Severe acute respiratory syndrome and critical care medicine: The Toronto experience

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Background: **The 2003 global outbreak of severe acute respiratory syndrome (SARS) provided numerous challenges to the delivery of critical care. The Toronto critical care community has learned important lessons from SARS, which will help in preparation for future disease outbreaks.**

Objectives: **The objectives of this study were to review the epidemiology and clinical characteristics of the Toronto SARS outbreak, the challenges SARS provided to the delivery of critical care, and how we would like to be better organized for a similar challenge in the future.**

Findings: **SARS manifests clinically as atypical pneumonia and ranges in severity from minor nonspecific symptoms to adult respiratory distress syndrome (ARDS). Approximately 20% of patients with SARS will become critically ill and require admission to the intensive care unit. ARDS develops in the majority of these patients. Mortality from ARDS in SARS is high, and outcome is associated with the presence of comorbid disease and the severity of illness at presentation. The influx of critically ill patients and the transmission of SARS to front line workers created a tremendous strain on Toronto's healthcare system. From a critical care perspective, the most important limitation in the response to SARS was the absence of a coordinated leadership and communication infrastructure. Other challenges encountered during SARS include the following: closure of intensive care unit beds and loss of staff through quarantine and illness, implementing novel infection control protocols, educating staff, conducting research to learn about SARS, system planning, and maintaining staff morale during this very difficult period.**

Conclusions: **Communication and leadership strategies were key components in the critical care response to SARS. Ideally, centers should have systems in place to allow for the rapid expansion and modification of critical care services in the event of a disease outbreak. Other critical care communities should consider their crisis response strategies in advance of similar events. (Crit Care Med 2005; 33[Suppl.]:S53–S60)**

Key Words: severe acute respiratory syndrome; critical care; respiratory infection; disease outbreak; disaster planning

The global outbreak of severe acute respiratory syndrome (SARS) originated in November 2002 in Guangdong province, China. Between February and June 2003, over 8,000 probable cases and 774 deaths were reported in 29 countries around the world (1). Coordinated efforts by several international laboratories identified a novel coronavirus as the etiologic agent of SARS (2–4). This virus is closely related to a coronavirus subsequently isolated in small mammals from a live animal market in Guangdong Province. Although the natural reservoir of the SARS coronavirus is not known, it is thought to have recently crossed from animals to humans (5). The last reported case of the 2003 outbreak was in Taiwan on June 15 (6). Since then, there have been two cases of SARS in Asia associated with medical research laboratories and a handful of cases in Southern China thought to be associated with wild animal markets (7–9).

SARS manifests clinically as atypical pneumonia and ranges in severity from minor nonspecific symptoms to fatal respiratory failure. Suspect cases are those individuals with fever, respiratory symptoms, and exposure to SARS (through close contact, travel, or living in an endemic area). Probable cases are suspects with radiographic evidence of pneumonia or the confirmed presence of SARS coronavirus (10). The purpose of this report is to review the epidemiology and clinical characteristics of the Toronto SARS outbreak. Emphasis is placed on challenges to the delivery of critical care in the midst of a disease outbreak. In addition, we discuss how the critical care community came together against this illness and how we would like to be better organized for a similar challenge in the future. We hope this information will help others in preparing to organize their hospitals or health systems for similar challenges.

The Toronto Outbreak

The Toronto outbreak followed a biphasic course with new cases occurring between March 5 and June 12, 2003. A total of 375 probable and suspect cases of SARS were reported in the province of Ontario, of which 44 died (11). The vast majority of these cases were contracted in Toronto hospitals by patients, visitors, and healthcare workers (HCWs) (12). Hospital-based transmission of SARS led to: the need to rapidly develop aggressive infection control guidelines, fear and anxiety in HCWs, loss of HCWs to quarantine or illness, and subsequently enormous challenges delivering health care to patients with SARS as well as patients without SARS. As a result, this unexpected outbreak pushed Toronto's healthcare system to its limits. For example, several hospitals were closed for periods of quarantine, including several intensive care units (ICUs). Elective clinics and

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surgeries were canceled in Toronto for extended periods. SARS also had significant repercussions on Toronto's economy and the daily life of its people. In addition, in an effort to control the outbreak, public health officials placed many thousands of individuals into extended quarantine.

The index case of SARS in Canada was an elderly woman who returned to Toronto from Hong Kong on February 23, 2003. She had stayed at a hotel in Kowloon, which was later identified as being the focus on a cluster of SARS cases (13). She subsequently developed symptoms of SARS and died at home on March 5, 2003. Several family members also developed symptoms of SARS, and one of them presented to the emergency department of a local community hospital, which became the epicenter of the Toronto SARS outbreak.

Nosocomial Transmission of SARS

Most experts believe SARS is transmitted through contact with respiratory droplets. Reported median incubation periods range from 4 to 6 days (14–16). Recent work indicates that the virus may survive for several hours on fomites or in body secretions (17). Accordingly, it is possible that transmission may occur indirectly after contact with contaminated objects. To date, there is no conclusive evidence of airborne transmission. However, existing literature suggests that in specific circumstances, other coronaviruses may spread by an airborne route (18). The vast majority of SARS transmission in Toronto occurred in the hospital setting or in households among affected family members. Four hospitals had major nosocomial outbreaks of SARS. Three of these outbreaks occurred in ICUs. With potentially higher viral loads in critically ill patients, and the performance of high-risk procedures (i.e., endotracheal intubation), HCWs in the ICU are at high risk of contracting SARS. Accordingly, the handling of patients with SARS and the protection of front line workers is of paramount importance in the critical care setting.

The community hospital that cared for the son of the index patient was the site of Toronto's largest nosocomial outbreak of SARS (14). This patient presented to the emergency department with respiratory symptoms and was eventually admitted to a medical ward. Within 18 hrs of presentation, he was admitted to the ICU and 3 hrs later was placed in an isolation room. This 21-hr period of unprotected contact occurred before the initial March 12 World Health Organization advisory of an outbreak of atypical pneumonia (later named SARS) (19). Within 24 hrs of this advisory, airborne, contact, and droplet precautions were implemented at the hospital. In total, 128 cases of SARS resulted from transmission of the virus within this hospital (42% HCWs, 28% patients or visitors, and 30% household contacts) (14). During this time, two patients, not recognized as having have SARS, were transferred to ICUs at other institutions because the hospital experiencing the outbreak was unable to cope with the influx of activity and loss of staff. These transfers led to further nosocomial outbreaks in the Toronto critical care community.

One of these patients was transferred to the ICU of a second community hospital (20). He was treated with noninvasive ventilation for 2 days and then mechanically ventilated for 11 days before the recognition of SARS exposure and implementation of respiratory isolation precautions. In addition to the patient's wife, 14 further cases of SARS resulted from transmission within this ICU (10 hospital staff and four patients). Mass voluntary quarantine of people exposed to the hospital included more than 5,000 people (20).

The second patient transferred from the original hospital was admitted to the ICU of a tertiary-care university hospital (15). Once again, the patient was managed before it was recognized that he had been exposed to SARS. He was initially administered high-flow oxygen by mask, followed by noninvasive ventilation, and ultimately mechanical ventilation. Within 24 hrs of arriving in the ICU, he was recognized to have been exposed to SARS and was transferred to a negative-pressure isolation unit at another hospital. The ICU was closed and 69 HCWs were quarantined. Seven of these individuals developed SARS, none of whom became critically ill. Retrospective analysis found the SARS attack rate was proportional to the amount of time spent in the patient's room. Three of the five individuals present in the room during intubation developed SARS, including one individual wearing a gown, gloves, and a N95 mask (15).

Toronto's third nosocomial outbreak in the critical care setting occurred in a university medical/surgical ICU during the intubation of a patient with SARS (21). Despite wearing gowns, gloves, goggles, and N95 masks, nine HCWs (who had been in the patient's room during the intubation) contracted the illness. Surprisingly, the only individual who did not contract SARS was the physician who actually performed the intubation (21, 22).

Infection control practices in Toronto hospitals changed dramatically during the SARS outbreak. All patients with suspected or probable SARS were placed in negative-pressure isolation rooms. HCWs wore gowns, gloves, N95 masks, and goggles for all patient contact. Despite these precautions, there were several instances of further nosocomial transmission of SARS.

Clinical Features, Therapy, and Outcome of SARS

As the world anxiously awaits another potential outbreak of SARS, it is important for the critical care community to understand how to recognize and best manage a patient with SARS. This is to not only ensure the patient's best outcome, but also to optimize protection of other patients and staff in the ICU. Currently, we find a detailed history to be the most effective tool in identifying potential patients with SARS. Questioning patients and/or family members about clusters of pneumonia, exposure to sick individuals, exposure to HCWs or healthcare facilities, and travel to countries experiencing an outbreak (or where a SARS reservoir may occur) are essential while a patient with symptoms consistent with SARS is in appropriate isolation.

The clinical presentation, therapy, and outcome of SARS have been reported by several groups. This review focuses on the findings from the largest reported cohorts in Toronto ($n = 144$) and Hong Kong ($n = 138$) (12, 16). As shown in Table 1 the common symptoms of SARS include fever, nonproductive cough, myalgia, dyspnea, and headache.

Other than fever, the physical examination is relatively nonspecific. Tachycardia, tachypnea, and inspiratory rales are seen in many patients. No patient in the Toronto or Hong Kong series presented with rash, purpura, or lymphadenopathy. (Unless otherwise noted, subsequent percentages expressed in parentheses reflect the Toronto and Hong Kong figures, respectively.) The nonspecific nature of the clinical presentation reemphasizes the need to do a detailed history.

Table 1. Clinical features of severe acute respiratory syndrome

Symptom	Toronto Cohort, % (n = 144) (12)	Hong Kong Cohort, % (n = 138) (16)
Reported fever	99	100
Nonproductive cough	69	57
Myalgia	49	61
Dyspnea	42	NA
Headache	35	56
Chills or rigors	28	73
Diarrhea	24	20
Nausea or vomiting	19	20
Productive cough	5	29
Dizziness	4	43
Rhinorrhea or coryza	2	23

NA, not available.

On admission to the hospital, most individuals have pulmonary infiltrates on chest radiograph, either unilateral (46% and 42%) or bilateral (29% and 36%). A substantial number of patients have normal chest radiographs on admission to the hospital (25% and 22%). Infiltrates are often peripheral and may be indistinguishable from other causes of bronchopneumonia (16, 23). Clinical deterioration or improvement is often accompanied by a corresponding worsening or resolution of radiographic infiltrate. It is important to note that in the Toronto series, 10% of patients never developed an infiltrate. In most individuals with a normal chest radiograph, computed tomography shows ground-glass opacities (16).

Typical laboratory features seen in both the Toronto and Hong Kong cohorts include lymphopenia (54% and 70%), elevated creatine kinase (54% and 32%), elevated lactate dehydrogenase (94% and 71%), and hypokalemia (43% and 25%). Hypomagnesemia and hypocalcemia were also common in the Toronto series (57% and 79%, respectively).

Standard management of patients with SARS included empiric broad-spectrum antibiotics (often including a respiratory fluoroquinolone) to treat pathogens associated with community-acquired pneumonia. The majority of patients both in Toronto (88%) and Hong Kong (100%) also received ribavirin. However, later in the SARS outbreak, *in vitro* evidence suggested ribavirin was not effective against the SARS coronavirus (24). A detailed analysis of ribavirin use in 110 patients with SARS in Toronto found a high incidence of hemolytic anemia (61%), hypocalcemia (57%), and hypomagnesemia (46%). Because of this significant toxicity, therapy was prematurely discontinued in 18% of individuals (12, 25). Corticosteroids (ranging from oral prednisone to pulse dosages of methylprednisolone) were commonly used in patients who deteriorated clinically or failed to show signs of improvement. With no randomized treatment trials, and the fact that almost all patients with SARS received antibiotics and ribavirin, it is not possible to make conclusions regarding the efficacy of these agents. Toward the end of the SARS outbreak, interferon was used with some success in small cohorts of patients (26). Other investigators have reported the agent to be efficacious *in vitro* against the SARS coronavirus (27).

Short-term outcomes of SARS have been reported by a variety of investigators. Comparison of mortality rates must be made with caution because of heterogeneity inpatient populations, differing case definitions of SARS, and varying lengths of patient follow up. Crude mortality from SARS has been reported from 4% to 10% (1, 12, 16, 28, 29). The incidence of critical illness was very consistent among reported cohorts. Admission to ICUs was required in 20% to 32% of hospitalized patients, and 14% to 25% of patients required mechanical ventilation. Predictors of poor outcome vary between studies (Table 2), although comorbid disease and increasing age appear to be important determinants of adverse outcome (12, 16, 28, 29).

Clinical Characteristics of SARS in the Intensive Care Unit

The clinical features and short-term outcomes of critically ill patients with SARS in Toronto and Singapore have been described in two recent publications (21, 30). Fowler and colleagues described a series of 38 patients with SARS admitted to ICUs within metropolitan Toronto (21). These patients comprised 19% of all patients with SARS admitted to the study's hospitals. Compared with the general SARS population in Toronto, those requiring ICU admission tended to be older (median age, 57 vs. 45 yrs) and were less likely to be HCWs (18% vs. 51%).

Lew and colleagues reported their findings in a cohort of 46 critically ill patients with SARS admitted to a single ICU in Singapore (30). As seen in Toronto, critically ill patients in Singapore were older (median age, 51 vs. 34 yrs) and less likely to be HCWs (22% vs. 50%) than noncritically ill patients.

As seen in Table 3, demographics, comorbid conditions, and severity of illness were similar between the two groups. (Unless otherwise noted, subsequent percentages expressed in parentheses reflect the Toronto and Singapore figures, respectively.) The course of disease followed a similar pattern in both groups; patients were admitted to the hospital a median of 5 days after symptom onset and admitted to the ICU on day 8 of symptoms. Reason for ICU admission was almost exclusively progressive and severe hypoxia. Most patients required mechanical ventilation (76% and 85%). Acute lung injury (ALI) or acute respiratory distress syndrome developed in 82% and 98% of the patients in the Toronto and Singapore cohorts, respectively. These observations about the development of respiratory failure are vitally important to critical care teams because the process of intubation and/or exposure to a patient in respiratory failure is dangerous. The experience shows that it is unlikely for patients to present to the hospital in respiratory failure. The vast majority of patients with SARS who progress to critical illness will do so over the course of several days. As a result, preparing the ICU, transferring the patient, and performing high-risk procedures (such as endotracheal intubation) can occur in an organized and controlled setting.

Common complications of critical illness were barotrauma (34% and 20%) and thromboembolic events (48% in Singapore). The high rate of thromboembolism seen in the Singapore cohort occurred despite routine use of prophylactic low-molecular-weight heparin. Most patients were treated with antibiotics (76% and 94%) and corticosteroids (79% and 70%). More patients in Toronto received ribavirin (87%) than in Singapore (39%).

Table 2. Studies of short-term outcomes in severe adult respiratory syndrome

Study	Crude Mortality, %	ICU Admission, %	Mechanical Ventilation, %	Outcome Assessed	Multivariate Predictors of Poor Outcome
Booth et al. (*n* = 144) (12)	6	20	14	Death or ICU	Diabetes, comorbid disease
Lee et al. (*n* = 138) (16)	4	23	14	Death or ICU	Advanced age, peak LDH, ANC on admission
Peiris et al. (*n* = 75) (28)	7	32	25	ARDS	Advanced age, chronic HBV infection
Tsang et al. (*n* = 218) (29)	10	24	20	Death	RT-PCR NPA, dyspnea at admission, comorbid disease, pulse methylprednisolone

ICU, intensive care unit; LDH, lactate dehydrogenase; ANC, absolute neutrophil count; ARDS, adult respiratory distress syndrome; HBV, hepatitis B virus; RT-PCR NPA, reverse transcriptase-polymerase chain reaction of nasopharyngeal aspirate.

Table 3. Clinical features of severe adult respiratory syndrome in the critically ill[a]

	Fowler et al. (*n* = 38) (21)	Lew et al. (*n* = 46) (31)
Demographics		
Median age, yrs	57	51
Healthcare workers (%)	7 (18)	10 (22)
Severity of illness (%)		
APACHE II at intensive care unit admission	19.5	18
ARDS or ALI/ARDS[b]	31/38 (82)	45/46 (98)
Mechanically ventilated	29/38 (76)	39/46 (85)
Comorbid disease (%)		
Diabetes mellitus	14/38 (37)	7/46 (15)
Cardiac disease	7/38 (18)	6/46 (13)
Hypertension	4/38 (11)	14/46 (30)
Course of illness, days[c]		
Hospitalization	5	5
Intensive care unit admission	8	8
Mechanical ventilation	8	NA
Complications (%)		
Barotrauma	10/38 (34)	9/46 (20)
Hemodialysis	3/38 (5)	9/46 (20)
Venous thromboembolism	NA	22/46 (48)
Treatment (%)		
Antibiotics	29/38 (76)	43/46 (94)
Ribavirin	33/38 (87)	18/46 (39)
Steroids	30/38 (79)	32/46 (70)
Mortality (%)		
28 days	13/38 (34)	17/46 (37)
28 days for mechanically ventilated patients	13/29 (45)	NA
56 days/91 days[d]	15/38 (39)	24/46 (52)

[a]Median values are displayed; [b]figures represent incidence of ARDS (acute respiratory distress syndrome) in Fowler et al. and combined incidence of ALI/ARDS (acute lung injury/acute respiratory distress syndrome) in Lew et al; [c]course of illness measured from day of symptom onset; [d]figures represent 56-day mortality for Fowler et al. and 91-day mortality for Lew et al.

Twenty-eight-day mortality was 34% in Toronto and 37% in Singapore. When comparing outcomes between the two groups, it is important to note that the Toronto study defined day 1 as the day of admission to the ICU, whereas in Singapore, day 1 was the first day of patient symptoms.

The median time to death in Toronto was 19 days and in Singapore most deaths (79%) occurred after the first week. Longer-term follow-up data provided evidence of further mortality. Eight-week mortality was 39% in the Toronto series and 13-wk mortality was 52% in Singapore.

In the Toronto cohort, analysis of ventilatory parameters during the first 7 days of ICU admission found no difference in median peak airway pressures between survivors and nonsurvivors (30 cm H_20). However, median tidal volume was greater for nonsurvivors (7.8 mL/kg of actual body weight) compared with survivors (6.0 mL/kg). The mortality for ventilated patients (52% at 8 wks) was similar to mortality reported in a large unselected group of patients with ARDS requiring mechanical ventilation (31). Barotrauma in SARS-related ARDS is more common than in other forms of ARDS (32, 33). The apparent steroid-responsiveness of this illness and the high rate of pneumothorax reminded many in our group of managing severe *Pneumocystis carinii* pneumonia in the days before *Pneumocystis carinii* prophylaxis for immunocompromised individuals became routine.

Predictors of outcome in the Toronto cohort were assessed by comparing survivors vs. nonsurvivors (at 28 days). Univariate analysis showed older age, diabetes mellitus, admission tachycardia, and elevated creatine kinase were associated with poor outcome. Multivariate analysis was not performed because of the small size of subgroups. In their Kaplan-Meier survival analysis, patients older than 65 yrs were much less likely to be alive at 28 days compared with younger patients (30% vs. 79%).

In the Singapore study, patients were characterized by outcome into four groups: early recovery (no ventilation required), intermediate recovery (ventilated for 14 days or less), late recovery (ventilated for >14 days), and nonsurvivors. The course of illness was different among the subgroups. Those patients who did not require mechanical ventilation (early recovery) had an abbreviated course of acute lung injury, with oxygen requirements peaking a median 8 days after symptom onset. The intermediate recovery group showed improved oxygenation and pulmonary compliance after being ventilated for a median of 5 days. The late survivors (mechanical ventilation for greater than 14 days) had protracted and severe ARDS, required the most interventions, and also had the most complications (i.e., severe hypoxia, multiorgan failure, venous thromboembolism, and sepsis). This progression to multisystem failure is consistent with other ARDS literature in which the mortality associated with protracted ARDS is largely related to other organ failure (34–36). Lew and colleagues postulate that the progression to severe ARDS is related to a patient's hyperimmune response to SARS (similar to severe ARDS associated with sepsis or systemic inflammatory response syndrome). This hypothesis has also been proposed by other SARS investigators (16, 28).

A low-tidal volume lung protective strategy was used in the Singapore SARS ICU, targeting tidal volumes of 6 mL/kg (of predicted body weight) and plateau pressures of less than 30 cm H_2O. Bronchospasm was not a typical feature of SARS-related ARDS. On day 7, the sickest patients (late recovery/nonsurvivors) had higher mean minute ventilation, higher mean $Paco_2$, and higher mean plateau pressures. These features suggest worsening ARDS in that group.

In their univariate analysis, Lew and colleagues found age and baseline APACHE II and Pao_2/Fio_2 ratios to be associated with early/intermediate recovery. In multivariate analysis, the only predictors of early/intermediate recovery were baseline APACHE II score and Pao_2/Fio_2 ratio. These factors suggest that severity of disease predicts eventual outcome.

SARS and Critical Care: Special Considerations

The Toronto SARS outbreak provided numerous challenges to all levels of the healthcare system. The influx of critically ill patients to the city's ICUs provided unique challenges to the delivery of critical care (Fig. 1).

Communication. We quickly learned that communication strategies both within the critical care community and between the critical care group and others such as hospital administrators, government, and public health officials was a key weapon in the fight against SARS (37). After an insurmountable number of E-mails and telephone calls, it was recognized the Toronto critical care community would benefit from regular teleconferences for several reasons. Because SARS was a new illness, a great deal was gained by providing a forum for the exchange of clinical information and advice. Many healthcare providers felt isolated during the outbreak because regular hospital rounds and meetings were canceled. Furthermore, with infection control regulations limiting interhospital patient transfers, individuals had to manage cases they may not usually have managed. Finally, regular communication would allow better coordination of activities (such as data collection for the purposes of better understanding the critical care aspects of the illness) so that efforts could be focused and efficiency optimized.

As a result, thrice-weekly teleconference calls involving critical care clinicians and invited representatives from public health, infection control, infectious diseases, government, and hospital administration were created. Participants were identified by searching individual E-mail contact lists, personal communication, and announcement to hospital administrators through the Ontario Hospital Association and the Ontario Council of Teaching Hospitals. During the calls, clinical information and therapeutic challenges were discussed. In addition, we were able to dispel rumors, clarify media reports, synthesize the barrage of faxes and government directives, answer questions, support those feeling isolated, and encourage the group as a whole to carry on the fight. The discussions generated new ideas about how to deal with this previously unknown illness and identified leaders to focus on specific tasks.

Other communication initiatives included a group of tertiary-care intensivists making themselves available to provide 24-hr on-call clinical support and advice to any critical care provider. These individuals were available through a government-sponsored toll-free line.

Resources. A major problem during the SARS outbreak became supply of critical care beds. Years of cost constraints and a lack of critical care nurses had resulted in bed reductions and high occupancy rates in ICUs throughout Ontario. This made it difficult to find beds for the influx of critically ill patients with SARS. Furthermore, with the high transmission rate of SARS to HCWs, fear, staff quarantine, SARS development, and emotional stress further limited the supply of critical care staff. Compounding this problem, as SARS transmission occurred, entire critical care units began to close for quarantine periods. For example, 73 ICU beds were closed during various phases of the SARS outbreak, representing 38% of the tertiary-care university medical–surgical ICU beds (some of which housed important regional programs such as trauma) and 33% of the community ICU beds in Toronto (21). Such closures limited beds for all critically ill patients. Another important task was to identify within and outside Toronto a workforce capable of working in any particular ICU in the event of a staffing shortage. Like many large cities, we found that the critical care community had not carefully thought out (at least in advance of SARS) our approach to a crisis that impacts on critical care beds. For example, ideally, we would have in place a mechanism whereby we could limit unnecessary flow of patients into ICUs (such as canceling elective surgeries) and preserve the care of emergent patients (such as trauma, cardiac, neurosurgery, and transplant) while at the same time handling the influx of new patients who were highly contagious and hence capable of closing critical care beds. Such a response appears to require a regionalized approach or systemwide thinking to the delivery of critical care (see the next section), at least during a crisis. When our regional trauma center closed, this type of system thinking was thrust on us, and the hurried response (which resulted in incredible tensions) was less than ideal.

Infection Control and Education. Infection control practices in the ICU became an essential component in the response to SARS. Novel and often-changing protocols needed to be rapidly and widely disseminated, as well as taught to front line workers. Rapid change proved to be one of the most stressful things we had to deal with. It is a credit to front line workers how they were able to respond to this challenge in a short period of time. Critical care HCWs are at particular risk of SARS because of the frequency of high-risk procedures in the ICU leading to potential droplet spread (i.e., cardiac resuscitation, intubation, bronchoscopy, noninvasive ventilation, suctioning, high-flow oxygen therapy, and high-frequency ventilation). Furthermore, these exposures occur in

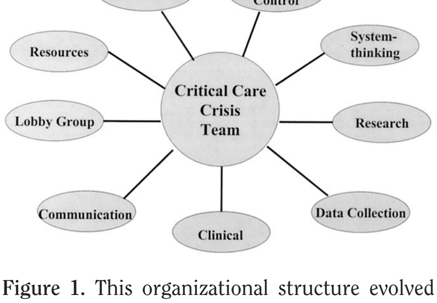

Figure 1. This organizational structure evolved during the Toronto severe acute respiratory syndrome outbreak; however, ideally, our center and others should have a similar system in place in preparation of future disease outbreaks.

critically ill patients who are thought to have a higher viral load than noncritically ill patients with SARS. Detailed infection control recommendations specific to the ICU setting have been described in several recent publications (15, 21, 38–40).

A team of intensivists worked with infection control colleagues to develop guidelines for ICU practices considered to be high risk for SARS transmission. This group rapidly agreed on several recommendations, ensured the recommendations, received government approval and mandates, disseminated the information on a broadly advertised Web site (see www.sars.medtau.org), developed instructional videos, and provided remote and local training (40). In addition, software specific to SARS was developed for handheld computers and available for broad distribution free of charge (41). By having a few individuals perform these activities for the entire province, we were able to allow others to focus on other important tasks and eliminate redundancy.

Research and Data Collection. An essential component in the international response to SARS was the facilitation of research into this novel disease. Like in other countries, in the midst of Toronto's outbreak, a tremendous amount of energy was devoted to learning about SARS as quickly as possible in an effort to not only provide better patient care, but also to understand how the outbreak could become controlled.

The regular teleconference calls allowed Toronto's critical care community to rapidly develop research studies (15, 21, 38). Research protocols, ethics approval, data collection, and dissemination of results happened at a remarkable speed. Patient care improved as clinicians gained experience in treating this new disease and as literature began to accumulate. It was truly a positive story that came from SARS to see so many individuals spend so much time and energy to rapidly answer questions for the greater good of the community. It was refreshing to see the often-competitive boundaries of academic medicine broken down by a common goal.

System Thinking and Lobby Group. A major challenge during SARS was the ability of front line physicians to communicate effectively with the various public health and government officials responsible for coordinating the response to SARS. Early in the outbreak, leaders from the ICU community were appointed to deal directly with the Ministry of Health to bring forward (in one voice) critical care issues and to assist in finding systemwide solutions to the critical care challenges. Important issues that were considered by this group included the following: whether to create "SARS hospitals"; how to keep other essential services (i.e., trauma and cardiac surgery programs) open while ICUs were being closed during SARS; the importance of providing up-to-the-minute clinical and epidemiologic information to front line clinicians as they managed patients in an ever-changing outbreak environment; and how to identify and train an adequate workforce.

Front Line Support and Staff Morale. Finally, on a more personal level, ICU leaders needed to communicate regularly with critical care staff in quarantine and those who were admitted to hospital with SARS. At many institutions, ongoing emotional support was provided to all levels of ICU staff through regular meetings and psychologic intervention (42). It was extremely important, both during and after the outbreak, to encourage and congratulate front line workers for getting the job done despite the incredible emotional and physical stresses of SARS (Fig. 2). In our opinion, the most fascinating and inspiring story that occurred during SARS was that of the front line workers. When the outbreak first occurred, the reader must remember that we did not even know if infection control measures would work. We also did not know what the true morbidity and mortality was. All we knew was that there was an atypical pneumonia with a high rate of attack on HCWs, particularly those in the ICU. We also had constant, very frightening media reports of high mortalities, including healthy young people. There were also predictions of a pandemic. Despite these uncertainties, the front line workers in the ICU continued to come to work. Even when their colleagues became sick with SARS, even when some of those colleagues were occasionally admitted to the ICU, they continued to come to work. Even when the public became afraid of HCWs and at times anecdotally treated them and their families poorly, they continued to come to work. These individuals elected to put their own health and potentially the health of their families on the line and work in enormously stressful conditions, often for mere strangers. These individuals are the true heroes of the SARS battle we faced.

Although SARS appears to have at least temporarily disappeared from Toronto, there are ongoing initiatives to prepare for the next disease outbreak. Education and training staff in using appropriate protective equipment continues. Efforts related to debriefing are also ongoing. Additional emotional and counseling support is being offered to those who are left with psychologic sequelae. This has particular importance in retention and recruitment of front line workers.

SARS and Critical Care: Lessons Learned

Several lessons emerged from our experience, the most important of which is preparedness. We were not prepared for SARS, nor did we have a systemwide critical care communication strategy in place. From a critical care perspective, the most important limitation in the response to SARS was the absence of a coordinated leadership and communication infrastructure. Accordingly, clinicians, researchers, and public health and government officials were often unsure of what each other were doing. Ideally, centers should have leadership and communication systems prepared to allow for the rapid expansion and modification of critical care services in the event of a disease outbreak or similar challenge. In the event of a future disease outbreak or natural disaster, it would be ideal to have a "war room" or "virtual war room" established with someone reporting to leadership daily about activities in each area highlighted here (i.e., communication, resources, infection control, education, research, system planning, and staff morale).

In a report commissioned by Health Canada, Dr. David Naylor (Dean of Medicine at the University of Toronto) highlighted numerous systemic deficiencies in Canada's response to SARS (Table 4) (43). Our ability to respond to the next disease outbreak will depend largely on the ability of governments and healthcare systems to implement many of his important recommendations.

CONCLUSIONS

The worldwide outbreak of SARS appears to have at least temporarily subsided. Recent sporadic cases have been associated with medical research laboratories and potential transmission within wild game markets in Guangdong, China

May 1, 2003

A Tribute to Heroes on the Front-line

On behalf of the hospitals of Ontario, I am writing to thank you for your extraordinary efforts in the war against Severe Acute Respiratory Syndrome (SARS).

You have been dealing with something that we have never faced before and you have been doing it twenty-four hours a day, seven days a week. In the battle against SARS, you have made huge sacrifices. Many of you knew, when entering your professions, that you would face challenging and unknown situations, but SARS has posed a supreme challenge.

With great pride, hospital leaders have told us about your commitment and professionalism throughout isolation and Code Orange procedures. They have told us about your exhaustion. How you have been tested on the limits of your dedication and far surpassed any expectations. How you have gone above and beyond the call of duty to care for your patients.

Your loved ones have worried about you. And you have worried about the safety of us all. Thank you.

You are our heroes.

Figure 2. Letter to encourage and congratulate front line workers for getting the job done.

Table 4. Deficiencies in Canada's response to severe adult respiratory syndrome as highlighted by the Naylor Report (43)

1. Lack of surge capacity in the clinical and public health systems
2. Difficulties with timely access to laboratory testing and results
3. Absence of protocols for data or information-sharing among levels of government
4. Uncertainties about data ownership
5. Inadequate capacity for epidemiologic investigation of the outbreak
6. Lack of coordinated business processes across institutions and jurisdictions for outbreak management and emergency response
7. Inadequacies in institutional outbreak management protocols, infection control, and infectious disease surveillance
8. Weak links between public health and the personal health services system, including primary care, institutions, and home care

(7–9). Although we remain vigilant for another outbreak, we have learned many important lessons. SARS highlighted the vulnerability of Toronto's healthcare system and illustrated the importance of strong infection control and public health systems. Centers must have leadership and communication systems established in preparation of future medical or natural disasters.

SARS remains very difficult to distinguish clinically from other viral or bacterial causes of pneumonia. This highlights the importance of strict infection control precautions for febrile respiratory illness and the need for a definitive microbiologic diagnostic test as well as detailed patient histories. Approximately 20% of patients with SARS will become critically ill and require admission to the ICU. ARDS develops in the majority of these patients. Like in other causes of ARDS, a low-tidal volume lung protective strategy should be used for mechanical ventilation. Optimal medical management of these patients remains unclear at this time. Future studies will need to assess the role of antibiotics, steroids, and interferon. Ribavirin is associated with numerous adverse events and is not likely beneficial in the treatment of SARS. Mortality from ARDS in SARS is high, and outcome is associated with the presence of comorbid disease and the severity of illness at presentation.

In summary, communication and leadership strategies were a key component in the critical care response to SARS. Other critical care communities should consider their crisis-response strategies in advance of similar events. The emergence of Avian flu in parts of Asia in early 2004 underscores this need (44). Despite the dramatic impact of SARS on our community, it was inspiring to witness the incredible spirit of cooperation that occurred at the local, national, and international level. This unprecedented level of cooperation will need to continue as the international critical care community prepares for the next infectious disease outbreak.

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