Original Article

An Outbreak of SARS in a Diabetes Room of a General Hospital without Infected Medical Staff

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Objective To investigate the epidemiologic features of an outbreak of SARS that occurred in a single diabetes room of a general hospital in Beijing in late March 2003.

Methods Field investigation was carried out in the ward, the nursing log and the hospitalization medical record of correlative patients were consulted. SARS-CoV in serum specimen from SARS patient was detected by PCR.

Results The room where SARS outbreak occurred was on the 13th floor of the 16-story main ward building. There were 6 beds in the room, living with 6 female patients (aged 45-67) who were all hospitalized due to type 2 diabetes. On March 24, 2003, Patient 1 began to have a fever and cough, chest X-ray showed pneumonia. Five and six days later, Patient 2 and Patient 3 began to have a fever, respectively. Finally, all of these 3 patients died. Their beds were all at the same side of the room, and the other 3 patients at the opposite side were not infected. Serum SARS CoV-RNA of the Patient 3 was positive by nest-PCR. The daughter-in-law of Patient 1 who accompanied Patient 1 by the bedside several days, mainly near the window, upwind of Patient 1, was not infected. Medical staff, family members and visitors of the 6 patients were not infected.

Conclusions This outbreak was not transmitted by aerosol. The distance droplets travels could be up to 3.43 meters. Droplet spread has direction, and the droplets direction of propagation is closely related with the wind direction and speed. Those at the downwind position of SARS patients were susceptible to be infected. Medical staff wore face masks and good natural ventilation of this ward building may be important reasons for the prevention of infection.

Key words: SARS; Outbreak; Nosocomial; Disease Transmission; Droplet

Severe acute respiratory syndrome (SARS) has high mortality rate and rapid transmission, and a striking feature is the high rate of medical staff infection. In this article, an nosocomial outbreak of SARS without medical staff infection was reported, which occurred in late March 2003 in Beijing. The investigation of this characteristic nosocomial outbreak of SARS may have some reference significance for the prevention and control of transmission of other respiratory infectious diseases.

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MATERIALS AND METHODS

The basic situation

This general hospital is located in the western part of Beijing, the main building has 16 floors, patients can arrive at floor 13 by taking 5 public elevators. One portion of the floor 13 is situated in the inpatient department of endocrinology. There are 9 hospital rooms and a total of 34 beds. Room A with 6 beds was the place where an outbreak of SARS had occurred and it is located at the end of the ward (Figures 1, 2).

Epidemic process

Index patient (Patient 1) began to have fever and cough in the morning of March 24, 2003 (32 days after admission), peak temperature was 39.3°C, the X-ray for her showed pneumonia on the same day, one day later, the chest CT showed: pneumonia in the right lower lobe, right upper lobe and left lingular.

On March 28, she moved to a single room, on March 29 she was admitted to the SARS observation ward of our hospital for suspected SARS case. On March 31, she was transferred to SARS hospital in Beijing. Patient 1 had gone back home several times by riding public transportation for seasonal clothing during hospital stay, and her home is about 3 km away from the hospital. She denied that she had been exposed closely to severe cough person.

Patient 2 was discharged from hospital on March 28, then had fever on March 29, diagnosed as pneumonia by X-ray in hospital outpatient department on March 30, and was admitted to another SARS hospital in Beijing on the same day for probable SARS case. Patient 3 had fever on March 30, and was transferred to the SARS observation ward of our hospital on March 31. All of the three patients (patients 1, 2 and 3) finally died.

Figure 1. Room A where the outbreak of SARS occurred.

Notes: All 6 patients were female with diabetes mellitus. The index patient was on bed 1. Three patients (Patients 1, 2 and 3) were all infected and died. Three patients (Patients 4, 5 and 6) were not found ill. The daughter-in-law of Patient 1 was not infected, who accompanied Patient 1 by the bedside several days. The distance between bed 1 and bed 3 is 3.43 meters.

Figure 2. The ward plan of endocrinology department on the 13th floor.

Notes: The doctor's office and nursing station are separated from hospital rooms, and are relatively far away from room A. The doors of room a, b, c and d are closed all the year round. The door of room A is diagonally opposite to the cleaning room whose window is opened all year round, which keeps room A good air convection.

Table1. The comparison of diabetes severity between SARS group and comparison group

Variable	SARS group				Comparison group			
Case (bed) number	1*	2	3	Average	4	5	6	Average
Age (years old)	60	62	46	56	49	67	47	53.7
The history of diabetes (years)	6	12	0.1	6	8	27	17	17.3
Complications	Coronary heart disease	+	+					
	Nephropathy						+	
	Maculopathy				+		+	
	Peripheral neuropathy		+				+	
	Foot gangrene					+		
	The total number			3				5
Date of onset of SARS (in 2003)	24/3	29/3	30/3					
SARS CoV RNA (serum) §			+					
Incubation period (days)		5	6					
Exposure time (days) †		4	4		3	4	4	

Notes: * Index patient; § Only the blood sample of Patient 3 was reserved; † Patient 1 moved to a single room on March 28. Patient 4 discharged on March 27.

Investigation methods

Scene investigation in the ward was carried out. Patients' information was acquired by consulting the hospitalization medical records and physician in charge of these patients. The nursing log was consulted. SARS CoV RNA was detected in serum specimens from SARS patients by PCR.

SARS case definition and exclusion criteria

According to the guidelines issued by the WHO "Case Definitions for Surveillance of Severe Acute Respiratory Syndrome (SARS)".¹

RESULTS

Related patient's medical information: nursing log records were consistent with physician medical records

On March 24, 2003, when Patient 1 (index patient) began to have fever, the ward had a total of 34 patients, 33 were diabetes patients.

Pathogen detection

Only the blood sample of Patient 3 was reserved (taken on April 7, 2003, the day of her death), the SARS-CoV RNA was positive by nest-PCR on May 3, 2003.

Epidemiology

Basic situation and ventilation of room A

The height is 3.35 meters, area is 44.6 m², and volume is 165.4 m³. There are 2 large windows facing west which are mainly used for natural light and are only partly opened on both sides, the maximum ventilation range of each side is 1.15 m×0.15 m (area 0.69 m²). In 2003, hundreds of meters in front of the windows had no high-rise buildings blocking wind. Both the doctor's office and nursing station are separated from hospital rooms, and are relatively far away from room A. The doors of room a, b, c and d are closed all the year round. But the door of room A is opposite to the cleaning room whose window is opened all year round, which keeps room A good air convection. The distance between bed 1 and bed 3 is 3.43 meters (Figure 1 and Figure 2).

Comparison of SARS patients and uninfected patients

There is only one different factor, that is, 3 SARS infected patients lived at the southern side of room A, 3 uninfected patients all lived at the northern side of the room (Figure 1). There were 6 female patients with diabetes mellitus in room A at that time, aged 45-67 years. There were no differences between SARS infected patients and uninfected patients in age, history length of diabetes mellitus and number

of complications (Table 1). All 3 uninfected patients (Patient 4, Patient 5 and Patient 6) had ever returned to the department of endocrinology for treatment of diabetes once again.

Medical staff of endocrinology department, family members of 6 patients of room A including those patients' accompanied relatives in the hospital and visitors, were all not infected

The daughter-in-law of Patient 1 was not infected with SARS, who had accompanied Patient 1 by the bedside mainly near the window ever since Patient 1 began to have a fever. She was not wearing face mask during the first 1-2 days, then wore face masks of 16-layer cotton. On March 28, when her mother-in-law was considered as suspected SARS, she wore the same cotton protective clothing as medical staff.

Nosocomial pneumonia is very rare in patients with diabetes mellitus

In 3 years from January 1, 2004 to December 31, 2006, only 2 diabetic patients had nosocomial pneumonia in department of endocrinology. Both of them had diabetes mellitus complicated with severe foot gangrene, and one had pneumonia in the late stage of multiple organ failure.

Prevention and control measures

Isolation of patients

Patient 1 was moved to the another room to be isolated on March 28, 2003, and she was admitted to the SARS observation ward of our hospital the next day. Patient 2 was admitted to another SARS hospital immediately, the next day of her fever onset, when she was diagnosed as pneumonia by X-ray. Patient 3 moved to a single room on the same day of fever onset, and transferred out of department of endocrinology the next day.

Protection of medical staff

From March 24 to 28, the nurses in the department of endocrinology operated routinely wearing face masks of 16-layer cotton. After March 28, medical staff entered isolated room of patients with fever must wear protective clothing (cotton) and disposable gloves.

DISCUSSION

In late March 2003, Beijing, there were 3 inpatients who had a fever within 6 days and all of them were diagnosed as pneumonia by X-ray in a 6-bed diabetes room of a general hospital, SARS-CoV of one patient

was positive by PCR. This could be confirmed as an nosocomial outbreak of SARS. The outbreak occurred in hospitalized patients, therefore, the information was accurate and reliable. SARS is an emerging infectious disease, this outbreak in March, 2003 occurred somewhat by chance and then almost irresistibly. Based on published literature, this outbreak has the lowest amount of infected cases of nosocomial outbreak of SARS and the only one without medical staff infection.

This outbreak had four striking features.

(1) Three SARS patients lived at the same side of room A, and 3 uninfected patients all lived at the other side of the room, which strongly suggested that this outbreak was not transmitted by aerosol.

(2) The index SARS patient's (Patient 1) bed was near the window, the daughter-in-law of Patient 1 who had accompanied Patient 1 by the bedside several days ever since Patient 1 began to have a fever, was not get infected with SARS. Her position was by the bedside, mainly near the window, upwind of Patient 1, while the infected Patient 2 and Patient 3 were downwind of Patient 1. Those strongly suggested that droplet transmission has direction, the direction of droplets transmission was closely related with wind direction and speed at the time when patient coughs, sneezes, talks or deep breathing. It's the first time that the evidence that droplet transmission has direction was discovered.

The maximum distance for droplet transmission is currently unresolved.² Historically, the area of defined risk has been a distance of < 3 feet around the patient and is based on epidemiologic and simulated studies of selected infections.²⁻⁴ A simple physical model was developed and used to investigate the evaporation and movement of droplets expelled during respiratory activities, and it's suggested that droplets could reach more than 2 m away at a velocity of 10 m/s (coughing).⁵

In this outbreak, the straight line distance between bed 1 and bed 3 was 3.43 meters, which was far more than 1 meter of defined historical records and 2 meters of farthest records. Spring wind in Beijing is strong and the position of room A is high in the ward building, which clearly suggested that with the help of wind, infectious droplets can result in long distance transmission, the distance of droplets transmission is closely related to wind speed at the time when an infected patient coughs, sneezes, talks or deep breathing.

(3) Three diabetic patients infected with SARS were all died in this outbreak. And all 3 died patients of the first 10 SARS cases in Canada had diabetes.⁶ Of 17 SARS deaths cases of a community hospital in Canada, 6(35.3%) were diabetes mellitus.⁷ But only 2 of diabetic patients in 3 years had nosocomial pneumonia in department of endocrinology, so hospital diabetes patients are not susceptible persons of pulmonary infection, which suggested that diabetic patients infected with SARS was more serious and the mortality rate was high.

(4) No medical staff was infected in this SARS outbreak. The only protective measures the medical staff in department of endocrinology had taken at early stage was only 16 layers cotton gauze mask. Seto et al did a case-control study in five Hong Kong hospitals, 241 non-infected staff and 13 staff infected with SARS were enrolled, the results showed that masks have protective effects.⁸ In late March 2003, medical staff in Beijing generally had a vigilance to SARS, and mask protection was commonly used during their routine work. The most severe period of fighting SARS in Beijing was April, 2003, 16 medical staff (physicians and nurses) worked in SARS observation ward of our hospital, the only protective measures were 16 layers cotton gauze masks, cotton protective clothing and disposable gloves, there's no people infected with SARS. Cotton gauze masks is effective for SARS protection.

Countries and regions that had been reported with SARS nosocomial outbreak included: Hong Kong, Singapore, Canada, Taiwan, Vietnam, Guangzhou, Tianjin and other places,^{7,9-14} all with a large number of medical staff infection. For example, in Hong Kong Prince Wales Hospital, there were total of 138 cases of suspected SARS patients, 69 of whom were medical staff (50%).⁹ In Singapore General Hospital, among 51 person infected with SARS, 24 were medical staff (47%).¹⁰ In a hospital in Toronto, Canada, 128 cases were considered as suspected SARS, 47 of whom were medical staff (36.7%).⁷ In a hospital in Guangzhou, total of 96 suspected SARS cases, 90 of whom were medical staff (93%).¹³

Of those articles concerning nosocomial outbreaks of SARS, 3 articles had illustrated the ventilation of hospital ward. In one hospital in Guangzhou,¹³ the SARS infection rate of medical staff was proportional to the ratios of the area of the ventilation windows to the volume of the rooms. Hong Kong Prince Welsh Hospital is central air conditioning ventilation.⁹

In Vietnam, in hospital A where SARS outbreak occurred, the rooms were small and individual air-conditioning units were used. However, in hospital B where no transmission occurred, there're large spacious rooms with high ceilings and ceiling fans and large windows kept open.¹²

In summary, good natural ventilation may be an important reason for the prevention of infection. It is suggested that natural ventilation is better than air conditioning ventilation in hospital ward.

This investigation has two limitations.

(1) The index SARS patient (Patient 1) had been in hospital for a long time, therefore, in the early stage of her fever onset, it was not considered she was infected with SARS. During less than 3 days after her illness aggravated, Patient 1 had been transferred for 3 times: single room, another ward of same hospital and another hospital, and soon she died. We had no enough time to understand the details on her way home during hospitalization, therefore we were unable to determine the precise route and the source of SARS infection.

(2) There has been built a new building about 100 meters in front of the windows of room A, so it's impossible to know the wind speed through the window, that is to say, at which wind speed could the droplets travel 3.43 meters.

Our findings of this investigation showed: 1. This outbreak was not transmitted by aerosol. 2. It's the first time that the evidence that droplet transmission has direction was discovered, and the direction of droplets transmission was closely related with wind direction and speed at the time when an infected patient coughs, sneezes, talks or deep breathing. People would be susceptible to be infected when at the downwind position of SARS patients. The evidence showed that the distance of droplets transmission could be up to 3.43 meters, this is the farthest distance droplets can reach that have been proved so far. 3. In hospital, diabetes patients are not susceptible to pulmonary infection, but the condition of diabetic patients infected with SARS was usually aggravated and the mortality rate was high. 4. Medical staff wore face masks and good natural ventilation of this ward building may be the important reasons for the prevention of infection.

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