P-ISSN 2586-9000
E-ISSN 2586-9027
Homepage : https://tci-thaijo.org/index.php/SciTechAsia
Science & Technology Asia
Vol. 27 No.4 October - December 2022
Page: [77-85]
Original research article

Assessment of Weaning from Mechanical Ventilation in Critically Ill Patients at Thammasat University Hospital

Narongkorn Saiphoklang*, Pattarin Pirompanich

Faculty of Medicine, Thammasat University, Pathum Thani 12120, Thailand

Received 16 June 2022; Received in revised form 8 December 2022;
Accepted 9 December 2022; Available online 31 December 2022

ABSTRACT

Separation from mechanical ventilation (MV) is a crucial process and a key challenge for intensive care unit (ICU) clinicians. Weaning methods vary widely in clinical practices. This study aimed to describe the clinical characteristics and outcomes of patients weaning from invasive MV in ICU settings. We conducted a prospective observational study in patients requiring MV with endotracheal intubation for at least 48 hours in a medical ICU. Patient and weaning characteristics, ICU length of stay, ICU mortality, and 90-day hospital mortality were recorded. Thirty-two patients (50% male) were included. Mean±SD age was 59.4±18.6 years. The sequential organ failure assessment (SOFA) scores were 10.7±4.3. The Acute Physiology and Chronic Health Evaluation (APACHE) II scores were 23.5±9.5. Hypoxemic respiratory failure (84.4%) was the most common indication for MV. Duration from initial weaning to successful separation from MV was 3.5±1.9 days. Weaning success within 14 days after ICU admission was 53.1%. ICU length of stay was 8.4±7.4 days. ICU mortality and 90-day hospital mortality rates were 31.3 % and 34.4%, respectively. There was no weaning of deceased patients. Compared to deceased patients, survivors had lower SOFA and APACHE II scores, peak airway pressure, respiratory rate, and positive end-expiratory pressure during MV use, but higher pH. The survived group had a higher proportion of effective cough than the deceased group. In conclusion, survived ICU patients had more effective cough. Deceased patients had higher ICU severity scores and worse respiratory parameters. These results suggest that ICU patients with severe illness who have ineffective cough need to be closely monitored and need to receive more interventions to improve clinical outcomes.

Keywords: Intensive care unit; Mechanical ventilation; Mortality; Weaning

***Corresponding author:** M_narongkorn@hotmail.com

1. Introduction

Separation from mechanical ventilation (MV) is a critical process and a key challenge for intensive care unit (ICU) clinicians [1, 2]. Weaning consists of 2 main processes: interruption of MV and extubation [3]. Weaning methods vary widely in clinical practices, including in the use of written directives to guide care, daily screenings, spontaneous breathing trial (SBT) strategies, ventilator modes, and clinician roles involving weaning [4]. Decision of extubation is usually done after a patient readiness test, involving an SBT with pressure support ventilation (PSV) or T-piece [5].

Daily screening of cardiopulmonary function, followed by SBTs can decrease ventilator-days and ICU cost, and is associated with less complications than usual care [6].

Weaning processes can be categorized into 3 groups according to the International Consensus Conference [1]: 1) simple weaning is successful extubation after the first SBT, 2) difficult weaning is the requirement of up to 3 SBTs or up to 7 days from the first SBT, and 3) prolonged weaning is the necessity for more than 3 SBTs or more than 7 days from the first SBT. Alternatively, weaning can also be classified into 4 groups according to the WIND (Weaning according to a New Definition) study: group NW is no weaning, group 1 is short weaning, group 2 is difficult weaning, and group 3 is prolonged weaning [7]. Up to 10 to 20% of patients are failed extubation which is associated with a higher mortality rate of 25 to 50% [5]. Hospital mortality rates were significantly increased in patients with prolonged (23.5%) and difficult (10.5%) weaning, compared to those with simple weaning (0%) [8].

Given the limited data on ventilator weaning in Thailand, this study aimed to describe the characteristics of weaning from invasive MV and clinical outcomes in ICU settings as it exists in the country of Thailand.

2. Materials and Methods

2.1 Study design and participants

From February to May 2018, we conducted a prospective observational study in the medical ICU at Thammasat University Hospital, Thailand. All patients aged 18 years or more who required MV with endotracheal intubation for at least 48 hours and ICU admission were included. Patients who died or underwent a tracheostomy before 48 hours were excluded from the study.

Ethics approval for this study was obtained from the Human Research Ethics Committee of Thammasat University No. 1 (Faculty of Medicine), Thailand (IRB No.MTU-EC-IM-1-179/60). All participants or their relatives provided written informed consent.

2.2 Baseline patient data and outcome measures

The collected data included age, gender, comorbidities, frailty severity as measured by the 7-point Clinical Frailty Scale [9] (a predictive tool used to assess frailty associated with death or need for institutional care), the sequential organ failure assessment (SOFA) score [10], the Acute Physiology and Chronic Health Evaluation (APACHE) II score, indications for ICU admission, admission source, initial mode of MV at ICU, respiratory parameters during initial MV use, and respiratory-related treatments. Reason for not starting weaning from MV, monitoring data during the first weaning attempt or day 2 of ICU admission, ventilatory support after extubation, status at ICU discharge and at 90 days, weaning duration, and ICU and hospital length of stay (LOS) were also recorded.

Cough strength was assessed through observation by doctors or nurses, every morning at 6am, and was classified into 1 of 3 groups; no cough, weak cough, or strong cough. An effective cough was defined as a strong cough.

The attending physicians supervised doctors and nurses in charge of the weaning process. All team members underwent pre-study training on weaning according to the standard recommendations of European/American respiratory and intensive care societies [1]. Weaning was attempted as early as possible during the patients' illnesses with a two-step approach in which readiness for weaning was assessed daily according to the standard criteria of the recommendation [1]. Patients who fulfilled these criteria underwent an SBT. The duration of the SBT was 30-120 minutes and consisted of either breathing with a T-piece or a weaning trial undergoing 5 cmH_2O pressure support with 5 cm H_2O positive end-expiratory pressure. When patients successfully passed the SBT, the physician in charge, in collaboration with the attending medical staff initiated the weaning process. If a patient failed the initial SBT, MV was reinstituted and the physician reviewed the possible reversible causes of the weaning failure, e.g., bronchospasm, secretion obstruction, pulmonary edema, and electrolyte imbalances. The SBT was repeated the following day if the patient then appeared ready for weaning. A patient was classified as a weaning success when he or she was extubated and breathing spontaneously without any invasive or noninvasive ventilatory support for ≥ 48 hours. Concordantly, weaning failure was defined as either the failure of an SBT or the need for reintubation within 48 hours following extubation [1]. Extubation failure in this study was defined as the inability to sustain spontaneous breathing after removal of an endotracheal tube and need for reintubation or non-invasive ventilation within 48 hours.

The clinical outcome measures were ICU LOS, hospital LOS, ICU mortality rate, and 90-day hospital mortality rate. Patients were divided into two groups; deceased and survived, based on their status at ICU discharge.

2.3 Statistical analysis

Data are expressed as either number (%), or mean ± SD. Chi-squared test was used to analyze the differences of categorical variables between the deceased and survived groups. Student's t-test was used to compare the means of continuous variables between two groups. A two-tailed *p*-value of less than 0.05 was interpreted as statistically significant. All statistical analyses were conducted using SPSS version 23.0 software (IBM Corp., Armonk, NY, USA).

3. Results

Thirty-five patients requiring MV were screened and 32 of these were included in the final analysis (Fig 1).

Mean patient age was 59.4±18.6 years and 50.0% were male. SOFA scores were 10.69±4.32 points. APACHE II scores were 23. 5±9.5 points. Diabetes was the most common comorbidity (34.4%). The most common indications for MV were hypoxemic respiratory failure (84.4%), sepsis/ septic shock (65.6%), and metabolic/ electrolyte disturbance (21.9%). General medical wards were the most common source of ICU admission (62.5%). The most common initial MV mode was pressure support (PS) ventilation (46.8%). Other patient baseline characteristics are shown (Table 1). The three most common reasons for not starting weaning were respiratory failure (62.5%), hemodynamic instability (46.9%), and fluid overload or pulmonary edema (40.6%) (Table 2). Effective cough was found in 59.4%. There was no weaning in deceased patients. A T-piece was more commonly used during MV weaning than was PS with positive end-expiratory pressure (PEEP) (53.1% vs 46.9%, *P*=0.075) for SBT (Table 2). Compared to deceased patients, survivors had significantly lower SOFA scores, higher use of PS ventilation as the initial MV mode, better respiratory parameters (lower peak airway pressure, lower total respiratory rate, lower PEEP, and higher pH), and lower use

of corticosteroids (Table 1). Moreover, the survived group had a higher proportion of effective cough than the deceased group (Table 2).

Table 3 shows weaning duration in survived patients (3.5±1.9 days). Patients in the survived group had a significantly longer hospital LOS but a lower 90- day hospital mortality rate than those in the deceased group (Table 3). The overall ICU mortality and 90-day hospital mortality rates were 31.3 % and 34.4%, respectively (Table 3). Five (22.7%) survived patients were rated as weaning failure. Causes of the weaning failure were bronchospasm (2 patients), secretion obstruction (1 patient), pulmonary edema (1 patient), and electrolyte imbalance (1 patient). Seven (100%) patients with daily sedation interruption were alive at ICU discharge and at 90 days. Six (85.7%) patients with daily sedation interruption were successfully weaned from MV.

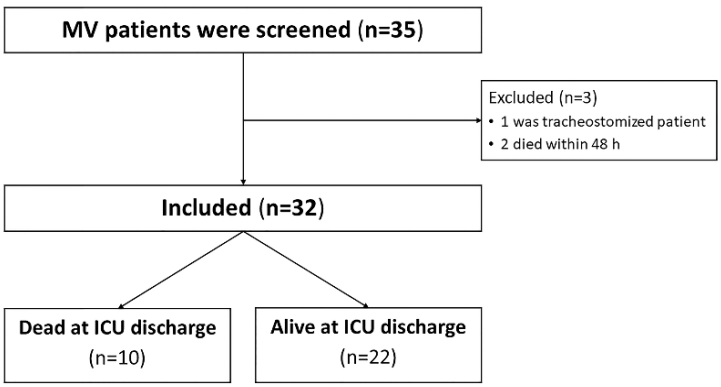

Fig. 1. Study flowchart of mechanically ventilated (MV) patients in intensive care unit (ICU).

Table 1. Baseline characteristics of patients requiring mechanical ventilation.

Characteristic	Total	Status at ICU discharge		*P*-value*
	n=32	Dead n=10	Alive n=22	
Age, years	59.4±18.6	56.40±21.3	60.8±17.7	0.547
Males	16 (50.0)	6 (60.0)	10 (45.5)	0.446
Body mass index, kg/m^2	22.5±4.3	21.0±3.9	23.1±4.4	0.206
Active smoker	3 (9.4)	0 (0)	3 (13.6)	0.534
Alcoholism	2 (6.3)	1 (10.0)	1 (4.5)	0.534
Comorbidity				
Diabetes	11 (34.4)	2 (20.0)	9 (40.9)	0.425
Dementia	7 (21.9)	1 (10.0)	6 (27.3)	0.480
Chronic heart failure	4 (12.5)	1 (10.0)	3 (13.6)	1.000
Chronic kidney disease	3 (9.4)	1 (10.0)	2 (9.1)	1.000
COPD	3 (9.4)	2 (20.0)	1 (4.5)	0.224
Solid malignancy	3 (9.4)	2 (20.0)	1 (4.5)	0.224
Hematologic malignancy	2 (6.3)	0 (0)	2 (9.1)	1.000
Chronic liver disease	2 (6.3)	1 (10.0)	1 (4.5)	0.534
ILD	1 (3.1)	0 (0)	1 (4.5)	1.000
Clinical Frailty Scale, points	4.2±1.7	4.6±2.0	4.0±1.6	0.396
SOFA score, points	10.7±4.3	14.3±4.6	9.1±3.1	0.001
APACHE II score, points	23.5±9.5	42.9±13.8	17.9±6.1	0.001
Indications for ICU admission				
Hypoxemic respiratory failure	27 (84.4)	8 (80.0)	19 (86.4)	0.506
Sepsis or septic shock	21 (65.6)	7 (70.0)	14 (63.6)	0.526
Metabolic or electrolyte disturbance	7 (21.9)	1 (10.0)	6 (27.3)	0.272
Cardiogenic pulmonary edema	6 (18.8)	2 (20.0)	4 (18.2)	0.627
Hypercapnic respiratory failure	2 (6.3)	2 (20.0)	0 (0)	0.091
Hypovolemic shock	2 (6.3)	0 (0)	2 (9.1)	0.466
Cardiac arrest	1 (3.1)	0 (0)	1 (4.5)	0.688
Neurologic impairment	1 (3.1)	0 (0)	1 (4.5)	0.688

Airway protection	1 (3.1)	0 (0)	1 (4.5)	0.688
Admission source				
General medical ward	20 (62.5)	6 (60.0)	14 (63.6)	1.000
Emergency department	6 (18.8)	3 (30.0)	3 (13.6)	0.264
Other ICUs	5 (15.6)	0 (0)	5 (22.7)	0.131
Other hospitals	1 (3.1)	1 (10.0)	0 (0)	0.313
Duration from intubation to ICU admission, hours	39.0±88.5	45.6±146.0	36.0±49.0	0.781
Initial mode of MV at ICU				
Pressure support ventilation	15 (46.8)	2 (20.0)	13 (59.1)	0.046
Pressure-controlled ventilation	11 (34.4)	4 (40.0)	7 (31.8)	0.474
Volume- controlled ventilation	6 (18.8)	4 (40.0)	2 (9.1)	0.060
Respiratory parameter at initial MV use				
Tidal volume, mL	474.6±133.7	438.4±91.0	491.8±148.8	0.307
Peak airway pressure, cmH_2O	22.1±7.0	27.9±8.6	19.4±4.0	0.013
Total respiratory rate, breaths/minutes	22.3±6.0	27.6±5.8	20.0±4.3	<0.001
PEEP, cmH_2O	6.7±2.9	8.9±4.1	5.6± 1.1	0.033
FiO_2	0.4±0.2	0.6±0.3	0.4±0.0	0.096
pH	7.39±0.10	7.30±.097	7.44±0.07	0.001
PaO_2, mmHg	124.0±60.1	104.6±54.9	135.9±62.1	0.257
$PaCO_2$, mmHg	36.3±13.9	39.6±20.1	34.2±8.6	0.491
SpO_2, %	97.5±4.6	94.9±6.8	99.0±1.8	0.110
Lactate, mmol/L	7.3±10.6	14.6±13.9	2.3±0.8	0.058
Respiratory-related treatments				
Opioids	17 (53.1)	6 (60.0)	11 (50.0)	0.445
Sedative agents	9 (28.1)	4 (40.0)	5 (22.7)	0.275
Neuromuscular blocking agents	4 (12.5)	3 (30.0)	1 (4.5)	0.079
Corticosteroids	15 (46.9)	9 (90.0)	6 (27.3)	0.001
Diuretics	14 (43.8)	7 (70.0)	7 (31.8)	0.051
Renal replacement therapy	7 (21.9)	4 (40.0)	3 (13.6)	0.115

Data are presented as n (%) or mean±SD.
**P*-value is used to compare between the deceased and the survived group.
APACHE II=Acute Physiology and Chronic Health Evaluation II, COPD=chronic obstructive pulmonary disease, FiO_2= fraction of inspired oxygen, ICU=intensive care unit, ILD=interstitial lung diseases, MV=mechanical ventilation, PaO_2=partial pressure of arterial oxygen, $PaCO_2$=partial pressure of arterial carbon dioxide, PEEP=positive end-expiratory pressure, pH=potential of hydrogen ion, SOFA=sequential organ failure assessment, SpO_2=pulse oxygen saturation

Table 2. Data of weaning from mechanical ventilation.

Data	Total n=32	Status at ICU discharge		*P*-value*
		Dead n=10	Alive n=22	
Reasons for not starting weaning from MV				
Respiratory failure	20 (62.5)	7 (70.0)	13 (59.1)	0.427
Hemodynamic instability	15 (46.9)	6 (60.0)	9 (40.9)	0.267
Fluid overload or pulmonary edema	13 (40.6)	3 (30.0)	10 (45.5)	0.335
Unconsciousness	5 (15.6)	1 (10.0)	4 (18.2)	0.494
Agitation or delirium	3 (9.4)	0 (0)	3 (13.6)	0.310
Airway protection	2 (6.3)	1 (10.0)	1 (4.5)	0.534
Monitoring during 1st weaning attempt or Day 2 of ICU admission				
Heart rate, beats/minutes	98.1±20.4	107.0±14.5	94.0±21.7	0.096
Mean arterial pressure, mmHg	85.6±19.2	77.1±21.0	89.5±17.4	0.090
Fluid balance in last 24 hours, mL	987.2±1518.2	1566.0±1962.0	724.1±1233.2	0.149
Serum sodium, mmol/L	139.0±6.7	136.7±8.6	140.1±5.5	0.190
Serum potassium, mmol/L	3.9±0.7	3.8±0.8	3.9±0.6	0.804
Moderate to large amount of secretions	14 (43.8)	4 (40.0)	10 (45.5)	0.541
Effective cough	19 (59.4)	2 (20.0)	17 (77.3)	0.004
Exercise in bed	2 (6.3)	0 (0)	2 (9.1)	0.466
Daily sedation interruption	7 (21.9)	0 (0)	7 (31.8)	0.051
SBT mode for weaning				
PS with PEEP	13 (40.6)	NA	13 (59.1)	NA
T-piece	9 (28.1)	NA	9 (40.9)	NA
Treatment option after extubation				
No oxygen therapy	3 (9.4)	NA	3 (13.6)	NA
Oxygen cannula or mask	7 (21.9)	NA	7 (31.8)	NA
Non-invasive ventilation	1 (3.1)	NA	1 (4.5)	NA
High-flow nasal cannula	9 (28.1)	NA	8 (36.4)	NA
Respiratory status at ICU discharge				

Intubation	4 (12.5)	NA	4 (18.2)	NA
Oxygen therapy	14 (43.8)	NA	14 (63.6)	NA
No oxygen therapy	4 (12.5)	NA	4 (18.2)	NA
Level of physical dependence at ICU discharge				
Independent	1 (3.1)	NA	1 (4.5)	NA
Partially dependent	15 (46.9)	NA	15 (68.2)	NA
Completely dependent	6 (18.8)	NA	6 (27.3)	NA

Data are presented as n (%) or mean±SD.
**P*-value is used to compare between the deceased and the survived group .
ICU=intensive care unit, MV=mechanical ventilation, NA=not applicable, PEEP=positive end-expiratory pressure, PS=pressure support, SBT=spontaneous breathing trial

Table 3. Clinical outcomes of patients requiring mechanical ventilation.

Data	Total n=32	Status at ICU discharge		*P*-value
		Dead n=10	Alive n=22	
Weaning success within 14 day after ICU admission	17 (53.1)	0 (0)	17 (77.3)	<0.001
Weaning duration, days	3.5±1.9	NA	3.5±1.9	NA
ICU length of stay, days	8.4±7.4	9.7±11.5	7.7±4.8	0.494
Hospital length of stay, days	36.6±51.1	11.1±7.4	48.2±58.1	0.007
ICU mortality	10 (31.3)	10 (100)	0 (0)	<0.001
90-day hospital mortality	11 (34.4)	10 (100)	1 (4.5)	<0.001

Data are presented as n (%) or mean±SD.
**P*-value is used to compare between the deceased and the survived group.
ICU=intensive care unit

4. Discussion

This is a prospective observational study among mechanically ventilated patients in the medical ICU of a tertiary care teaching hospital in Thailand. Although there are limited healthcare resources in our country (e.g. numbers of ICUs, beds, ICU devices and equipment, and trained ICU staff/ health care personnel), the clinical outcomes in our study, especially the 90-day hospital mortality rate (34%), were better than the predicted mortality rate (40%) assessed by ICU severity scores (SOFA score of 10 points and APACHE II score of 23 points) [11, 12]. This finding corresponds with the previous prospective study in our hospital by Saiphoklang et al. [8]. The study showed that the overall in-hospital mortality rate of MV patients in mixed wards including the medical ICU was 7.8%, and illness severity scores assessed by APACHE II were 12.5 points with a predicted mortality rate of 16.5% [8]. These findings may indicate that the standard of treatment at our medical ICU is higher than that at general hospitals.

The common indications for MV in our patients were hypoxemic respiratory failure or sepsis/septic shock, which corresponded to an international survey by Esteban et al. [13]. A majority of those patients requiring MV had postoperative respiratory failure, sepsis, pneumonia, acute respiratory distress syndrome, congestive heart failure, and trauma [13].

Daily sedation interruption was occasionally used (21%) for MV patients in our study but there was not a statistically significant difference between the deceased and the survived groups. The benefit of daily sedation interruption has been previously demonstrated in a study by Girard et al. [14]. They revealed that daily SBTs with sedative interruption had better clinical outcomes for MV patients than the standard care (ventilator-free day at 28 days, ICU LOS, and hospital LOS) but a higher proportion of self-extubation occurred in patients in the intervention group than in the control group.

In this study, there were no weaning attempts in deceased patients. For the weaning group, a T-piece was more commonly used (53%) as the SBT mode of weaning than PS ventilation (47%). SBT performance in this study differed from that of a multinational study. That multinational survey of weaning from MV in Asia by Leung et al. found that SBT as the initial weaning step was done 78.9% of the time; frequently to always PSV use alone in 44.3%, intermittent SBTs with PS in between

in 53.4%, and synchronized intermittent mandatory ventilation (SIMV) with PSV in 19.8% [15]. A study by Esteban et al. showed that once-daily SBTs led to extubation about 3 times quicker than SIMV and about twice as quickly as PSV; moreover, multiple daily SBTs were equally successful [16]. PS ventilation as an SBT mode produced significantly more successful weaning rates than T-piece use according to a study by Subirà et al. [17]. This randomized clinical trial investigating SBT modes of weaning in patients requiring MV showed that 30 minutes of 8-cmH_2O PS ventilation resulted in higher successful extubation rates than 2 hours of T-piece ventilation (82.3% vs 74.0%, P=0.001) [17]. Moreover, a post-hoc analysis of a clinical trial by Thille et al. found that in ICU patients at high risk of extubation failure, implementing an initial SBT using PSV was independently associated with successful extubation [18].

High-flow nasal cannula (HFNC) was the most common treatment used (36%) after extubation in our study. However, a study by Vaschetto et al. [19] found that the immediate use of noninvasive ventilation (NIV) after extubation increased days free of invasive MV without affecting the ICU LOS. The use of HFNC with NIV immediately after extubation in patients at high risk of extubation failure significantly decreased the risk of reintubation compared with HFNC alone [20].

Survived MV patients in our study had lower ICU severity scores (assessed by SOFA) and better respiratory parameters than deceased patients. These findings correspond to a study by Cheng et al. which found that among elderly patients requiring MV, the survived group had lower illness severity scores (as assessed by APACHE II) than the deceased group [21]. A study by Lee et al. showed that a lower APACHE II score was associated with weaning success, and furthermore, the successful weaning group had a significantly lower in-hospital mortality rate than the unsuccessful weaning group (0% vs 23.1%, respectively, P=0.01) [22].

Additionally, the survived MV patient group in our study had a higher proportion of effective cough than the deceased group. Weak cough was found to be a risk factor for weaning failure in a review by McConville et al. [23]. Cough strength assessed by cough peak expiratory flow can be a valuable method to predict extubation failure in MV patients who have passed an SBT according to a review by Jiang et al. [24]. Other risk factors for weaning failure are age 65 years or more, patients in medical, pediatric, or multispecialty ICUs, an APACHE II score greater than 12 on the day of extubation, pneumonia as a cause of respiratory failure, chronic heart failure, more than one coexisting condition other than heart failure, failure of at least 2 consecutive SBTs, a partial pressure of arterial carbon dioxide of more than 45 mmHg after extubation, and upper-airway stridor at extubation [23]. Moreover, bronchospasms, pneumonia, and malnutrition are also important risk factors for weaning failure [8].

There were a few limitations of this study. Firstly, the sample size was not large which decreased statistical power to distinguish significant differences in some variables. Secondly, the short duration of this observational study may have influenced study results because we could not exclude the possibility of revised decisions by the physician in charge, even though our medical ICU has a local ventilator weaning protocol for MV patients. Lastly, these study results come from a single center and so they might not reflect clinical outcomes at other hospitals.

5. Conclusion

Survived MV patients had a more effective cough. Respiratory failure was the most common reason for not starting weaning. Deceased patients had higher illness severity scores and poorer respiratory parameters. These results suggest that more

critical ICU patients who have an ineffective cough need to be closely monitored and should receive more interventions to improve clinical outcomes.

Acknowledgements

The authors would like to thank Michael Jan Everts, Faculty of Medicine, Thammasat University, for proofreading this manuscript.

The work was supported by Faculty of Medicine, Thammasat University, Thailand. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

References

[1] Boles JM, Bion J, Connors A, Herridge M, Marsh B, Melot C, et al. Weaning from mechanical ventilation. Eur Respir J 2007;29(5):1033-56.

[2] Caroleo S, Agnello F, Abdallah K, Santangelo E, Amantea B. Weaning from mechanical ventilation: an open issue. Minerva Anestesiol 2007;73(7-8):417-27.

[3] Alia I, Esteban A. Weaning from mechanical ventilation. Crit Care 2000;4(2):72-80.

[4] Burns KEA, Rizvi L, Cook DJ, Lebovic G, Dodek P, Villar J, et al. Ventilator weaning and discontinuation practices for critically ill patients. JAMA 2021;325(12):1173-84.

[5] Thille AW, Richard JC, Brochard L. The decision to extubate in the intensive care unit. Am J Respir Crit Care Med 2013;187(12):1294-302.

[6] Ely EW, Baker AM, Dunagan DP, Burke HL, Smith AC, Kelly PT, et al. Effect on the duration of mechanical ventilation of identifying patients capable of breathing spontaneously. N Engl J Med 1996;335(25):1864-9.

[7] Beduneau G, Pham T, Schortgen F, Piquilloud L, Zogheib E, Jonas M, et al. Epidemiology of weaning outcome according to a new definition. The WIND study. Am J Respir Crit Care Med 2017;195(6):772-83.

[8] Saiphoklang N, Auttajaroon J. Incidence and outcome of weaning from mechanical ventilation in medical wards at Thammasat University Hospital. PLoS One 2018;13(10):e0205106.

[9] Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173(5):489-95.

[10] Vincent JL, Moreno R, Takala J, Willatts S, De Mendonca A, Bruining H, et al. The SOFA (Sepsis- related Organ Failure Assessment) score to describe organ dysfunction/ failure. On behalf of the Working Group on Sepsis- Related Problems of the European Society of Intensive Care Medicine. Intensive Care Med 1996;22(7):707-10.

[11] Vincent JL, de Mendonca A, Cantraine F, Moreno R, Takala J, Suter PM, et al. Use of the SOFA score to assess the incidence of organ dysfunction/ failure in intensive care units: results of a multicenter, prospective study. Working group on "sepsis-related problems" of the European Society of Intensive Care Medicine. Crit Care Med 1998;26(11):1793-800.

[12] Ferreira FL, Bota DP, Bross A, Melot C, Vincent JL. Serial evaluation of the SOFA score to predict outcome in critically ill patients. JAMA 2001;286(14):1754-8.

[13] Esteban A, Anzueto A, Frutos F, Alia I, Brochard L, Stewart TE, et al. Characteristics and outcomes in adult patients receiving mechanical ventilation: a 28- day international study. JAMA 2002;287(3):345-55.

[14] Girard TD, Kress JP, Fuchs BD, Thomason JW, Schweickert WD, Pun BT, et al. Efficacy and safety of a paired sedation and ventilator weaning protocol for mechanically ventilated patients in intensive care (Awakening and Breathing Controlled trial): a randomised controlled trial. Lancet 2008;371(9607):126-34.

[15] Leung CHC, Lee A, Arabi YM, Phua J, Divatia JV, Koh Y, et al. Mechanical ventilation discontinuation practices in Asia: a multinational survey. Ann Am Thorac Soc 2021;18(8):1352-9.

[16] Esteban A, Frutos F, Tobin MJ, Alia I, Solsona JF, Valverdu I, et al. A comparison of four methods of weaning patients from mechanical ventilation. Spanish Lung Failure Collaborative Group. N Engl J Med 1995;332(6):345-50.

[17] Subira C, Hernandez G, Vazquez A, Rodriguez-Garcia R, Gonzalez-Castro A, Garcia C, et al. Effect of pressure support vs T-piece ventilation strategies during spontaneous breathing trials on successful extubation among patients receiving mechanical ventilation: a randomized clinical trial. JAMA 2019;321(22):2175-82.

[18] Thille AW, Coudroy R, Nay MA, Gacouin A, Demoule A, Sonneville R, et al. Pressure-support ventilation vs T-piece during spontaneous breathing trials before extubation among patients at high risk of extubation failure: a post-hoc analysis of a clinical trial. Chest 2020;158(4):1446-55.

[19] Vaschetto R, Longhini F, Persona P, Ori C, Stefani G, Liu S, et al. Early extubation followed by immediate noninvasive ventilation vs. standard extubation in hypoxemic patients: a randomized clinical trial. Intensive Care Med 2019;45(1):62-71.

[20] Thille AW, Muller G, Gacouin A, Coudroy R, Decavele M, Sonneville R, et al. Effect of postextubation high-flow nasal oxygen with noninvasive ventilation vs high-flow nasal oxygen alone on reintubation among patients at high risk of extubation failure: a randomized clinical trial. JAMA 2019;322(15):1465-75.

[21] Cheng AC, Liao KM, Ho CH, Lai CC, Chao CM, Chiu CC, et al. The prognosis in extremely elderly patients receiving orotracheal intubation and mechanical ventilation after planned extubation. Medicine (Baltimore) 2020;99(38):e21970.

[22] Lee JM, Lee SM, Song JH, Kim YS. Clinical outcomes of difficult-to-wean patients with ventilator dependency at intensive care unit discharge. Acute Crit Care 2020;35(3):156-63.

[23] McConville JF, Kress JP. Weaning patients from the ventilator. N Engl J Med 2012;367(23):2233-9.

[24] Jiang C, Esquinas A, Mina B. Evaluation of cough peak expiratory flow as a predictor of successful mechanical ventilation discontinuation: a narrative review of the literature. J Intensive Care 2017;5:33.