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Epidemiologic characteristics and outcomes of major trauma patients requiring prolonged mechanical ventilation

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Abstract

The epidemiologic characteristics and outcomes of severe trauma patients requiring prolonged mechanical ventilation (PMV) remain unclear. This retrospective study aims to investigate the outcomes of PMV in this specific group. All patients with major trauma admitted to the respiratory care center (RCC) requiring PMV (duration ≥21 days between January 2014 and December 2016) were enrolled. A total of 36343 trauma patients visited our emergency department for management, and 1388 (3.82%) were admitted to the intensive care unit (ICU) after initial resuscitation. After ICU management, 93 major trauma patients required PMV, and were then transferred to the RCC. Their mean age of these 93 patients was 68.6 ± 18.3 years and 65 patients (70.0%) were older than 65 years. Head/neck trauma (n = 78, 83.9%) were the most common injury, followed by thoracic trauma (n = 30, 32.2%), and extremity trauma (n = 29, 31.2%). Their median injury severity score was 25 (interquartile range [IQR] 16–27). The median length of hospital stay was 50 days (IQR, 39–62). Six patients died of ventilator-associated pneumonia for an in-hospital morality rate of 6.5%. In addition, 11 PMV patients became mechanical ventilator-dependent and were transferred to the respiratory care ward for further long-term care. In conclusion, <0.3% of trauma patients required PMV, and their in-hospital mortality rate was only 6.5%. Ventilator-associated pneumonia was the main cause of death and nosocomial infections were common in patients with long-term mechanical ventilator dependence.

Abbreviations: DM = diabetes mellitus, ICU = intensive care unit, IQR = interquartile range, ISS = injury severity score, MV = mechanical ventilation, NHI = National Health Insurance, PMV = prolonged mechanical ventilation, RCC = respiratory care center, RCW = respiratory care ward, VAP = ventilator-associated pneumonia.

Keywords: outcome, prolonged mechanical ventilation, trauma

1. Introduction

Worldwide, traumatic injury is a major cause of mortality, especially for young adults. For severely injured patients, comprehensive management consumes many resources, including aggressive resuscitation efforts, extensive image studies, multiple surgeries, prolonged intensive care, and complex rehabilitation programs.[1] Acute respiratory failure is a common complication in critical patients with major trauma and most of them require the support of mechanical ventilation (MV). Although many patients survive the acute stage and are successfully weaned off MV, whereas in the intensive care unit (ICU), a few have weaning problems and require prolonged mechanical ventilation (PMV), (duration >21 days).[2,3] In Taiwan, National Health Insurance (NHI) is a mandatory universal program, which covered 99% of the Taiwanese population by 2007. The NHI bureau developed an integrated prospective payment program to effectively use critical care resources for patients requiring PMV. In this system, MV care is divided into 4 types according to duration of use: fee-for-service intensive care unit (ICU) care (for up to 21 days), respiratory care centers (RCC) (for ≤42 days), capitation-based reimbursement for respiratory care ward (RCW), and per-month home ventilator services.[4] It is important to understand the outcomes and the prognosis of major trauma patients requiring PMV. Therefore, this study aims to investigate the epidemiologic characteristics and outcomes of major trauma patients requiring PMV.

2. Material and methods

2.1. Patients and hospital setting

This study was conducted in a regional hospital, which has 26 adult surgical ICU beds and 20 beds in an RCC. In our hospital, ICU care is given by an intensivist and the trauma team. In the RCC, a specialist in pulmonary and critical care medicine cares for all patients. The criteria for RCC admission include stable hemodynamic status without the demand for vasopressors, no

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new development of complicated arrhythmia or signs of acute coronary artery syndrome, stable renal function and normal acid-base balance, infection under control, and age >17 years. In our RCC, the nurse-to-patient ratio is 1:4; there is one respiratory therapist on every shift.

In this retrospective study, all major trauma patients requiring PMV and admitted to the RCC between January 2014 and December 2016 were identified from the registered trauma databank. Because the data were collected on a routine basis and the analysis was carried out retrospectively, informed consent was waived. Approval was obtained from the institutional review board of Chi Mei Medical Center.

2.2. Measurement of variables

The medical records of all recruited patients were retrospectively reviewed and the following information was collected: age, sex, initial triage[5] and presentation, injury severity score (ISS),[6] types of injuries to anatomical structures,[7] trauma mechanisms, comorbidities, surgical intervention, length of hospital stay, healthcare-associated infections (including ventilator-associated pneumonia [VAP], catheter-associated bloodstream infections, and catheter-associated urinary tract infections), and outcomes. As in a previous study,[3] comorbidities were defined as congestive heart failure, arrhythmia, coronary artery disease, chronic obstructive pulmonary disease, chronic kidney disease, chronic liver disease, diabetes mellitus (DM), dementia, parkinsonism, and cancer. The primary outcome was considered in-hospital mortality, and the secondary outcome was mechanical ventilator dependence.

2.3. Definitions

Healthcare-associated infection was defined according to the National Nosocomial Infection Surveillance guideline.[8] VAP was defined as pneumonia occurring >48 hours after patients had been intubated and received MV.[9,10] Catheter-associated urinary tract infection * was diagnosed for a urinary tract infection when an indwelling foley catheter was in place for >2 days on the date of the event.[11] Central line-associated bloodstream infections * was defined as a primary bacteremia or fungemia (excluding skin flora) in a patient with a central line at the time of (or within 48 hours before) the onset of symptoms and the infection was not related to an infection from another site.[12] In-hospital mortality was defined as death owing to any cause during hospitalization. Mechanical ventilator dependence was defined as failure to wean a patient from a ventilator during hospitalization and continued use of a ventilator after hospital discharge.

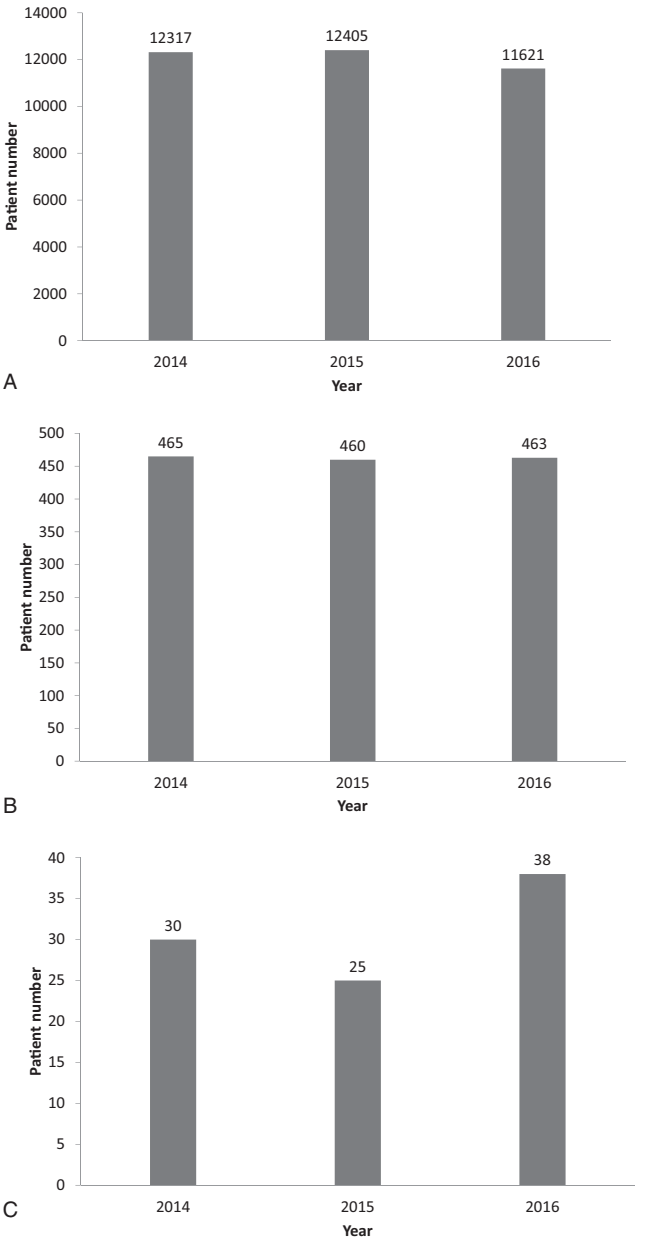

Figure 1. Annual number of traumatic patients visited emergency department (A), admitted to intensive care unit (B), and requiring prolonged mechanical ventilation (C).

3. Results

3.1. Patient characteristics

During the 3-year period, a total of 36,343 trauma patients visited our emergency department for management, and 1388 (3.82%) were admitted to the ICU after initial resuscitation. After ICU management, 93 major trauma patients required PMV, and were then transferred to the RCC (Fig. 1). Their mean age was 68.6±18.3 years, ranging from 19 to 98 years, and 65 patients (70.0%) were older than 65 years. Males comprised most of the patients (n=64, 68.8%). A total of 88.2% of patients had an initial triage level ≤2. The mean initial Glasgow coma score was 9.4. Head/neck trauma (n=78, 83.9%) was the most common injury, followed by thoracic trauma (n=30, 32.2%) and extremity trauma (n=29, 31.2%). The median ISS was 25 (interquartile range [IQR], 16–27) and 80 patients (86.0%) had an ISS ≥16. Hypertension was the most common comorbidity (n=46, 49.5%), followed by DM (n=28, 30.1%). Seventy-nine patients required surgical intervention of whom 68 (86.1%) required emergency surgery (Table 1).

3.2. Outcome analysis

The median length of hospital stay was 50 days (IQR, 39–62 days). The in-hospital mortality rate was 6.5% (n=6). Five of these 6 patients were older than 65 years. Four of them had only traumatic brain injury, 1 had only blunt chest trauma, and 1 had polytrauma. Five of them had an initial presentation of shock, and all of them had comorbidities. Five of them had an ISS >25

Table 1

Characteristics of major trauma patients required prolonged mechanical ventilation.

	No. (%) of patients (n = 93)
Age, y, mean ± SD	68.1 ± 17.6
Age ≥65 y, n (%)	65 (70.0)
Male, n (%)	64 (68.8)
Initial triage level ≤2, n (%)	82 (88.2)
Glasgow coma scores, median (IQR)	8 (5–15)
Type of injured anatomical structure	
Head and neck	78 (83.9)
Thorax	30 (32.2)
Abdomen and pelvis	13 (14.0)
Extremities	29 (31.2)
Face	9 (9.7)
ISS, median (IQR)	25 (16–27)
ISS ≥16	80 (86.0)
Co-morbidities	
Hypertension	46 (49.5)
Diabetes mellitus	28 (30.1)
Coronary artery disease	9 (9.7)
Congestive heart failure	5 (5.4)
Chronic obstructive pulmonary disease	5 (5.4)
Arrhythmia	5 (5.4)
Chronic kidney disease	3 (3.2)
Dementia	2 (2.2)
Asthma	2 (2.2)
Cancer	1 (1.1)
Parkinsonism	1 (1.1)
Chronic liver disease	1 (1.1)
Old stroke	1 (1.1)
Surgical intervention	79 (84.9)
Length of hospital stay, day, median (IQR)	50 (39–62)
Outcome	
Ventilator-dependent	11 (11.8)
In-hospital mortality	6 (6.5)

Data expressed as number (%), mean ± standard deviation (SD) or median with IQR. IQR = interquartile range, ISS = Injury Severity Score.

and 1 patient had a score of 9. The cause of death was VAP for all of 6 patients (Table 2). In addition, 11 PMV patients became mechanical ventilator-dependent and were transferred to a RCW for further long-term care. Nine (81.8%) of these patients were older than 65 years. Traumatic brain injury was the most common injury. Hypertension and DM were the most common medical conditions. During hospitalization, 9 (81.8%) patients had nosocomial infections, and VAP was the most common infection (Table 3).

4. Discussion

This study investigating the outcome of major trauma patients requiring PMV in Taiwan has several significant findings. First, among 36,343 patients who were admitted to our emergency department with trauma, 1388 (3.82%) patients required ICU admission and 93 (0.26%) required PMV. More than 80% of these 93 patients had head/neck injuries. The most common causes of respiratory failure in these PMV patients were poor consciousness and poor ability to clear secretions, which are features of neurologic impairment. A previous study[13] identified several risk factors for PMV including total fluid resuscitation, facial trauma, age, positive end-expiratory pressure ≥10 mmHg on admission, arterial partial pressure of oxygen divided by the fraction of inspired oxygen ratio <300 at 24 hours, and chest abbreviated injury scale score. In summary, major trauma patients requiring PMV are a specific group, which may have specific epidemiologic characteristics. In this study, only 0.26% of trauma patients required PMV, and head/neck injury-related poor consciousness level and poor airway maintenance were the main reasons. Second, VAP was the cause of all 6 deaths in this study. In contrast, the rate of VAP among the 87 survivors was only 23.0% (n = 20). A similar finding was shown in previous report[14] in which 43% of 51 trauma patients with respiratory failure had VAP. Actually, major trauma itself should be an acute illness. After surviving this acute critical illness, most patients do not have long-term life-threatening sequelae. Therefore, preventing complications, such as VAP, while in the ICU is important, as it can result in a fatal outcome. We introduced a ventilator bundle in all ICUs in our hospital in 2010 and this has effectively decreased the incidence of VAP.[9] In several previous reports, a ventilator bundle decreased the incidence of VAP, days of MV, length of ICU stay, and hospital costs.[15–18] However, we have not implemented this useful preventive measure in the RCC. Based on the findings of this study, we strongly suggest the importance of a ventilator bundle to prevent VAP in the RCC. It may help improve the outcomes of major trauma patients requiring PMV in the RCC.

Third, our overall in-hospital mortality rate was only 6.5%, which was much lower than in previous studies.[3,19,20] In an investigation based on Taiwan's longitudinal health insurance and death certificate data, the 3-month survival rate of a nationally representative sample of 25,482 patients with PMV from 1998 to 2003 was 51.4%, and the 1-year survival rate was 31.9%.[19] In another study conducted in a medical center in southern Taiwan between January 2006 and December 2014, a total of 320 of 1821 PMV patients died during hospitalization and the in-hospital mortality rate was 17.6%.[3] In another

Table 2

The clinical manifestations of 6 patients with mortalities.

Case	Age, y	Sex	Type of injured anatomical structure	Trauma mechanism	Initial shock	Medical disease	Injury severity score	Surgical intervention	Cause of death
1	68	Male	TBI, blunt chest trauma, facial trauma	MVA	Yes	Hypertension, DM	33	Yes	VAP
2	61	Male	TBI	MVA	Yes	ESRD, Hypertension, DM, chronic hepatitis B	75	No	VAP
3	75	Male	Blunt chest trauma	Falling	Yes	chronic hepatitis C	9	Yes	VAP
4	85	Male	TBI	MVA	Yes	Arrhythmia, prostatic cancer	75	Yes	VAP
5	72	Male	TBI	Falling	No	Hypertension, DM	25	Yes	VAP
6	83	Female	TBI	Falling	Yes	DM	25	Yes	VAP

DM = diabetes mellitus, ESRD = end stage renal disease, MVA = motor vehicle accident, TBI = traumatic brain injury, VAP = ventilator-associated pneumonia.

Table 3

The clinical manifestations of eleven patients with mechanical ventilator-dependent.

Case	Age, y	Sex	Type of injured anatomical structure	Medical disease	Injury severity score	Surgical intervention	Infectious complication
1	95	Female	TBI	Hypertension	25	No	VAP
2	77	Male	TBI	Hypertension, DM	33	Yes	No
3	76	Female	TBI, blunt chest trauma, blunt abdominal trauma	No	24	Yes	VAP, CAUTI
4	88	Female	TBI	Congestive heart failure	25	No	VAP
5	55	Male	TBI, blunt chest trauma, facial trauma	DM	24	Yes	VAP
6	65	Male	TBI	No	25	Yes	VAP
7	55	Male	TBI	DM	25	Yes	VAP
8	72	Male	Blunt abdominal trauma	Hypertension, CAD, COPD	16	Yes	VAP
9	86	Male	TBI	COPD	25	Yes	VAP
10	77	Female	Extremity trauma	CAD, asthma, chronic kidney disease	9	Yes	VAP, CLABSI
11	80	Female	TBI	Hypertension	16	Yes	No

CAD = coronary artery disease, CAUTI = catheter-associated urinary tract infection, CLABSI = catheter-associated bloodstream infection, COPD = chronic obstructive pulmonary disease, DM = diabetes mellitus, MVA = motor vehicle accident, TBI = traumatic brain injury, VAP = ventilator-associated pneumonia.

medical center in northern Taiwan, Kao et al[20] enrolled 1301 RCC patients between May 2001 and April 2007 with RCC survival rates ranging from 29.6% to 50.8%. In the US, Rubano et al[21] showed that in-hospital mortality rates were 17% to 34% for trauma patients requiring MV for at least 96 hours following injury. In another study[22] in the United States, hospital mortality rates were 29% to 49% for patients requiring MV >14 days. The difference in terms of mortality between this study and previous reports[2,3,19–22] could be because of different study populations and different definitions of PMV. In our study, we only enrolled patients with major trauma, and most did not have severe medical conditions. In contrast, most patients reported in previous studies[2,3,19] had various underlying comorbidities, such as end-stage renal disease and cancer, and these factors are notorious for poor outcomes in PMV patients.

Fourth, 11 patients (11.8%) became mechanical ventilator-dependent in this study. The age of this group was higher than the other 76 surviving patients without the use of MV (75.1 ± 12.7 vs 67.2 ± 19.3, $P < .05$). Previous studies[23] have also shown that age is a poor prognostic factor for PMV in trauma patients. In addition to age, we found that most of these ventilator-dependent patients had complications from nosocomial- and device-associated infections, including VAP, catheter-associated urinary tract infection, and central line -associated bloodstream infections. We should use more effort to prevent these infections in PMV patients. The implementation of central-line bundles, catheter-associated urinary tract infection bundles and ventilator bundles may help decrease these infectious complications.[9,11,12,24]

Our study has 2 major limitations. First, only the in-hospital mortality rate was measured in the present work. We did not assess the outcomes of patients after discharge, so long-term outcomes such as the 1-year survival rate are lacking. Second, our findings were based on a single institution and strict admission criteria were applied in our institution. Therefore, it cannot be generalized to patients in other hospitals or countries. Finally, many variables can affect patient outcomes, such as how many patients with VAP receive antibiotics in the first hour, or how many are on a lung protective ventilation strategy. These were not accounted for in this retrospective analysis. Further detailed analysis is warranted.

In conclusion, <0.3% of trauma patients required PMV, and their in-hospital mortality rate was only 6.5%. The major trauma patients requiring PMV in this study had favorable outcomes and the in-hospital mortality rate was lower than in other groups with PMV. VAP was the main cause of death and nosocomial infections were common in patients with long-term mechanical ventilator dependence.

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