ORIGINAL ARTICLE

Outcome of adult critically ill patients mechanically ventilated on general medical wards

WM Tang 鄧偉明
CK Tong 唐澤君
WC Yu 余衛祖
KL Tong 唐國隆
Thomas A Buckley 畢嘉霖

Objective A significant number of critically ill mechanically ventilated patients are not admitted to the Intensive Care Unit but are cared for on general wards. This study looked at the outcome of these patients.

Design Case series.

Setting A 1100-bed tertiary hospital in Hong Kong.

Patients All adult patients admitted in a 2.5-year period who received invasive mechanical ventilation on general medical wards without admission to Intensive Care Unit or other special care areas.

Interventions Invasive mechanical ventilation.

Main outcome measures The observed number of deaths, the expected number of deaths as derived from the Mortality Probability Model II system admission model, and other morbidity measures.

Results Among 755 patients studied, the observed number of deaths was 673, which amounts to a mortality of 89.1%. The expected number of deaths was 570. The risk-standardised mortality ratio was 1.18 (95% confidence interval, 1.09-1.28; P<0.0005). Patients with chronic obstructive pulmonary disease had the lowest mortality rate of 70.8% (P<0.005). The post–cardiac arrest subgroup had the highest mortality of 99.0%.

Conclusions There was a worse-than-predicted survival in the absence of Intensive Care Unit care for the critically ill patients who received mechanical ventilation on general wards. Patients with chronic obstructive pulmonary disease warranted more Intensive Care Unit admissions. Early discontinuation of invasive support should be seriously considered in the post–cardiac arrest patients.

New knowledge added by this study

- Implementing invasive mechanical ventilation on general wards involves a high risk and such critically ill patients have a worse-than-predicted survival.
- When invasive mechanical ventilation is to be performed on general wards, the prognosis is better indicated for chronic obstructive pulmonary disease, while the post–cardiac arrest subgroup has the highest mortality of 99%.

Implications for clinical practice or policy

- Critically ill patients should be carefully selected for tracheal intubation and implementing invasive mechanical ventilation.
- Patients with obstructive pulmonary disease warrant more intensive care unit admissions.
- Early discontinuation of invasive support should be seriously considered in post–cardiac arrest patients.

Key words
Critical care; Hospital bed capacity; Intensive care units; Respiration, artificial

Hong Kong Med J 2012;18:284-90

Princess Margaret Hospital, Laichikok, Kowloon, Hong Kong:
Intensive Care Unit
WM Tang, MB, BS, FHKCP
CK Tong, MB, BS, FRCP
TA Buckley, MB, ChB, FCICM
Department of Medicine and Geriatrics
WC Yu, MB, BS, FCCP
KL Tong, MB, BS, FRCP

Correspondence to: Dr WM Tang
Email: tangwm2@ha.org.hk

Introduction

Invasive mechanical ventilation of adult patients in settings outside the intensive care unit (ICU) or other special care areas—such as high dependency unit, respiratory ward and coronary care unit—is an infrequent occurrence and its appropriateness remains controversial in Hong Kong. It ensues for a number of reasons. First, the number of critically ill patients requiring intensive care may exceed the number of beds available in ICU or other special care areas. Second, the provision of ICU beds may be further limited by a shortage of trained nurses resulting in closure of ICU beds. Third, patients may be too ill and may not meet ICU admission criteria. In the Hong Kong public health care system, the number of ICU admissions in 2007 was 11 602. In a systematic review of critical care bed rationing involving 2092 referred patients in five international centres (including one university medical-surgical ICU in Hong Kong), 26% of referrals were not admitted to ICUs.[1] Regarding patients who were refused ICU admission and those who were admitted, the pooled odds ratio for mortality was 3.04.[1] Similarly, Hersch et al[2] concluded from an observational, comparative study that in medical patients requiring mechanical ventilation, there was a higher in-hospital survival rate in ICU-ventilated patients as compared to those ventilated on medical wards (38% vs 20%, P<0.05). However, the process of selection or refusal of ICU admission was not random and the two patient groups in these studies differed in terms of age and severity of illness. Moreover, the number of such outcome studies appearing in the medical literature has been limited. We therefore carried out a retrospective observational study on a single cohort of adult medical patients who were mechanically ventilated outside the settings of an ICU or other special care areas over a 2.5-year period. The expected mortality based on a prediction model was compared with the observed mortality in order to assess outcomes.

危重病成人患者在普通病房內進行機械通氣的結果

目的 很多須接受機械通氣的危重病患者不能入住深切治療部，而在普通病房內進行機械通氣。本研究探討這些病人的治療結果。

設計 病例系列。

安排 香港一所設有1100張病床並提供第三層醫療服務的醫院。

患者 兩年半內所有在普通病房接受機械通氣的成人患者，他們並無入住深切治療部或其他加護病房。

介入治療 有創機械通氣。

主要結果測量 觀察所得的死亡人數、死亡概率模型II得出的預計死亡人數及併發症。

結果 共755名病人被納入研究範圍。觀察所得的死亡人數為673人，死亡率達89.1%，預計死亡人數則為570人。計算風險標準化死亡率為1.18（95%置信區間：1.09-1.28；P<0.0005）。慢性阻塞性肺部疾病患者的死亡率最低，數字為70.8%（P<0.005）。因心臟驟停而入院的病人則有最高死亡率，達99.0%。

結論 未能接受深切治療而須於普通病房內接受機械通氣的成人患者，其存活率較預期差。應認真考慮因心臟驟停而入院的病人或須提早終止通氣治療。

Methods

This study was carried out in a 1100-bed tertiary hospital in Hong Kong, which has a mixed medical and surgical ICU with a capacity of 20 beds. During ICU consultations, patients were triaged by ICU specialists or trainees with reference to a prioritisation model.[3] Critically ill patients deemed to need intensive treatment and monitoring (priority 1), or potentially needed immediate intervention (priority 2) were to be admitted to the ICU. Some patients were critically ill but they had a reduced likelihood of recovery because of underlying disease or the nature of their acute illness (priority 3). Also, many of them were admitted depending on bed availability. Admission was largely declined for patients who were either too well or too sick to benefit from ICU care (priority 4). Most patients on general wards deemed to require mechanical ventilatory support for respiratory failure or airway protection were admitted to the ICU after assessment by the ICU team. For patients considered as low priority for ICU admission and no available bed in other special care areas, they stayed on general wards where mechanical ventilation was carried out. The management of these patients remained the responsibility of the original specialty.

The subjects were identified through two sources: (i) the Clinical Data Analysis and Reporting System (CDARS), a reporting system connected to the hospital electronic patient record database, and (ii) ventilator loan records maintained by the medical respiratory team. The respiratory team retained responsibility for ventilators in the medical unit, and every ventilator used on medical wards was known to and recorded by the team. Eligible patients included all adults aged 18 years or older, admitted to the hospital between 1 July 2004 and 31 December 2006, and who received continuous invasive mechanical ventilation for more than 2 hours. Only those managed on general medical wards were included. Patients who were managed in non-medical specialties, adult or paediatric ICUs, surgical or neurosurgical high dependency units, the medical respiratory ward, or coronary care unit any time during their hospitalisation were excluded. Patients who were started on mechanical ventilation in other hospitals and subsequently transferred to our facility were also excluded.

The clinical notes of all relevant listed patients in the CDARS and the ventilator loan records were examined. The observed number of deaths, the expected number of deaths, and the risk-standardised mortality ratio (R-SMR) were the primary outcomes. The R-SMR refers to the ratio of observed-to-expected numbers of deaths, the expected number being derived from the Mortality Probability Model II admission model (MPM_0).[4] The model uses age and 14 other dichotomised variables

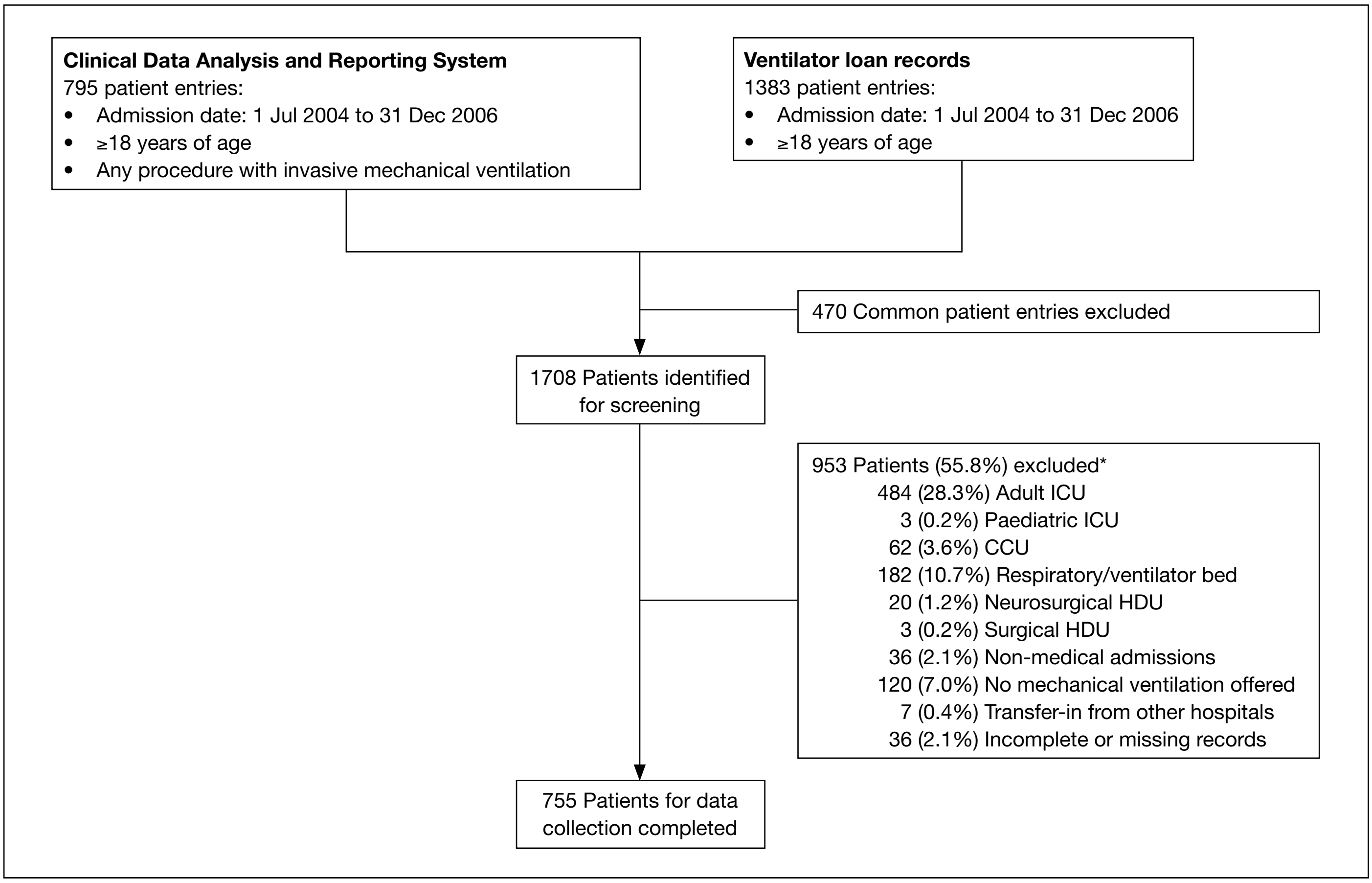

FIG. Patient enrolment

* ICU denotes intensive care unit, CCU coronary care unit, and HDU high dependency unit

for this purpose. They include: (1) heart rate ≥150 beats/min, (2) systolic blood pressure ≤90 mm Hg, (3) mechanical ventilation, (4) coma or stupor, (5) chronic renal failure, (6) acute renal failure, (7) cirrhosis, (8) metastatic neoplasm, (9) unscheduled admission, (10) cardiopulmonary resuscitation within 24 hours, (11) gastro-intestinal bleeding, (12) cerebrovascular incident, (13) intracranial mass effect, and (14) cardiac dysrhythmias. The variables were retrieved from medical or nursing assessment at the time of tracheal intubation documented in the medical records. The expected number of deaths was the sum of the individual subject's probability of mortality computed from the model.

$$logit = \sum_{i=1}^{15} \beta_i \alpha_i + \beta_0$$

$$Probability\ of\ mortality = \frac{e^{logit}}{1 + e^{logit}}$$

where β_0 is the constant term, $\beta_i \alpha_i$ is the i^{th} coefficient times the value of the i^{th} variable

Secondary outcomes included length of hospital stay, duration of mechanical ventilation, and complications associated with mechanical ventilation (ventilator-associated pneumonia [VAP], pressure sores, stress ulcer bleeding, barotrauma, and unplanned extubation). The occurrence of a tracheostomy was noted. The diagnosis of VAP was established when, after 48 hours of mechanical ventilation, there were new or progressive radiographic infiltrates, as well as at least two of three other clinical features (body temperature ≥38°C, white blood cell count ≥12 000 /mm^3 or <4000 /mm^3, purulent secretions), and a positive tracheal aspirate (presence of bacteria or inflammatory cells).[5] Barotrauma referred to pneumothorax, pneumomediastinum, or subcutaneous emphysema during mechanical ventilation. Stress ulcer bleeding was defined as fresh blood or coffee-ground material vomited or aspirated from the nasogastric tube, or passage of tarry stool per rectum, after mechanical ventilation was initiated; an endoscopy to establish the diagnosis was not required.

The multi-organ dysfunction score (MODS)[6] was used to determine the number and severity of organ dysfunctions. Each of the six organ systems (respiratory, renal, hepatic, cardiovascular, haematological, and neurological) was represented by one variable. They were: (1) PO_2/FIO_2 (the partial pressure of arterial oxygen to fraction of inspired oxygen ratio), (2) the serum creatinine, (3) the serum bilirubin, (4) the pressure-adjusted heart rate, (5) the platelet count, and (6) the Glasgow Coma Scale score, respectively. The pressure-adjusted heart rate was calculated as the product of the heart rate and the ratio of the central venous pressure to mean arterial pressure. Each variable was scored 0 to 4 points based on the level of severity, with 0 as normal organ function. When a value was missing or not measurable, it was recorded as 0, unless an abnormal value was recorded previously, in which case that value was carried forward. The MODS of a patient was the sum of the scores for each organ system (24 points maximum in total) and was measured once for each patient with the first set of data recorded after tracheal intubation.

The study was approved by the Kowloon West Cluster Clinical Research Ethics Committee. Patient consent was waived in view of the observational nature of the study.

All the data were tabulated and analysed on Excel spreadsheets (Excel 2008 for Mac Version 12.1.2, Microsoft Corporation, Redmond [WA], US). Any P value of <0.05 was considered statistically significant. The R-SMR was expressed as a ratio. The 95% confidence interval (CI) for the R-SMR was calculated using Byar's approximation to the Poisson distribution,[7] and its P value was determined from the one-sample log rank test[8] and a table of the Chi squared distribution, with a degree of freedom equal to 1. The Chi squared statistic was used to compare mortality rates of different patient subgroups. The MODS was expressed as a median with an interquartile range.

Results

During the 2.5-year period studied, 1708 unique patient entries were obtained from CDARS and the ventilator loan records. The reasons for exclusion of 953 patients are shown in the Figure. In all, 120/1708 (7.0%) of the ventilated patients were very ill or dying and ventilated for less than 2 hours or not connected to ventilators. All but two of the 755 enrolled patients were hospitalised as emergency admissions. The baseline characteristics and the admission diagnoses of the 755 eligible patients are shown in Table 1. The observed and expected numbers of deaths were 673 and 570, respectively. The observed hospital mortality was 89.1%. The R-SMR was 1.18 (95% CI, 1.09-1.28; P<0.0005).

Complications associated with mechanical ventilation are shown in Table 2. Prolonged respiratory failure was noted in 34 (4.5%) of the patients who had received mechanical ventilation for 14 days or more, and 11 (1.5%) of those ventilated for 21 days or more. A tracheostomy was performed in six (0.8%) patients. The mean time from intubation to tracheostomy was 28 days. The MODS revealed that the central nervous system was the most frequent organ system prone to dysfunction, followed by

TABLE 1. Baseline characteristics and different admission diagnoses (n=755)

Characteristic	Mean ± standard deviation or No. (%)
Mean age (years)	73.9 ± 12.6
Male sex	430 (57.0%)
Mean length of hospital stay (days)	8.8 ± 14.5
Mean ventilator days	3.6 ± 6.6
Intensive Care Unit consultation	217 (28.7%)
Admission diagnoses	
Respiratory	
Chronic obstructive airway disease	48 (6.4%)
Pneumonia	171 (22.6%)
Asthma	5 (0.7%)
Others*	37 (4.9%)
Cardiovascular	
Acute coronary syndrome	122 (16.2%)
Acute pulmonary oedema	29 (3.8%)
Arrhythmia	21 (2.8%)
Others†	5 (0.7%)
Neurological	
Cerebral infarct	63 (8.3%)
Cerebral haemorrhage	117 (15.5%)
Others‡	14 (1.9%)
Neoplasm	43 (5.7%)
Renal failure	25 (3.3%)
Sepsis	16 (2.1%)
Drug overdose	11 (1.5%)
Metabolic	4 (0.5%)
Others§	24 (3.2%)

* Included upper airway obstruction by foreign body, bronchiectasis, and massive haemoptysis
† Included pulmonary embolism and dissecting aortic aneurysm
‡ Included encephalomyelitis, transverse myelitis, and epilepsy
§ Included cirrhosis, gastro-intestinal bleeding, and rheumatic disease

TABLE 2. Complication rates of mechanical ventilation on general wards (n=755)

Complication	No. (%)	Event rates
Ventilator-associated pneumonia	52 (6.9)	19*
Pressure sores	57 (7.5)	9†
Stress ulcer bleeding	68 (9.0)	10†
Barotrauma	4 (0.5)	1†
Unplanned extubation	19 (2.5)	3†

* Rate per 1000 ventilator-days
† Rate per 1000 patient-days

TABLE 3. The multi-organ dysfunction score (MODS) of overall patients

Organ system	Median (interquartile range)
Respiratory	1 (0-3)
Renal	1 (0-2)
Hepatic	0 (0-0)
Haematological	0 (0-0)
Neurological	4 (3-4)
Cardiovascular	0 (0-0)
Total MODS	**6 (5-8)**

TABLE 4. Mortality of patients with different major admission diagnoses

Diagnosis (No. of patients)	No. of deaths		Risk-standardised mortality ratio (95% confidence interval)
	Observed	Expected	
COPD (48)	34 (70.8%)*	32.6	1.04 (0.72-1.46)†
Pneumonia (171)	159 (93.0%)	125.4	1.27 (1.08-1.48)‡
Acute coronary syndrome (122)	112 (91.8%)	97.4	1.15 (0.95-1.38)†
All stroke (180)	170 (94.4%)	130.5	1.30 (1.11-1.51)§
Infarct (63)	59 (93.7%)	48.2	1.22 (0.93-1.58)†
Haemorrhage (117)	111 (94.9%)	82.3	1.35 (1.11-1.62)‡

* COPD denotes chronic obstructive pulmonary disease; P<0.005 when compared mortality of COPD group to each of the other disease groups
† Not significant
‡ P<0.005
§ P<0.001

TABLE 5. Characteristics of patients admitted for chronic obstructive pulmonary disease (COPD) and patients in whom invasive mechanical ventilation was started after cardiopulmonary resuscitation (CPR) for cardiac arrest*

Characteristic†	COPD patients (n=48)	CPR subgroup (n=307)
Mean age (years)	77.2 ± 8.5	74.2 ± 12.4
Male sex	28 (58.3%)	163 (53.1%)
Length of hospital stay (days)		
Total	522	1852
Mean	10.9 ± 10.8	6.0 ± 12.7
Ventilator days		
Total	163	768
Mean	3.4 ± 5.4	2.5 ± 4.5
Median MODS	6 (4-8)	8 (6-9)
Mortality		
Observed deaths	34 (70.8%)	304 (99.0%)
Expected deaths	32.6 (67.9%)	288.8 (94.1%)
R-SMR	1.04 (0.72-1.46)	1.05 (0.94-1.18)

* Data are shown as mean ± standard deviation, No. (%), or median (interquartile range)
† MODS denotes multi-organ dysfunction score, and R-SMR risk-standardised mortality ratio

respiratory and renal systems (Table 3). Notably 56.4% of the patients were in shock (systolic blood pressure ≤90 mm Hg) at around the time of tracheal intubation. Because only 25 (3.3%) of the patients had central venous catheters inserted (permitting central venous pressure measurement), in the majority of the shocked patients cardiac dysfunction was not documented.

After grouping of patients according to several major admission diagnoses, those with chronic obstructive pulmonary disease (COPD) were observed to have the lowest mortality (70.8%, P<0.005) when compared with subjects with other admission diagnoses (Tables 4 and 5). By contrast, 307/755 (40.7%) of the patients were commenced on invasive mechanical ventilation after cardiopulmonary resuscitation for cardiac arrest. Post–cardiac arrest patients had an observed hospital mortality of 99.0%, which was significantly higher than overall mortality (P<0.0005) [Table 5]. When the post–cardiac arrest patients were excluded from analysis, the observed mortality rate was 82.4% and the R-SMR 1.32 (95% CI, 1.18-1.46; P<0.0005).

Overall, 217 (28.7%) of the patients were referred to the ICU but were refused admission. Among them, 27.6% (60/217) were considered as low admission priority (priority 3) when the availability of ICU bed was tight. The mortality of this group of patients was 60.0%. The remaining 72.4% (157/217) were too ill (priority 4) to benefit from ICU support. The mortality of this group of patients was 93.0%. Among the 48 COPD patients, 11 (22.9%) were referred for ICU assessment.

Discussion

In this retrospective study, 755 mechanically ventilated adult patients on general medical wards were investigated. The R-SMR of 1.18 means that there was an 18% increment in mortality compared to expectations. The overall mortality and that in major disease groups other than COPD were very high.

From our ICU registry in 2006, the standardised mortality ratio based on APACHE (Acute Physiology and Chronic Health Evaluation) II was 0.74. In that year, 1352 consultations were assessed and 822 (61%) patients were admitted to the ICU. Among the latter, 400 patients received mechanical ventilation, with an average of 8 ventilator-days for each patient. For those who were mechanically ventilated, 282 and 245 patients survived to ICU and hospital discharge, respectively; their respective ICU and hospital mortality rates were 30% and 39%. The average VAP and pressure sore rates were 39 and 13 per 1000 ventilator-days, respectively. The rates for stress ulcer bleeding, barotrauma, and unplanned extubation were not available from our database.

In our ICU, the lower VAP rate per 1000 ventilator-days (19 vs 39) and pressure sore rate per 1000 ventilator-days (9 vs 13) associated with mechanical ventilation may just be a reflection of higher mortality and thus shorter average number of ventilator days (4 vs 8). Such adverse outcomes may also suggest the use of this invasive treatment option to be inappropriate on general medical wards, due to inappropriate patient selection, or inadequate resources and monitoring to provide a suitable level of care. The management of such patients requires expertise not readily available in the general ward settings. Hersch et al[2] showed more ventilatory changes (8 vs 1 per day per patient, $P<0.001$), more arterial blood gas analyses (8 vs 2 per day per patient, $P<0.001$), and less endotracheal tube–related inadvertent events (20% vs 62%, $P<0.05$) in ICU-ventilated patients compared to patients ventilated on general medical wards. In view of the high-risk nature of implementing invasive mechanical ventilation on general wards, critically ill unstable patients should be carefully selected for tracheal intubation, and those not likely benefit from such invasive support should be excluded. Instead, non-invasive positive pressure ventilation should be applied whenever appropriate for patients suffering acute exacerbations of COPD, acute cardiogenic pulmonary oedema, and immunocompromised states.[9,10] If hospital resources allow, the services of respiratory high dependency units may be expanded, with daily care provided by respiratory specialists, anaesthetists, or intensivists.[11]

The mechanically ventilated COPD patients on general wards had a more favourable observed hospital mortality rate (70.8%) compared with other disease groups. Absence of significant dysfunction in other organ systems and the potentially reversible nature of bronchospasm may explain their better survival. For various reasons they were not admitted to the ICU. Often because some general ward physicians triaged them as not for ICU management.[12] Secondly, they might not have met prevailing ICU admission criteria. The assessment of critically ill patients by ICU physicians is still relatively subjective and heavily influenced by the experience of the doctor assessing the patient, despite attempts to define appropriate assessment criteria.[3,13] Thus, it may well be that ward doctors should refer more COPD patients to the ICU, and ICU staff should be more lenient in the selection of these patients for ICU admission.

Of the 307 patients who received mechanical ventilation after successful resuscitation from cardiac arrest, almost all of them eventually died on the general wards. This group entailed 1852 patient-days and 768 ventilator-days, and together with a high median MODS, they imposed a heavy workload on the medical and nursing staff. In the international guidelines for life-sustaining treatment in the terminally ill, it is ethical and legally acceptable to withhold or withdraw life-sustaining treatment when the treatment is considered futile,[14] or when there is a consensus between the health care team, the patient, and the family.[15] These patients should be carefully reviewed early after resuscitation for any benefit of ongoing supportive care.

Nearly one third of patients who were declined ICU admission belonged to the low priority category (priority 3). The hospital policy allowing invasive mechanical ventilation on general wards sometimes affected the decision of ICU doctors during patient assessment, especially when occupancy of ICU beds was high. This group could enjoy a relatively low mortality of about 60%. When resources are adequate, they should be admitted to the ICU.

Regarding limitations of this study, firstly, this was a retrospective analysis without controls and from a single centre, which may have biased it towards a certain case mix. Retrospective data collection could be less reliable and the worst physiological values may have been omitted in the records. Moreover, the investigators were not blinded to the survival status of the patients when collecting MPM_0 and MODS variables. Secondly, the list of eligible patients could be incomplete, due to missing entries in the CDARS and the ventilator loan records. Possibly, up to 913 cases could have been left out, if CDARS alone had been used for case selection. The unsatisfactory quality of output from CDARS may be explained by incomplete clinical data input. However, owing to our large sample size, the missing patients should not have an important impact on the final results. Thirdly, although each of the ICU scoring systems currently in use exhibits good discrimination and calibration, the prediction models have only been validated in ICU patients, not in non-ICU settings. The MPM_0 is no exception, which in this study was applied to general medical ward patients at the time of endotracheal intubation. The admission model included 15 variables reflecting baseline measures for severity of illness, which were independent of ICU interventions. This was the reason for choosing MPM_0 as the tool to predict mortality. Likewise, the MODS has not been validated in non-ICU settings. The cardiovascular score may also have been seriously underestimated, as very few patients had central venous measurements.

Conclusions

For critically ill patients who were mechanically ventilated on general medical wards, this study demonstrated a worse-than-predicted survival in the absence of ICU care. It reinforced the fact that critically ill patients fulfilling low-priority ICU admission criteria should be cared for in an ICU environment, where resource levels are sufficient to enable higher standards of care than on general wards. While the present triage system functions well, the unexpected finding of relatively satisfactory outcomes in the COPD subgroup raises questions about the applicability of conventional ICU triaging criteria for these patients. Further studies to identify better outcome indicators for these patients are needed. The extremely poor prognosis of post–cardiac arrest patients who remained on general wards suggests that serious consideration be given to discontinuation of invasive support following return of spontaneous circulation.

Acknowledgements

Special thanks to Drs Miu-yee Tang and Darshana H Kandamby (from the Intensive Care Unit, Princess Margaret Hospital, Hong Kong SAR, China) for data collection and data entry.

References

1. Sinuff T, Kahnamoui K, Cook DJ, et al. Rationing critical care beds: a systematic review. Crit Care Med 2004;32:1588-97.
2. Hersch M, Sonnenblick M, Karlic A, Einav S, Sprung CL, Izbicki G. Mechanical ventilation of patients hospitalized in medical wards vs the intensive care unit—an observational, comparative study. J Crit Care 2007;22:13-7.
3. Guidelines for intensive care unit admission, discharge, and triage. Task Force of the American College of Critical Care Medicine, Society of Critical Care Medicine. Crit Care Med 1999;27:633-8.
4. Lemeshow S, Teres D, Klar J, Avrunin JS, Gehlbach SH, Rapoport J. Mortality Probability Models (MPM II) based on an international cohort of intensive care unit patients. JAMA 1993;270:2478-86.
5. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. Am J Respir Crit Care Med 2005;171:388-416.
6. Marshall JC, Cook DJ, Christou NV, Bernard GR, Sprung CL, Sibbald WJ. Multiple organ dysfunction score: a reliable descriptor of a complex clinical outcome. Crit Care Med 1995;23:1638-52.
7. Breslow N, Day NE. Statistical methods in cancer research. Volume II—The design and analysis of cohort studies. IARC Sci Publ 1987;82:1-406.
8. Finkelstein DM, Muzikansky A, Schoenfeld DA. Comparing survival of a sample to that of a standard population. J Natl Cancer Inst 2003;95:1434-9.
9. Ambrosino N, Vagheggini G. Noninvasive positive pressure ventilation in the acute care setting: where are we? Eur Respir J 2008;31:874-86.
10. Hill NS, Brennan J, Garpestad E, Nava S. Noninvasive ventilation in acute respiratory failure. Crit Care Med 2007;35:2402-7.
11. Torres A, Ferrer M, Blanquer JB, et al. Intermediate respiratory intensive care units: definitions and characteristics [in Spanish]. Arch Bronconeumol 2005;41:505-12.
12. Levin PD, Sprung CL. The process of intensive care triage. Intensive Care Med 2001;27:1441-5.
13. Fair allocation of intensive care unit resources. American Thoracic Society. Am J Respir Crit Care Med 1997;156:1282-301.
14. List of ethical guidance: Withholding and withdrawing – guidance for doctors. General Medical Council website: http://www.gmc-uk.org/guidance/ethical_guidance/witholding_lifeprolonging_guidance.asp. Accessed 8 May 2010.
15. Australian and New Zealand Intensive Care Society and College of Intensive Care Medicine of Australia and New Zealand: Statement on withholding and withdrawing treatment. Available online at: http://www.bonntech.com.au/testing/cicm/cmsfiles/IC-14%20Statement%20on%20Withholding%20and%20Withdrawing%20Treatment.pdf. Accessed 8 May 2010.