131 (70.8)
Other		54 (29.2)
Health status†	1.41 (0.64)	

SD = standard deviation.

*Median, 22 years.

†Assessed on a scale from 1 ("excellent") to 5 ("poor").

agent in the past, including human immunodeficiency virus, tuberculosis, hepatitis, polio, cholera, typhoid, and prion disease. Eighty-three (43%) of the respondents knew someone who had contracted SARS, and this individual was most often a colleague (61; 80.3%). Thirty-five (18.1%) of the respondents reported experiencing new SARS-like symptoms when working during the outbreaks. One hundred seventy (88.1%) of the physicians thought they had been given appropriate, adequate, and timely information about proper infection control precautions to take regarding SARS. Physicians rated the hospital infection control procedures as effective in limiting the spread of SARS (mean, 3.97; standard deviation [SD], 0.79). Their mean personal perceived risk of contracting SARS was 1.74 (SD, 0.81).

Demographic, logistic, and attitudinal factors postulated to affect perceived risk were investigated. A univariate analysis of covariance (SPSS General Linear Model procedure, version 11.0.1; SPSS, Inc., Chicago, IL) was used to predict physicians' perceived risk of contracting SARS. After adjustment for covariates, a significant difference in perceived risk was found ($F [10] = 3.40$; $P < .001$; adjusted $R^2 = 12.4\%$; eta-squared = .18; Table 2). These results suggest that after controlling for gender, ethnocultural background, years in medical practice, and perceived health, those who perceived greater risk of contracting SARS personally knew someone who had contracted SARS (mean, 2.00; SD, 0.91) and had previous exposure to an infectious agent (mean, 1.90; SD, 0.89) when compared with participants who perceived lesser risk (mean, 1.53; SD, 0.65 and mean, 1.57; SD, 0.68, respectively).

DISCUSSION

Some physicians are appropriately fearful of contracting SARS¹¹ given the communicability of the virus, its

TABLE 2
ANALYSIS OF VARIANCE PREDICTING PHYSICIAN PERCEPTION OF LIKELIHOOD OF CONTRACTING SEVERE ACUTE RESPIRATORY SYNDROME (SARS)

Variable	df	F	P	eta-squared
Gender	1	0.12	.73	.001
Ethnicity	1	2.02	.16	.013
Years of medical practice	1	0.17	.68	.001
Perceived health	1	0.71	.40	.004
Provides direct care to SARS patients	1	1.33	.25	.008
Knows someone who contracted SARS	1	6.08	.02	.037
Previous occupational exposure to an infectious agent	1	5.51	.02	.034
New SARS symptomatology experienced during outbreaks	1	1.07	.30	.007
Perception of timely and adequate information received	1	1.68	.20	.010
Perceived effectiveness of hospital infection control practices	1	1.63	.20	.010

novelty, the contradictory information regarding infection control precautions,¹¹ the lack of effective treatment,¹² and the increased risk of infection and death among HCWs.¹³ However, in this sample of physicians working in affected hospitals, physicians generally perceived it unlikely that they would personally contract SARS. Future studies should attempt to determine whether physicians' sense of invulnerability contributes to their heroism and ability to perform vitally essential work in caring for patients with highly infectious and dangerous diseases and to what extent this may interfere with prudence and strict adherence to infection control precautions.

Although risk perception of the lay population is often assumed to be based on past experience and affect, physician risk perception is assumed to be based on scientific knowledge and probability.⁸ Based on the available scientific evidence to date, SARS transmission occurs through droplets, and strict adherence to infection control precautions can reduce nosocomial transmission.¹⁴ Therefore, a scientific approach to risk appraisal would suggest that direct contact with SARS patients and ineffectiveness of infection control precautions would be strongly related to risk of contracting SARS. Although most physicians (88%) thought they were well informed about precautions and almost one-fourth provided direct care to one or more SARS patients, the scientific variables did not significantly predict physicians' perceived risk in our multivariate model. This may reflect low perceived susceptibility¹⁵ or a sense of invulnerability, despite the fact that HCWs are at greatly increased risk.¹⁶

Instead, our results suggest that physicians erro-

neously judged their likelihood of contracting SARS based on their experience with colleagues who contracted SARS and their previous occupational exposure to infectious agents. The availability heuristic¹⁷ refers to the common human tendency to judge the likelihood of events in terms of how readily instances come to mind. Thus, physicians who are familiar with an infected colleague may perceive greater risk because the possibility of contagion is personally salient. Alternatively, an optimistic bias may also explain the findings, given that physicians rated their health status highly, and only slightly more than half reported previous occupational exposure to any infectious agent. Undoubtedly, all physicians would have had some personal exposure to infectious agents during training or practice, so responses to this question were presumably based on personal exposure to serious infections that readily came to mind.

The main limitation of this study pertains to the response rate, although our rate is similar to that of other reported physician surveys.¹⁸ The generalizability of our findings to nonresponders, non-academic physicians, or those in other reimbursement systems is unknown.

Despite the increased risk among HCWs of contracting SARS, these highly trained academic physicians generally perceived a low personal risk of infection. Similar to lay populations, their risk perception was more strongly related to personally salient examples than to scientific evidence. Future study is required to understand the constellation of cognitive and affective factors at play. The relationship among risk perception, willingness to treat infectious patients, and infection control practices should also be investigated.

The authors are from the University Health Network Women's Health Program, Toronto, Ontario, Canada. Ms. Hershenfield and Dr. Stewart are also from the University of Toronto, Toronto, Ontario, Canada. Dr. Grace is also from York University, Toronto, Ontario, Canada.

Address reprint requests to Sherry L. Grace, PhD, Assistant Professor, York University, Kinesiology and Health Sciences, Affiliated Scientist, Toronto General Research Institute, Toronto, Ontario, Canada.

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A Large-Volume Nebulizer Would Not Be an Infectious Source for Severe Acute Respiratory Syndrome

Gwo-Hwa Wan, PhD; Ying-Huang Tsai, MD; Yao-Kuang Wu, MD; Kuo-Chien Tsao, MSc

ABSTRACT

We attempted to detect the presence of airborne SARS-coronavirus (CoV) in a healthcare setting when a patient with SARS used a humidifier or a large-volume nebulizer (LVN). All of the air samples from the humidifier and LVN were found to have negative SARS-CoV-specific DNA products (*Infect Control Hosp Epidemiol* 2004;25:1113-1115).

Severe acute respiratory syndrome (SARS) is a recently emergent disease that started in Asia and spread to other continents through international travel.¹ Patients infected with SARS coronavirus (CoV) have fever, dry cough, dyspnea, headache, and hypoxemia. Death may result from progressive respiratory failure due to alveolar damage.²

The SARS-CoV may be carried in droplets produced by aerosolization that can occur as a result of coughing or talking.³ In primary clinical therapy, SARS patients were treated with oxygen therapy combined with humidification using a humidifier or a large-volume nebulizer. Until recently, no studies had confirmed whether a large-volume nebulizer was a risk factor for SARS transmission in a healthcare setting. Therefore, we specifically evaluated airborne SARS-CoV DNA concentrations using filter sampling and SARS-CoV-specific reverse transcriptase polymerase chain reaction (RT-PCR) assay when a SARS patient was treated with a humidifier or a large-volume nebulizer.

METHODS

Subjects

A patient with the diagnosis of SARS confirmed by symptoms, chest radiograph, throat swab, and nasopharyngeal aspirate was treated with oxygen therapy and

TABLE 1
DISTRIBUTIONS OF AIRBORNE SEVERE ACUTE RESPIRATORY SYNDROME (SARS)-CORONAVIRUS WHEN THE SARS PATIENT USED A HUMIDIFIER OR A LARGE-VOLUME NEBULIZER

	Device		
	Humidifier	Large-Volume Nebulizer	Blank
Sample size	3	3	6
Sampling filter	PTFE	PTFE	PTFE
Pore size of filters	1 µm	1 µm	1 µm
Positive PCR results	0%	0%	0%

PTFE = polytetrafluoroethylene; PCR = polymerase chain reaction.

ryngeal aspirates on May 12, 2003, was recruited from a negative pressure isolation room at Chang Gung Memorial Hospital. After informed consent was obtained from interview, air samples were collected from a patient isolation room.

Environmental Sampling

When the SARS patient was treated with oxygen therapy by means of a bubble diffuser humidifier or a large-volume nebulizer, a three-piece cassette with a 1-µm polytetrafluoroethylene (PTFE) filter was placed approximately 30 cm above the patient's head, thus simulating the human breathing zone. The indoor air was filtered at a flow rate of 4.5 L/min for 20 minutes. Sample controls of the environment were also taken. All of the staff involved in collecting the air samples in a negative pressure isolation room were advised to wear full personal protective equipment (such as N-95 respirators, eye protection, and disposable fluid-resistant gowns and gloves) for protection against SARS.

Aerosol Generation

To evaluate the filtration efficiency of 1- or 0.2-µm PTFE and 0.2-µm polycarbonate filters for airborne SARS-CoV, we generated a SARS-CoV virucidal spray with a small-volume nebulizer (Whisper Jet, Marquest Medical Products, Englewood, CO). Three different filters (1- and 0.2-µm PTFE filters and a 0.2-µm polycarbonate filter) were used to collect air samples at 4.5 L/min for 20 minutes.

Analysis

The filters were shaken in AVL buffer containing carrier RNA (QIAamp Viral RNA Mini Kit, Qiagen, Valencia, CA) and phosphate buffered saline for 20 minutes at room temperature. For extracting the RNA from the filter samples, we used the QIAamp Viral RNA Mini Kit (Qiagen) and followed the manufacturer's protocol. Following extraction, the viral RNA was quantitatively measured using a real-time RT-PCR method, as per the protocol from Taiwan's Center for Disease Control and Prevention.⁴

TABLE 2
POSITIVE RATES OF DIFFERENT FILTERS ON POLYMERASE CHAIN REACTION (PCR)

	Sampling Filter		
	PTFE (1 µm)	PTFE (0.2 µm)	PC (0.2 µm)
Sample size	3	3	3
Positive PCR results	100%	100%	100%
Positive blank PCR results	0%	0%	0%

PTFE = polytetrafluoroethylene; PC = polycarbonate.

RESULTS

In this study, the patient was confirmed to have SARS after environmental sampling in the negative pressure isolation room. None of the environmental samples revealed any positive SARS-CoV-specific DNA products when the patient was treated with oxygen therapy by a humidifier and a large-volume nebulizer, respectively (Table 1). It was demonstrated that the PCR positive rates of the filters (1- and 0.2-µm PTFE filter and 0.2-µm polycarbonate filter) were 100% (Table 2).

DISCUSSION

In 2003, SARS became a subject of concern to health-care workers and to the public in general throughout the world. Previous studies have shown that aerosolized rhinovirus, concentrated on PTFE filters with a 2-µm pore, was detected by a semi-nested RT-PCR assay.⁵ We attempted to collect SARS-CoV aerosols of high concentration from a small-volume nebulizer using different filters. The PCR positive rates for 0.2- and 1-µm PTFE filters and 0.2-µm polycarbonate filters were 100%. Therefore, these filters may be suitable for environmental sampling of the SARS-CoV.

This study demonstrated that all negative airborne SARS-CoV PCR runs were obtained from 1-µm PTFE filters in the patient's room while the patient was being treated with either a humidifier or a large-volume nebulizer. These negative PCR runs for a large-volume nebulizer for airborne SARS-CoV do not correspond with the general perception that a nebulizer, because it produces aerosols, might be a transmitting source for SARS in hospitals. However, PTFE filters were shown not to yield positive PCR runs from the large-volume nebulizer. One explanation might be related to the possibility that there is an extremely low existence of airborne SARS-CoV. Moreover, the current study included only one patient.

To date, no previous studies have addressed the characteristics of airborne SARS-CoV in a healthcare setting. Therefore, we evaluated the distributions of airborne SARS-CoV in patient rooms in a hospital when a SARS patient was being treated with oxygen therapy combined

with a humidifier and a large-volume nebulizer. PCR amplification of the air samples in this patient isolation room detected 0% of the offending pathogens. It demonstrated that a large-volume nebulizer perhaps would not be a risk factor for SARS transmission.

Dr. Wan is from the Department of Respiratory Care, College of Medicine, Chang Gung University, Taiwan, Republic of China. Drs. Tsai and Wu are from the Department of Pulmonary and Critical Care and Ms. Tsao is from the Department of Clinical Pathology, Chang Gung Memorial Hospital, Taiwan, Republic of China.

Address reprint requests to Ying-Huang Tsai, Department of Pulmonary and Critical Care, Chang Gung Memorial Hospital, 5, Fu-Shing St., Kwei-San, Tao-Yuan, Taiwan, Republic of China.

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Transmission of Tuberculosis Among Patients With Human Immunodeficiency Virus at a University Hospital in Brazil

Mariângela R. Resende, MD, PhD; Maria Cecília B. Villares, BS, PhD; Marcelo de C. Ramos, MD, PhD

ABSTRACT

This study evaluated the IS6110-RFLP patterns of 109 *Mycobacterium tuberculosis* isolates of patients with HIV cared for at a Brazilian university hospital. Thirteen clusters involving 35 (32.1%) individuals were identified. Nosocomial transmission was possible in 5 cases. Strategies to prevent *M. tuberculosis* transmission should be implemented in hospitals in developing countries (*Infect Control Hosp Epidemiol* 2004;25:1115-1117).

Co-infection with human immunodeficiency virus (HIV) is the greatest risk factor for both progression of primary tuberculosis (TB) on recent exposure and reactivation of latent infection.¹ Admission of patients co-infected with *Mycobacterium tuberculosis* and HIV to healthcare facilities is often associated with delayed isolation precautions, diagnosis, and treatment, which may contribute to the spread of *M. tuberculosis* and trigger outbreaks.² TB was the second most common opportunistic infection among the 157,775 patients with acquired immunodeficiency syndrome (AIDS) reported in Brazil from 1980 to

1999.³ TB and HIV co-infection leads to a larger number of hospital admissions. In Brazil, as in other developing countries, the transmission of TB has not been well characterized by molecular methods.

This study was performed to evaluate patterns of TB transmission among HIV-infected patients cared for at a Brazilian referral hospital, using conventional epidemiology and IS6110 restriction fragment length polymorphism (RFLP) molecular fingerprinting.

METHODS

Setting

This study was performed at the university teaching hospital of the Universidade Estadual de Campinas (HC-UNICAMP), São Paulo, Brazil. This is a 400-bed, tertiary-care facility and regional referral center for HIV care. During the past decade, an average of 288 new TB cases per year were reported to the Epidemiologic Surveillance Office at the hospital. Transmission-based precautions, consisting of private rooms (without negative pressure) and the use of N-95 respirators by the hospital staff, were implemented in 1996. These precautions were applied to all patients presenting respiratory symptoms, such as cough, shortness of breath, and chest pain, for more than 2 weeks until a definitive diagnosis was made. No additional precautions were adopted for HIV-positive patients.

Design

A retrospective, conventional, and molecular-based epidemiologic study was performed among hospital inpatients and outpatients.

Study Population

A case-patient was defined as an HIV-positive patient with a culture positive for *M. tuberculosis* reported to the Epidemiologic Surveillance Office at HC-UNICAMP from January 1996 to July 2001. Exclusion criteria were non-banked *M. tuberculosis* isolates, cases of probable laboratory cross-contamination, and recurrent TB episodes in the same patient. Laboratory cross-contamination was suspected when the patient's clinical presentation was not consistent with TB and the specimen had been processed concomitantly with another isolate exhibiting an identical IS6110-RFLP pattern. Demographic, epidemiologic, and clinical variables were collected from medical records. This study was reviewed and approved by the Medical Ethics Committee of the university.

Molecular Strain Typing

One *M. tuberculosis* isolate from each enrolled patient was submitted for fingerprinting using IS6110-RFLP according to standard protocols.⁴ IS6110-RFLP patterns were compared visually and by Gel Compar computer software (version 4.0; Applied Maths, Kortrijk, Belgium). Isolates were considered to be clustered if they had five or more IS6110 bands and identical patterns. Statistical analysis was performed using Epi-Info software

FIGURE. IS6110 band patterns and similarity matrices for each of the 13 *Mycobacterium tuberculosis* clusters identified. RFLP = restriction fragment length polymorphism.

(version 6.04b; Centers for Disease Control and Prevention, Atlanta, GA). Categorical variables were analyzed using chi-square (Yates correction) or two-tailed Fisher's exact tests, as appropriate. Continuous variables were analyzed using the Kruskal–Wallis test. *P* values less than .05 were considered statistically significant.

RESULTS

From January 1996 through July 2001, 254 cases were identified. HIV infection and TB were concomitantly diagnosed in 32.7% of the case-patients. The mean age of

case-patients was 32.5 years, and 182 (71.7%) were male. Their median CD4+ count was 86 cells/mm³. Pulmonary involvement was present in 206 (81.1%) of the case-patients. Lung cavitations on chest x-ray were present in only 16 (6.3%) of the 254 case-patients. Sputum smear samples were positive for acid-fast bacilli in 78 (37.9%) of the 206 case-patients with pulmonary disease. Forty-four (56%) of the 78 case-patients with positive results for acid-fast bacilli were admitted to the hospital. At least one component of the airborne precautions protocol (eg, use of N-95 respirators or isolating a patient in a private room) was violated for 50% of the admitted patients.

One hundred twelve (44.1%) of the 254 isolates were available for IS6110-RFLP. Three cases were excluded from the analysis due to probable cross-contamination or too few IS6110-RFLP bands. The epidemiologic and clinical variables and temporal occurrence of case-patients had a similar distribution among typed and nontyped isolates. Samples recovered from the respiratory tract accounted for 53.6% of all typed isolates. The IS6110-RFLP from the valid 109 *M. tuberculosis* isolates revealed 87 distinct patterns, with 5 to 21 bands each (median, 10 bands). Cluster analysis revealed that 35 (32.1%) of the isolates belonged to 13 distinct clusters (2 to 6 isolates per cluster; Figure).

Demographic variables and clinical characteristics of AIDS and TB were not associated with clustering (Table). On the other hand, hospital visits proved to be a risk factor for clustering in our analysis (*P* = .039). Among case-patients with infectious pulmonary TB, previous AIDS diagnosis was associated with clustering (*P* = .009). Epidemiologic links were identified in 11 (31.4%) of 35 clustered case-patients. For 6 case-patients, exposure to *M.*

TABLE

RISK FACTORS AMONG CLUSTERED AND NONCLUSTERED PATIENTS WITH CO-INFECTION WITH TUBERCULOSIS AND HUMAN IMMUNODEFICIENCY VIRUS

Risk Factor	Clustered (n = 35)	Nonclustered (n = 74)	<i>P</i>	OR (CI ₉₅)
Male	24 (68.6%)	57 (77.0%)	.479	1.54 (0.57–4.16)
Median age, y	34	33	.388	-
Pulmonary involvement	29 (82.9%)	61 (82.4%)	.829	1.03 (0.32–3.41)
Sputum positive for AFB	6 (17.1%)	27 (36.5%)	.067	0.36 (0.12–1.07)
Previous TB treatment	5 (14.3%)	9 (12.2%)	.765	1.20 (0.32–4.40)
Illicit drug use	9 (25.7%)	34 (45.9%)	.070	0.41 (0.15–1.07)
Previous AIDS-defining illnesses	19 (54.3%)	30 (40.5%)	.254	1.74 (0.71–4.28)
Previous AIDS-defining illnesses and AFB-positive sample	5 (14.3%)	6 (8.1%)	.009	17.5 (1.39–94.56)
Median CD4+ count (cells/mm ³)	57	81	.659	-
Previous follow-up at HC-UNICAMP	26 (74.3%)	38 (51.3%)	.039	2.74 (1.05–7.31)
Visit to the HIV day care unit	7 (20.0%)	10 (13.5%)	.556	1.60 (0.48–5.24)
Previous hospitalization	11 (31.4%)	17 (23.0%)	.479	1.54 (0.57–4.16)
Previous institutionalization*	4 (11.4%)	22 (29.7%)	.182	0.38 (0.09–1.44)

OR = odds ratio; CI₉₅ = 95% confidence interval; AFB = acid-fast bacilli; TB = tuberculosis; AIDS = acquired immunodeficiency syndrome; HC-UNICAMP = Universidade Estadual de Campinas; HIV = human immunodeficiency virus.

*Data were not available for the clustered and nonclustered group, respectively: 15 and 19.

tuberculosis had probably occurred in their household (3 clusters of 2 case-patients each). Nosocomial transmission was possible for the other 5 individuals: 3 case-patients had received long-term follow-up care at the same HIV outpatient clinic and 2 had concurrent visits to the HIV day care unit.

DISCUSSION

The cluster rate observed in this study (32.1%) supports the hypothesis of recently transmitted TB among HIV-infected patients.⁵ In the United States, hospital-based studies among HIV and non-HIV patients have found higher cluster rates, between 43% and 54%.^{6,8} In Brazil, previous studies performed in two metropolitan areas showed clustering rates of 38% among HIV-infected patients seeking care at an outpatient care facility in São Paulo and 19% among hospitalized patients in Rio de Janeiro.^{9,10}

Several risk factors for clustering observed in other studies, such as illicit drug use and institutionalization in correctional and residential facilities, were not related to clustering in our study population. It is possible that this finding is related to characteristics of the study group. Our study also demonstrated that follow-up at the hospital was associated with clustering. We speculate that this may be an indirect indicator of nosocomial exposure to infectious TB patients as a result of inadequate adherence to the recommended airborne precautions.

Epidemiologic links could be demonstrated in 11 (31.4%) of 35 case-patients in this study. As shown by other authors, there was a poor association between conventional contact tracing and molecular methods.^{7,10} Our data reinforce the need for more extensive contact tracing and more detailed prospective evaluation. Some authors have suggested that this poor association may be related to undetectable exposure circumstances, such as those occurring in waiting rooms or other public areas.⁷

In the current study, retrospective epidemiologic investigation detected five TB cases probably acquired within the confines of the hospital. Although no association between delayed adoption of airborne precautions and clustering was demonstrated, this delay was frequently reported among recently admitted patients with infectious pulmonary TB. These data reinforce the need for continued education to encourage adherence to airborne precautions.

Drug susceptibility tests were not systematically performed in the current study, preventing comparisons among groups. In previous studies, multidrug resistance was associated with recent TB transmission and outbreaks.^{1,2} In Brazil, prospective population-based studies are needed to better characterize the risk factors for TB transmission in HIV and non-HIV patients, with special focus on multidrug resistance.

Nosocomial transmission of TB probably occurs in developing countries and is likely underestimated. Our results suggest that hospital infection control precautions, in addition to community TB control programs, are

needed to prevent TB transmission in HIV-infected patients.

Drs. Resende and de C. Ramos are from Disciplina de Moléstias Infecciosas, Departamento de Clínica Médica, and Dr. Villares is from Divisão de Microbiologia, Departamento de Patologia Clínica, Faculdade de Ciências Médicas, Universidade Estadual de Campinas, UNICAMP, Campinas, São Paulo, Brasil.

Address reprint requests to Mariângela R. Resende, Joaquim Novaes 53/102, Campinas, SP, Brazil, 13015140.

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Booster Effect of Two-Step Tuberculin Skin Testing Among Hospital Employees From Areas With a High Prevalence of Tuberculosis

Abdulrahman M. Al Mazrou, MBBS, FRCPC

ABSTRACT

During a baseline survey of TST, 236 nurses underwent a two-step TST. Overall, 29 (12%) showed boosting. All age groups showed boosting; the rate was 9.7% in those younger than 35 years. Subjects older than 45 years were more likely to have a booster effect than younger individuals (29% vs 10.1%) (*Infect Control Hosp Epidemiol* 2004;25:1117-1120).

TABLE 1
CHARACTERISTICS OF THE SUBJECTS PARTICIPATING IN TWO-STEP TESTING (N = 236)

Characteristic	
Age, y	
Mean	40.8
Range	25 to 56
Female:male ratio	12:1
Country of origin (TB prevalence per 100,000 population)	
Philippines (297)	163 (69%)
India (178)	50 (21%)
Ghana (201)	6 (2.5%)
United Kingdom (12)	5 (2.1%)
Pakistan (171)	3 (1.3%)
Other	9 (3.8%)
BCG scar	
Present	177 (75%)
Absent	53 (22.5%)
Unknown	6 (2.5%)
Work area	
Inpatient	179 (75.8%)
Outpatient	46 (19.5%)
Administration	11 (4.7%)
First PPD	
0 to < 5 mm	198 (84%)
5 to < 10 mm	38 (16%)

TB = tuberculosis; BCG = bacille Calmette-Guérin; PPD = purified protein derivative.

The recent resurgence of tuberculosis (TB) and the increased risk of nosocomial TB have made TB control in healthcare facilities a priority.^{1,2} Periodic tuberculin skin testing (TST) of high-risk healthcare workers (HCWs) has been recommended to discover recent converters and to institute appropriate measures.¹ Baseline two-step TST has been advocated to identify individuals with latent infection who otherwise would be classified on their next test as recent converters.^{1,3,4}

Two-step TST involves administering a second test to those individuals whose initial test yields negative results prior to finalizing their status. Individuals whose delayed hypersensitivity to tuberculin may have waned over the years would show an enhanced (booster) reaction to the second test due to an anamnestic response stimulated by the first test. Without a two-step TST, such individuals may be misclassified as recent converters if tested later.^{3,8}

The booster phenomenon has been described in individuals with latent TB infection as well as in those with previous exposure to other mycobacteria or bacille Calmette-Guérin (BCG) vaccine.^{3,6,8-11}

In Saudi Arabia, most nursing staff in hospitals have come from areas with a high prevalence of TB (ie, > 100 per 100,000 population) and most have previously

received BCG vaccine. In 1998, a program of baseline TST for HCWs was initiated at King Khalid University Hospital in Riyadh. We used its results to study the utility of two-step TST in this setting, the factors associated with the booster phenomenon, and whether a two-step TST was useful for employees younger than 35 years.

METHODS

The study was conducted at King Khalid University Hospital in Riyadh, Saudi Arabia. This is a tertiary-care center with 660 beds. Approximately 25 smear-positive patients with TB are seen at the hospital annually. As part of the enhancement of the TB control program at the hospital, a baseline TST of all nurses was initiated in 1998.

Nurses whose TST had been documented to have yielded positive results previously were excluded from testing. The initial TST was applied using 5 IU in 0.1 mL of commercially prepared (Biocine Test-PPD, Chiron Vaccines, Oxford, United Kingdom) purified protein derivative (PPD) injected intradermally. All TSTs were applied by two infection control nurses who had received training in proper injection techniques. Reading was by experienced staff at the employee health clinic after 48 to 72 hours. Nurses whose initial test yielded negative results were scheduled for a second test 1 to 3 weeks later. The dose, administration, and reading were identical to those of the first test.

A positive result on the initial test was defined as an induration of 10 mm or greater in the transverse diameter using the palpation method. A positive result on the second test was defined as an increase of at least 6 mm of induration from a negative result on the first test (< 10 mm) to a total induration of 10 mm or greater.^{4,7,9-14} Data collected included age, gender, nationality, work area, and previous PPD testing. BCG status was determined by the presence or absence of a BCG scar. The data were analyzed using StatPac Gold (Walonick Associates, Inc., Minneapolis, MN), a statistical analysis package. Chi-square was used to compare proportions and Student's *t* test was used to compare means. A *P* value of less than .05 was considered significant.

RESULTS

Three hundred sixty-seven nurses whose PPD status prior to employment was either negative or unknown were tested initially. One hundred twenty-eight (35%) were found to have positive results (≥ 10 mm) and were excluded from further testing. Of the remaining 239 subjects, 3 failed to complete the two tests and were excluded. The characteristics of the remaining 236 subjects who completed the two-step testing are listed in Table 1. A BCG scar was present in 177 subjects (75%). The size of the first PPD reaction was 4 mm or less in 198 (84%) of the subjects.

The mean age of the subjects was 41 ± 5.2 years; 15% were 35 years or younger. Twenty-nine (12%) of the subjects fulfilled the definition of a booster reaction. The median increase in the size of the boosted TST was 11 mm and the mean was 12.6 ± 3.7 mm.

The mean age as well as the median age of those who boosted was 42 years (range, 30 to 55 years). The rate of boosting in relation to age is detailed in Table 2. Subjects older than 45 years were threefold more likely to boost than were younger individuals (29% vs 10.1%; $P = .008$). Those with an initial PPD induration of 5 to 9 mm were twice as likely as those with a reaction size of less than 5 mm to show a booster effect (21% vs 10.6%; $P > .05$). There was no difference between those with a BCG scar and those without in terms of the rate of boosting (11.9% vs 13.2%) or the mean increase in the size of induration (12.7 vs 12.6 mm).

DISCUSSION

The rate of boosting in two-step TST varies widely between different studies, ranging from 0% to 31%.^{4-7,9-19} Studies involving HCWs have reported rates of boosting ranging from 0% to 10%.^{4-7,14,17,18} Studies involving residents of chronic care facilities reported boosting rates ranging between 6% and 19.2%.^{12,13,15-17} Studies involving university students in Canada and in Chile reported boosting rates between 5.2% and 19.6%.⁹⁻¹¹

The variation in the rate of boosting among the different studies reflects differences in the populations studied regarding age, BCG vaccination status, and previous exposure to *Mycobacterium tuberculosis* or environmental mycobacteria. The boosting rate reported in this study (12%) is higher than that of some of the studies of hospital employees^{4-7,14,17,18}; however, it is similar to the rates reported by Simon et al. (13%)¹⁵ and Welty et al. (11.3%).¹⁶ The difference may be explained by the higher mean age of our study population (41 ± 5.2 years) compared with some of the studies of HCWs.^{7,14,18}

The boosting rate in staff older than 45 years was almost threefold higher than that in the younger age groups (Table 2). Previous studies have documented a relationship between boosting and increasing age.^{4,5,10,15} Some investigators have recommended restricting two-step TST to HCWs older than 35 years.^{4,17} Our findings do not support this recommendation as the rate of boosting in those younger than 35 years was substantial (Table 2).

The fact that most of our study population came from countries with a high prevalence of TB also contributed to the high boosting rate. Similar findings were noted by other investigators.^{9,18,19} Two studies involving university students and young adults in Quebec, Canada, found the two-step boosting rate to be 5.2% and 16% in the Canadian-born and foreign-born young adults, respectively.^{9,10}

The positive results on second tests in this study probably did not reflect recent nosocomial TB infections because there was no clustering in any specific work area and the rate of boosting in the areas where patients with TB were housed was similar to that in other areas.

BCG vaccination was found by other investigators to be associated with an increasing rate of boosting.^{8-11,17,18} In this study, no difference was found in the boosting rate

TABLE 2
RATE OF BOOSTING ACCORDING TO AGE GROUP*

Age Group (y)	Total No.	No. Boosted (%)
25 to 34	31	3 (9.7)
35 to 40	75	9 (12)
41 to 45	91	8 (8.8)
> 45	31	9 (29)

*Chi-square, 8.989; $P = .029$.

between vaccinated and unvaccinated subjects. The lack of BCG effect in our study population could be related to the fact that most of our subjects came from countries with a high prevalence of TB. A previous study found that the augmenting effect of BCG vaccination on the booster effects was greater in subjects originating from countries with a low prevalence of TB than in those originating from countries with a higher prevalence.⁹

The size of the initial PPD induration was found to have an important effect on boosting.^{10,13,15,16} The proportion of positive booster reactions increased with a larger size of the initial reaction. Menzies et al. reported a frequency of boosting of 3.7%, 17.1%, and 28.4% in those whose initial reactions measured 0 mm, 1 to 4 mm, and 5 to 9 mm, respectively.¹⁰ Alvarez et al. found the boosting rate to be 12.7% and 35.5% in those with an initial reaction measuring 0 to 4 mm and 5 to 9 mm, respectively.¹³ In our study, individuals with an initial reaction of 5 to 9 mm were twice as likely to show a booster effect compared with those with a reaction of 0 to 4 mm. The difference, however, was not statistically significant.

Dr. Al Mazrou is from the College of Medicine, King Saud University, Riyadh, Saudi Arabia.

Address reprint requests to Abdulrahman M. Al Mazrou, MBBS, FRCPC, College of Medicine, King Saud University, P.O. Box 2925, Riyadh 11461, Saudi Arabia.

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Medical News

EDITED BY GINA PUGLIESE, RN, MS; MARTIN S. FAVERO, PhD

Hygiene in Endoscopy: Data on the Quality of Reprocessing Flexible Endoscopes and Endoscopic Accessories in Hospitals and Private Practices

Guidelines for reprocessing flexible endoscopes have been published in many countries. Compliance with the German guidelines, published in 2002 by the Commission on Hospital Hygiene and Infection Prevention of the Robert Koch Institute, is mandatory in all endoscopic units, in hospitals as well as in private practices. Heudorf et al. conducted a survey of current reprocessing practices in an urban region in Germany that covered all hospitals and private practices in this region. In the summer of 2003, all endoscopic units in Frankfurt/Main, Germany—15 hospitals and 23 private practices—were visited by members of the public health service, using a checklist based on the recommendations of the German guidelines. In these institutions, more than 70,000 endoscopic examinations are performed per year. Eighty-seven percent (13 of 15) of the hospitals and 43% (10 of 23) of the private practices reported that they conducted more than 1,000 procedures per year. Great differences were found in hygienic quality on comparing endoscopic units in hospitals with those in private practices. In hospitals, compliance with the guidelines was satisfactory. Main problems in the practices were lack

of facilities for ultrasonic cleaning (74%) and sterilization (43%), faults in reprocessing the bottle and tube for air/water-channel flushing (26%) that used non-sterile water (48%), storage of the endoscope where there was a risk of recontamination (48%), and omitting routine tests of the endoscopes after reprocessing (44%). Generally, hygienic conditions and procedures were worse in small units than in bigger ones.

The data from Frankfurt hospitals were satisfactory. In private practices, however, especially in smaller ones, improvements are needed. Improvements should cover the quality of structure and process (ie, specific education of the nurses and availability of ultrasonic cleaners and sterilizers and, preferably, automatic dishwashers) as well as implementation of a written protocol for hygiene in endoscopy, based on the German guidelines.

FROM: Heudorf U, Hofmann H, Kutzke G, Otto U, Exner M. Hygiene in endoscopy: data on the quality of reprocessing flexible endoscopes and endoscopic accessories in hospitals and private practices, 2003. *Z Gastroenterol* 2004;42:669-676.