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Impact of enhanced infection control procedures on clinical outcome following resuscitation attempts

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Summary The impact of infection control measures (ICMs) on emergency resuscitation during an outbreak is unclear. The purpose of this retrospective observational study was to investigate the outcomes of emergency resuscitation after implementation of ICMs. Data were collected for the period 1 January to 4 July in 2003 from a 1732-bed tertiary care hospital in central Taiwan. Non-trauma patients who required emergency resuscitation were classified into two groups: before (period 1) and after (period 2), the date on which strict ICMs were implemented. The analysis variables included demographic data of patients, place of resuscitation, number of participating resuscitators, response time and duration of resuscitation, fever, pneumonia status and results of resuscitation. The response time was unchanged but the number of patient resuscitations without an emergency intubation, rapid sequence intubation or a ‘do not resuscitate’ order increased from 88 (24.4%), 23 (6.4%) and 16 (4.4%) in period 1 to 103 (33.0%), 32 (10.3%) and 29 (9.3%) in period 2, respectively. The failure rate of resuscitation was significantly higher in period 2 (odds ratio: 1.59, 95% confidence interval: 1.17e2.16). The number of emergency resuscitations in patients with fever or pneumonia was not significantly different between these two periods. In conclusion, strict ICM implementation appeared to play a role in the increased failure rate in emergency resuscitation. Normal provision of healthcare to patients and adequate protection of healthcare
workers during emergency resuscitation will be of paramount importance during the next outbreak of a highly contagious disease.
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Introduction

Severe acute respiratory syndrome caused by coronavirus (SARS-CoV) was a novel contagious infectious disease that first emerged in November 2002 in Guangdong province, China. It spread rapidly, infecting thousands of people in 30 countries across five continents, and resulted in hundreds of fatalities. The high infectivity, morbidity and mortality created panic around the world. The evidence suggests that SARS-CoV was transmitted primarily by droplets and by direct contact.\(^1\)\(^-\)\(^3\) Working at the frontline in the battle against a previously unknown lethal pathogen, healthcare workers (HCWs) were victims of the SARS catastrophe from nosocomial infection.\(^4\)\(^-\)\(^8\) The procedure of emergency resuscitation, such as endotracheal intubation or airway management, can stimulate coughing and often necessitates open suctioning of respiratory secretions. These close-contact procedures put resuscitators at high risk of exposure to the SARS-CoV. Frontline HCWs who directly participated in endotracheal intubation had an increased risk of subsequently developing SARS.\(^9\) For the purposes of providing adequate infection control procedures to protect staff, several infection control measures (ICMs) were implemented in our hospital.

Before the SARS epidemic, protection of resuscitators was simple and individualized. After the first SARS case was admitted to this hospital, strict ICMs were implemented and enforced. However, the implementation of ICMs was a great challenge, especially in emergency resuscitation. HCWs had to spend extra time preparing for resuscitation procedures and, even with prior training, the additional protective measures made it harder to perform emergency resuscitation. Several ICMs limited the capacity of HCWs to provide emergency care. Furthermore, the increasing number of cumulative probable cases of SARS reported in the news media and in government announcements was a cause of great stress among HCWs during emergency resuscitation.

There are few data on the effects of ICMs on the clinical practice of HCWs who came into close contact with patients during the SARS outbreak. The purpose of this study was to investigate the effects of ICMs in emergency resuscitation prior to and during the SARS period. Infection control experts, hospital managers and health policymakers may find these data of use in preparing for the next outbreak of a rapidly spreading pathogen.

Methods

This was a retrospective observational study which was approved by the institutional review committee. Data were collected from a 1732-bed hospital, located in central Taiwan, with eight probable SARS cases, including two proven cases (confirmed by polymerase chain reaction test), during the SARS period. The first probable SARS case who had been infected by his brother, a resident at Amoy Gardens, an apartment building in Hong Kong, was admitted to this hospital on 3 April 2003 with a fever and cough. The World Health Organization removed Taiwan from its list of areas with local transmission of SARS on 4 July 2003. There was no SARS outbreak at this hospital and no HCWs became infected with SARS-CoV.

Resuscitation record sheets, which have been used for chronologically recording procedures and administration of drugs during cardiopulmonary resuscitation (CPR) and other resuscitations at our hospital since 2001, were reviewed from 1 January to 4 July 2003. They are used in cases with sudden apnoea or respiratory distress, sudden hypotension, bradycardia or sudden loss of consciousness. Non-trauma patients who received emergency resuscitation from January 1 to April 2 (total, 92 days) or from April 3 to June 3 (total, 92 days) were classified into two groups: before (period 1), and during (period 2), strict implementation of ICMs. In period 1, protection during emergency resuscitation consisted of surgical mask and gloves. Immediately following confirmation of the first SARS case in our hospital (period 2), strict ICMs were implemented and the personal protection equipment (PPE) during emergency resuscitation was upgraded to an N95 respirator and/or surgical mask, gloves, gown and goggles as well as rapid sequence intubation if indicated. ICMs before and during resuscitation of suspected SARS patients included the standard operating procedures of wearing gloves and gown, in addition to use of airway and breathing...
equipment, intubation and ventilator. Other strict hospital ICMs in period 2 included the following: (i) all new admissions were required to be examined by our emergency department’s SARS screening team; (ii) all febrile patients were required to be admitted to the fever screening ward regardless of their diagnoses; (iii) unnecessary contact between HCWs was restricted and regular meetings and conferences were cancelled; (iv) each step of the standard operating procedure was strictly audited during resuscitation.

Data collection included: patients’ age and sex; whether or not emergency endotracheal intubation with rapid sequence intubation was performed; clinical areas where resuscitation was performed; response time and duration of resuscitation; number of resuscitators involved; and the result of resuscitation. The records of patients with fever >38 °C within 3 days prior to emergency resuscitation were reviewed, as well as those who had been diagnosed with pneumonia before resuscitation.

Areas for resuscitation were classified as emergency department (ED), intensive care unit, ordinary ward and any other locations within the hospital. Response time was calculated from the time the emergency call was received to the time the physician arrived. The duration of resuscitation, the period from start to end of resuscitation, was also recorded. The number of participating resuscitators (physicians or nurses) who had been involved in the resuscitation was collected by reviewing the names signed on the special resuscitation sheet. A repeat resuscitation occurring 6 h after the previous resuscitation was defined as a different event. The result of resuscitation was classified into ‘failure’ and ‘having response’. ‘Having response’ indicated that the patient’s condition was persistently stable more than 6 h after emergency resuscitation. A ‘failure’ result meant that the patient died after resuscitation.

The changes in proportion of the different variables between the two periods were compared by Chi-squared test.

**Results**

The incidence of emergency resuscitation accounted for 360 of 14 264 (2.5%) hospitalized cases in period 1 and 312 of 10 444 (3.0%) hospitalized cases in period 2 (Table I). The numbers of cases that were not intubated, rapid sequence intubation cases and ‘do not resuscitate’ orders signed during resuscitation were significantly higher in period 2 compared with period 1. The ED coped with more patients requiring emergency resuscitation in period 2. The age distribution and number of pneumonia cases were not significantly different between the two periods. However, the numbers of female patients and cases with a fever episode within 3 days prior to resuscitation significantly increased. The failure rate of resuscitation in period 2 was 1.59 times [95% confidence interval (CI): 1.17–2.16] that in period 1.

A comparison of changes in the process in emergency resuscitation between periods 1 and 2 is shown in Table II. There was no significant difference in response time or number of participating resuscitators between the two periods. The proportion of cases who received emergency resuscitation less than 30 min in duration was 51.9% (187 cases) in period 1 compared with 38.5% (120 cases) in period 2 [odds ratio (OR): 0.58; 95% CI 0.42–0.79].

The changes of process in emergency resuscitation in patients with fever or diagnosis, including pneumonia, are shown in Table III. There were no differences in the number of cases with regard to location, time of resuscitation and result of resuscitation. However, the number of emergency intubations with rapid sequence intubation in fever was significantly higher in period 2 (OR: 4.74; 95% CI: 1.00–23.11). Furthermore, the number of cases receiving emergency treatment from fewer than two participating resuscitators was significantly higher in period 2 (OR: 2.76; 95% CI: 1.08–5.96) for fever patients, but there was no change for pneumonia patients.

**Discussion**

The percentage of patients requiring emergency resuscitation increased during the period of strict implementation of ICMs (period 2). This may have been because many patients were likely to have delayed visiting a hospital out of fear of catching SARS, especially in areas where hospital-associated transmission of SARS had occurred.10 Strict implementation of ICMs, such as a fever screening station, a fever triage ward, and restricted admission of fever patients, prolonged the processes in the ED and decreased the accessibility of healthcare. These measures may have resulted in an increased number of complicated cases and a higher demand for emergency resuscitation. Changes in habits of hospital healthcare after infectious control precautions were announced may also have affected emergency care. One such change was shortened patient–physician contact, which resulted in less communication between patients and physicians as well as
reduced frequency of meetings and chart rounds. There were also more emergency resuscitations performed without intubation and a higher number of 'do not resuscitate' orders signed during resuscitation in the period of strict implementation of ICMs. These changes resulted in an abnormal situation in which the hospital's facilities were adversely affected and the ability of the hospital to provide patients with medical care during the SARS outbreak was reduced.

Several reports have noted that when intubation is necessary, measures should be taken to reduce unnecessary exposure of HCWs to droplets by adequately sedating or paralysing the patient to reduce cough.\textsuperscript{11} The preintubation steps of rapid sequence intubation include preparation, preoxygenation, premedication and paralysis. Each step requires additional time when combined with other ICMs and this prolongs the duration of resuscitation. Furthermore, if physicians have insufficient experience with the techniques, the ICMs may be less effective.\textsuperscript{12,13}

The incidence of emergency resuscitation occurred most frequently in ordinary wards, but the proportion was significantly increased in the ED in the period of strict implementation of ICMs. Ho et al. reported that when there was a high index of suspicion for SARS during the SARS period, hospitals were recommended to avoid admitting patients with undiagnosed SARS to general wards, where protection was likely to be inadequate and infection control awareness low.\textsuperscript{4} This policy may lessen the likelihood of outbreaks in other parts of the hospital but it could increase the length of stay at the ED. During the SARS outbreak, ICMs were more strictly applied in the ED because most of the ED visits had ill-defined symptoms or signs and the contact or travel history was often

### Table I
Demographic data for emergency resuscitation before and during the outbreak of severe acute respiratory syndrome

| Changes of characteristics                      | Period 1 (%) | Period 2 (%) | P-value | Odds ratio\textsuperscript{a} (95% CI) |
|------------------------------------------------|--------------|--------------|---------|--------------------------------------|
| No. of emergency resuscitation/total no. of admissions | 360/14 264 (2.5) | 312/10 444 (3.0) | 0.027 | 1.19 (1.02–1.39) |
| No. without emergency intubation                | 88 (24.4)    | 103 (33.0)   | 0.018 | 1.52 (1.09–2.13) |
| Emergency intubation with RSI                   | 23 (6.4)     | 32 (10.3)    | 0.028 | 1.96 (1.11–3.46) |
| No. of DNR signed during resuscitation          | 16 (4.4)     | 29 (9.3)     | 0.019 | 2.20 (1.17–4.14) |
| Place of emergency resuscitation                |              |              |         |                                      |
| Emergency department                            | 74 (20.6)    | 86 (27.6)    | 0.042 | 1.47 (1.03–2.10) |
| Ordinary wards                                  | 197 (54.7)   | 164 (52.6)   | 0.630 | 0.92 (0.68–1.24) |
| Intensive care units                            | 89 (24.7)    | 60 (19.2)    | 0.106 | 0.72 (0.5–0.15)  |
| Others                                          | 0 (0.0)      | 2 (0.6)      | —     | —                                    |
| Gender: female                                  | 140 (38.9)   | 147 (47.1)   | 0.038 | 1.40 (1.03–1.92) |
| Age distribution (years)                        |              |              |         |                                      |
| <18                                             | 25 (6.9)     | 18 (5.8)     | 0.643 | 0.82 (0.44–1.53) |
| 18–45                                           | 50 (13.9)    | 35 (11.2)    | 0.356 | 0.78 (0.49–1.24) |
| 46–64                                           | 92 (25.6)    | 80 (25.6)    | 0.949 | 1.00 (0.71–1.42) |
| ≥65                                             | 193 (53.6)   | 179 (57.4)   | 0.394 | 1.16 (0.85–1.57) |
| Fever episode in previous 3 days                | 59 (16.4)    | 73 (23.4)    | 0.029 | 1.56 (1.06–2.29) |
| Diagnosis of pneumonia                          | 35 (9.7)     | 32 (10.3)    | 0.919 | 1.06 (0.64–1.76) |
| Failure of resuscitation                        | 182 (50.6)   | 193 (61.9)   | 0.004 | 1.59 (1.17–2.16) |

RSI, rapid sequence intubation; DNR, do not resuscitate.

\textsuperscript{a} Period 2 compared with period 1.

### Table II
The changes in quality and outcome before and during the outbreak of severe acute respiratory syndrome

| Quality indicators of resuscitation | Period 1 (%) | Period 2 (%) | P-value | Odds ratio\textsuperscript{a} (95% CI) |
|-------------------------------------|--------------|--------------|---------|--------------------------------------|
| (N = 360)                           |              |              |         |                                      |
| Time to start resuscitation <5 min  | 49 (13.6)    | 39 (12.5)    | 0.756   | 0.91 (0.58–1.42) |
| Duration of resuscitation ≤30 min   | 187 (51.9)   | 120 (38.5)   | <0.001  | 0.58 (0.42–0.79) |
| No. of participating resuscitators ≤2 | 104 (28.9)   | 108 (34.6)   | 0.131   | 1.30 (0.94–1.81) |

\textsuperscript{a} Period 2 compared with period 1.
unknown in patients requiring emergency resuscitation. Patients were typically required to undergo some ICMs, such as examination by the ED’s SARS screening team, before admission during period 2. Additional waiting time could result in a deterioration of patients’ conditions and an increased requirement of emergency resuscitation in an ordinary ward.

The response time of resuscitation was unchanged during period 2 despite the fact that physicians and nurses spent more time performing emergency resuscitation during this period. This may have been due to the resuscitators putting more effort into saving the patients’ lives, or there may have been an association with patients’ underlying disease or other conditions. The implementation of additional control measures, such as preintubation ICMs before resuscitation and standard operative procedures during resuscitation, may also have extended the duration of resuscitation. Ho et al. recommended routine use of several protective devices and training of staff in infection control in order to expedite isolation of all patients with clinically confirmed or suspected SARS. Prolonged preparation of PPE and ICMs could influence the outcome of resuscitation.

The procedure that had the greatest psychological impact on HCWs during the SARS outbreak appears to have been resuscitation of fever and pneumonia patients. Our data found, however, that the factor ‘fever or pneumonia’ did not significantly affect the results of resuscitation. This may have been due to the requirement that all of the ICMs had to be implemented for all patients who required resuscitation, without exception. Therefore, the implementation of strict ICMs, rather than specifically affecting fever or pneumonia, had a general effect on all patients.

Although the duration of preparation of ICMs before or during resuscitation was not recorded in this study, our subjective experience was that the prolonged period of preparation for implementation of ICMs, including the increased proportion of rapid sequence intubation, seemed to delay the start of resuscitation and prolonged the process of resuscitation. It is well known that delays in supplementation of oxygenation, ventilation or tissue perfusion can affect the results of resuscitation. Obviously, these changes will decrease HCWs’ risk of exposure to contagious disease, but it is important to note the serious ethical implications involved.

There were several limitations in this study. First, these data were from a single hospital so the extent to which data could be extrapolated was limited. Second, the duration of preparation of ICMs in resuscitation was not recorded. Third, the severity and different kinds of underlying diseases were not entered into the analysis. Finally, no adjustments were made for seasonal factors in the analysis.

It is imperative that strict infection control measures be implemented during a pandemic but it is important to recognize that these may affect the ability of an ED to provide emergency care. Although it is unclear from our findings whether or not strict ICMs affected the outcome of resuscitation, it was our experience that the implementation of strict ICMs caused major changes in the ED which had an obvious potential to influence the outcomes of regular medical care, such as emergency resuscitation. Infection control experts, hospital administrators and health policymakers must develop clear guidelines so that HCWs can adequately protect themselves from infection while meeting their ethical obligation

| Measurements                                    | Fever (%) | ORa (95% CI) | Pneumonia (%) | ORa (95% CI) |
|-------------------------------------------------|-----------|--------------|---------------|--------------|
| No. of cases/no. of admissions                   |           |              |               |              |
| Location                                        |           |              |               |              |
| Emergency room                                  | 59 (16.4) | 1.56 (1.06–2.29) | 35 (9.7) | 1.06 (0.64–1.76) |
| Ward                                            | 12 (20.3) | 0.77 (0.32–1.87) | 8 (22.9) | 1.13 (0.37–3.46) |
| Intensive care unit                             | 39 (66.1) | 0.91 (0.45–1.87) | 20 (57.1) | 1.10 (0.41–2.90) |
| Emergency intubation                            | 8 (13.6)  | 1.25 (0.48–3.30) | 7 (20.0)  | 0.74 (0.21–2.62) |
| Intubation with RSI                             | 39 (66.1) | 1.05 (0.51–2.17) | 24 (68.6) | 0.40 (0.15–1.09) |
| Duration of resuscitation ≤ 30 min              | 2 (5.3)   | 4.74 (1.00–23.11) | 0 (0) | 2.76 (1.08–5.96) |
| <2 participating resuscitators                  | 13 (22.0) | 0.83 (0.42–1.66) | 21 (60.0) | 0.97 (0.37–2.59) |

OR, odds ratio; CI, confidence interval; RSI, rapid sequence intubation.

a Period 2 compared with period 1.
to save the life of a patient during emergency resuscitation. This dilemma will certainly be an important problem in the next outbreak of a highly contagious disease.

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None declared.

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