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Predictors of 1-year mortality in patients on prolonged mechanical ventilation after surgery in intensive care unit: a multicenter, retrospective cohort study

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Abstract

Objectives: The requirement of prolonged mechanical ventilation (PMV) is associated with increased medical care demand and expenses, high early and long-term mortality, and worse life quality. However, no study has assessed the prognostic factors associated with 1-year mortality among PMV patients, not less than 21 days after surgery. This study analyzed the predictors of 1-year mortality in patients requiring PMV in intensive care units (ICUs) after surgery.

Methods: In this multicenter, respective cohort study, 124 patients who required PMV after surgery in the ICUs of five tertiary hospitals in Beijing between January 2007 and June 2016 were enrolled. The primary outcome was the duration of survival within 1 year. Predictors of 1-year mortality were identified with a multivariable Cox proportional hazard model. The predictive effect of the ProVent score was also validated.

Results: Of the 124 patients enrolled, the cumulative 1-year mortality was 74.2% (92/124). From the multivariable Cox proportional hazard analysis, cancer diagnosis (hazard ratio [HR] 2.14, 95% confidence interval [CI] 1.37–3.35; $P < 0.01$), no tracheostomy (HR 2.01, 95% CI 1.22–3.30; $P < 0.01$), enteral nutrition intolerance (HR 1.88, 95% CI 1.19–2.97; $P = 0.01$), blood platelet count $\leq 150 \times 10^9$/L (HR 1.77, 95% CI 1.14–2.75; $P = 0.01$), requirement of vasopressors (HR 1.78, 95% CI 1.13–2.80; $P = 0.02$), and renal replacement therapy (HR 1.71, 95% CI 1.01–2.91; $P = 0.047$) on the 21st day of mechanical ventilation (MV) were associated with shortened 1-year survival.

Conclusions: For patients who required PMV after surgery, cancer diagnosis, no tracheostomy, enteral nutrition intolerance, blood platelet count $\leq 150 \times 10^9$/L, vasopressor requirement, and renal replacement therapy on the 21st day of MV were associated with shortened 1-year survival. The prognosis in PMV patients in ICUs can facilitate the decision-making process of physicians and patients' family members on treatment schedule.

Keywords: Intensive care unit, Prolonged mechanical ventilation, Postoperative patients, 1-year mortality

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Introduction

Mechanical ventilation (MV) is a frequently applied invasive technique to patients admitted in the intensive care unit (ICU). Although MV is usually seen as a life-saving strategy, it has a strong potential to worsen the prognosis with prolonged use. According to the 2005 consensus of the National Association for Medical Direction of Respiratory Care (NAMDRC), prolonged mechanical ventilation (PMV) is defined as the requirement of MV for more than 6 h daily and that lasts for more than 21 consecutive days [1]. The requirement of PMV is associated with increased medical care demand and expenses [2, 3], high early and long-term mortality [4, 5], and worse life quality [6–9]. Therefore, it is necessary to evaluate the prognosis in PMV patients in ICUs to facilitate the decision making process of the physicians and patients' family members on treatment schedule in the ICUs.

In 2008, Carson and colleagues [10] developed a mortality-prediction model (Prognosis for Prolonged Ventilation, i.e., ProVent score) to estimate the risk of 1-year mortality in patients receiving MV for at least 21 days. They used four factors including age, platelet count, use of vasopressors, and requirement of renal replacement therapy to calculate the ProVent score. Another study showed only low platelet count on the 21st day of MV as a predictor of 1-year mortality in patients requiring PMV in a medical ICU in Korea [11]. However, in a mixed ICU study in France, use of vasopressors, and requirement of renal replacement therapy are predictors of 1-year mortality in patients requiring PMV [12]. Therefore, due to the inconsistent findings, further studies are needed to evaluate this further. In addition, no study has yet to demonstrate the predictors of 1-year mortality in patients requiring PMV in ICU after surgery. The purpose of this study was to analyze the predictors of 1-year mortality in patients requiring PMV in ICU after surgery.

Material and methods

This was a multicenter, retrospective cohort study.

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of Peking University First Hospital (2017[1422]). As the study was purely observational and retrospective in nature, the Ethics Committee agreed to exempt the written informed consent. However, all enrolled patients or their family members had to verbally agree to participate in the long-term follow-up before the data collection.

Patients

Patients who required MV after surgery in the ICUs in five tertiary hospitals (Peking University First Hospital, Peking University Third Hospital, China-Japan Friendship Hospital, Beijing Cancer Hospital, and Beijing Hospital) in Beijing between January 2007 and June 2016 were screened. The inclusion criteria were those aged 18 years or older, admitted to the ICU after surgery, and received MV for at least 21 consecutive days. Patients who met any of the following criteria were excluded: acute or chronic neuromuscular diseases (such as Guillain-Barré syndrome, muscular dystrophy, amyotrophic lateral sclerosis, or myasthenia gravis), requirement of invasive MV before ICU admission, or incomplete clinical information.

Patient and public involvement

The research question and outcome were not informed by patients' priorities, experience, and preference. Patients didn't involve in the design of this study. Patients didn't involve in the recruitment to and conduct of the study. The results wasn't disseminated to study participants. All enrolled patients or their family members verbally agree to participate in the long-term follow-up before the data collection and researchers thanked them.

Clinical data collection

Data were collected using the medical record system in each hospital. Baseline data included demographic characteristics (age and gender), preoperative comorbidities, the New York Heart Association (NYHA) functional classification, liver and renal function tests, radio- or chemotherapy within 6 months, reason for surgery, location of surgery. Others included the scores of Sequential Organ Failure Assessment (SOFA) [13] and Acute Physiology and Chronic Health Evaluation (APACHE) II within the first 24 h after ICU admission.

On the 21st day of MV, data including platelet count, requirement of renal replacement therapy (currently or within 48 h), use of vasopressors (currently or within 48 h), mode of nutritional supplementation, state of consciousness, presence of multi-drug resistant bacterial infection, and performance of tracheostomy were collected. Other data including the duration of MV, length of stay in ICU and hospital, and ICU and hospital mortalities, were recorded. The 3-month, 6-month, and 1-year survival status after day 21 of MV were documented from the medical record system or at follow-up. The record was checked every three months.

Statistical analysis

Patients were divided into survivor and non-survivor groups according to the 1-year survival status.

Continuous variables were presented as means ± standard deviation (SD) or median (interquartile range [IQR]) and compared with unpaired t test or Mann-Whitney U test. Categorical variables were presented as numbers (%) and compared using χ^2 or Fisher's exact test. The 95% confidence interval (CI) of mortality in patients was estimated by the Bootstrap method (the number of execution samples was 1000).

Factors in association with 1-year survival were analyzed using the Cox proportional hazard model. Factors with number of events > 10 were screened. Ten factors were identified at univariate analysis. Those with $P <$ 0.10 were included in the multivariate model after testing for collinearity. Collinearity of factors were tested using linear regression. Independent factors in association with 1-year survival were identified using a backward stepwise method. The effects of the combination of our multivariate factors and the ProVent score in predicting 1-year survival in patients with PMV were compared using the receiver operator characteristic (ROC) curves and the area under the curve (AUC). All tests were two-sided. P values ≤0.05 were considered statistically significant. Statistical analysis was performed with the SPSS 21.0 software package (Inc, Chicago, IL).

Results
Patient recruitment and baseline characteristics
From January 2007 to June 2016, 33,131 patients who were admitted to ICUs in the 5 tertiary hospitals were screened for study participation. Of these, 156 patients (0.5%) required PMV after surgery (incidence of PMV was 0.5%); and 124 (0.4%) fulfilled the inclusion/

exclusion criteria and were included in the final statistical analysis (Fig. 1).

Of 124 patients included in the study, mean (±SD) age was 66.5 (±16.5) years, 72.6% (90/124) were male, and 35.5% (44/124) underwent cancer surgery (Table 1).

Status on day 21 of mechanical ventilation
Compared with 1-year non-survivors, those who survived underwent more tracheostomy ($P < 0.01$) and enteral nutrition ($P = 0.01$), suffered less from low platelet-count ($\leq 150 \times 10^9$/L; $P = 0.02$), and required less renal replacement therapy ($P = 0.03$) (Table 2).

Outcomes
Of all included patients, when counted from the 21st day of MV, the median duration of MV was 35 days (interquartile range [IQR] 27–61). The median length of stay in ICU and hospital were 44.0 (IQR 31.3–73.5) and 65.5 (IQR, 41.3–117.3) days, respectively. The mortality rates were 67.7% [84/124] (95% confidence interval [CI] 59.7–75.8%) in ICU, 71.0% [88/124] (95% CI 62.9–79.0%) in hospital, and 74.2% [92/124] (95% CI 66.9–81.5%) at 1 year. The main cause of death was multiple organ failure syndrome (MODS) induced by septic shock (67.0% [59/124]).

Factors associated with 1-year survival
Factors with number of events > 10 were screened. Ten factors were identified at univariate analysis ($P < 0.10$) (Table 3).

Of these, SOFA score was excluded because of collinearity with APACHE II score. The remaining nine
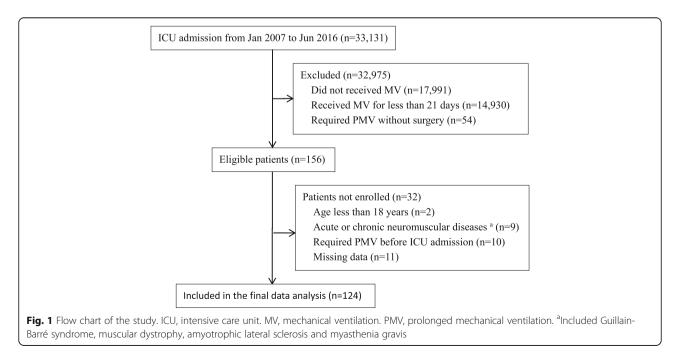

Fig. 1 Flow chart of the study. ICU, intensive care unit. MV, mechanical ventilation. PMV, prolonged mechanical ventilation. [a]Included Guillain-Barré syndrome, muscular dystrophy, amyotrophic lateral sclerosis and myasthenia gravis

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Table 1 Baseline characteristics

	Total (N = 124)	Non-survivors (N = 92)	Survivors (N = 32)	P value
Age (y)	66.5 ± 16.5	67.8 ± 15.8	62.8 ± 18.1	0.138
Male sex	90 (72.6)	67 (72.8)	23 (71.9)	0.917
Preoperative comorbidities				
Central nervous system	24 (19.4)	19 (20.7)	5 (15.6)	0.535
Stroke	16 (12.9)	13 (14.1)	3 (9.4)	0.760
Cephalomeningitis	5 (4.0)	3 (3.3)	2 (6.3)	0.603
Parkinsonism	2 (1.6)	2 (2.2)	0 (0.0)	> 0.999
Intracranial aneurysm	1 (0.8)	1 (1.1)	0 (0.0)	> 0.999
Dementia	1 (0.8)	1 (1.1)	0 (0.0)	> 0.999
Respiratory system	37 (29.8)	27 (29.4)	10 (31.3)	0.839
Smoking [a]	31 (25.0)	22 (23.9)	9 (28.1)	0.636
Tuberculosis	5 (4.0)	5 (5.4)	0 (0.0)	0.326
Asthma	4 (3.2)	3 (3.3)	1 (3.1)	> 0.999
COPD	4 (3.2)	2 (2.2)	2 (6.3)	0.274
Pulmonary heart disease	1 (0.8)	1 (1.1)	0 (0.0)	> 0.999
Circulatory system	79 (63.7)	59 (64.1)	20 (62.5)	0.869
Hypertension	66 (53.2)	49 (53.3)	17 (53.1)	0.989
Coronary heart disease	27 (21.8)	22 (23.9)	5 (15.6)	0.328
Arrhythmia	14 (11.3)	8 (8.7)	6 (18.8)	0.122
Cardiomyopathy	1 (0.8)	1 (1.1)	0 (0.0)	> 0.999
Metabolic and immune system	35 (28.2)	30 (32.6)	5 (15.7)	0.066
Diabetes	24 (19.4)	21 (22.8)	3 (9.4)	0.097
Hyperlipemia	5 (4.0)	5 (5.4)	0 (0.0)	0.326
Thyroid disease	2 (1.6)	2 (2.2)	0 (0.0)	> 0.999
Rheumatoid arthritis	2 (1.6)	1 (1.1)	1 (3.1)	0.451
Gout	1 (0.8)	1 (1.1)	0 (0.0)	> 0.999
Systemic lupus erythematosus	1 (0.8)	0 (0.0)	1 (3.1)	0.258
NYHA functional classification				0.058
I	63 (50.8)	42 (45.7)	21 (65.6)	
II	34 (27.4)	30 (32.6)	4 (12.5)	
III	17 (13.7)	11 (12.0)	6 (18.8)	
IV	10 (8.1)	9 (9.8)	1 (3.1)	
Abnormal liver function [b]	5 (4.0)	4 (4.4)	1 (3.1)	> 0.999
Abnormal renal function [c]	5 (4.0)	4 (4.4)	1 (3.1)	> 0.999
Radio–/chemotherapy in 6 months	4 (3.2)	2 (2.2)	2 (6.3)	0.274
Cancer surgery	44 (35.5)	40 (43.5)	4 (12.5)	0.002
Location of surgery				0.015
Intra-thoracic	45 (36.3)	39 (42.4)	6 (18.8)	
Intra-abdominal	40 (32.3)	30 (32.6)	10 (31.3)	
Others [d]	39 (31.5)	23 (25.0)	16 (50.0)	
Preoperative ASA classification				0.270
I	10 (8.1)	9 (9.8)	1 (3.1)	
II	63 (50.8)	43 (46.7)	20 (62.5)	

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Table 1 Baseline characteristics *(Continued)*

	Total (N = 124)	Non-survivors (N = 92)	Survivors (N = 32)	P value
III	22 (17.7)	16 (17.4)	6 (18.8)	
IV	29 (23.4)	24 (26.1)	5 (15.6)	
Urgent surgery	37 (29.8)	27 (29.3)	10 (31.3)	0.839
ICU admission for new onset POCs	31 (25.0)	18 (19.6)	13 (40.6)	0.018
Scores on ICU admission				
SOFA score	7.4 ± 3.3	7.6 ± 3.4	6.5 ± 2.5	0.051
APACHE II score	20.0 ± 7.3	20.9 ± 7.7	19 ± 5.7	0.210

Results are presented as mean ± SD and numbers (%)

COPD, chronic obstructive pulmonary diseases. NYHA, the New York Heart Association. ICU, intensive care unit. POCs, postoperative complications. SOFA, sequential organ failure assessment. APACHE, acute physiology and chronic health evaluation

[a]Smoking for more than 10 cigarettes per day for more than 1 year, including current or past smokers

[b]Serum alanine transaminase or aspartate transaminase higher than 5 times of the normal upper limit

[c]Defined as glomerular filtration rate (GFR) < 60 ml/min/1.73 m^2

[d]Include neurosurgery, thyroid surgery and orthopedic surgery

factors were included in the multivariate Cox proportional hazard model. Six independent factors were identified to be associated with 1-year survival. Cancer surgery (hazard ratio [HR] 2.14, CI 1.37–3.35; $P < 0.01$), no tracheostomy (HR 2.01, 95% CI 1.22–3.30; $P < 0.01$), enteral nutrition intolerance (HR 1.88, 95% CI 1.19–2.97; $P = 0.01$), platelet count ≤150 × 10^9/L (HR 1.77, 95% CI 1.14–2.75; $P = 0.01$), vasopressor requirement (HR 1.74, 95% CI 1.11–2.74; $P = 0.02$), and renal replacement therapy (HR 1.71, 95% CI 1.01–2.91; $P = 0.047$) on the 21st day of MV were associated with shortened 1-year survival (Table 4).

Comparison between the combination of our multivariate factors and the ProVent score in predicting 1-year mortality

The combination of multivariate factors could be used in predicting 1-year survival in these patients with PMV after surgery (area under curve [AUC] 0.81 [95% CI 0.72–0.89]). The ROC curve was based on the combination of all the 6 independent predictors of death.

There was significant difference between the combination of our multivariate factors and the ProVent score in predicting 1-year mortality in these patients with PMV after surgery (area under curve [AUC] 0.81 [95% CI 0.72–0.89] vs. 0.69 [95% CI 0.58–0.80]; $P < 0.01$) (Fig. 2).

Discussion

Despite a small incidence of postoperative PMV of only 0.5%, among patients, the mortality were as high as 67.7 and 71.0% in the ICU and hospital, respectively. In studies on patients with PMV in ICUs, the reported 1-year mortality varied from 48 to 67% [11, 12, 14], which is lower than that in our cohort (74.2%). Patients on PMV after surgery had worse 1-year prognosis than patients in mixed and medical ICUs. From the China National Committee on Aging data (http://www.cncaprc.gov.cn/

Table 2 Patients' situation on the 21st day of mechanical ventilation

Situation on 21st day of MV	Total (N = 124)	Non-survivors (N = 92)	Survivors (N = 32)	P value
No tracheostomy	31 (25.0)	30 (32.6)	1 (3.1)	< 0.01
Consciousness (GCS = 15)	74 (59.7)	54 (43.6)	20 (62.5)	0.71
Drug-resistant bacteria infection	63 (50.8)	51 (55.4)	12 (37.5)	0.08
MDR	50 (40.3)	39 (42.4)	11 (34.4)	0.43
XDR	13 (10.5)	12 (13.0)	1 (3.1)	0.18
Intolerance of enteral nutrition[a]	43 (34.7)	38 (41.3)	5 (15.6)	0.01
Platelet ≤150 × 10^9/L	49 (39.5)	42 (45.7)	7 (21.9)	0.02
On vasopressors	41 (33.1)	33 (35.9)	8 (25.0)	0.26
On renal replacement therapy	24 (19.4)	22 (23.9)	2 (6.3)	0.03

Results are presented as mean ± SD, median (interquartile range) and numbers (%)

MV, mechanical ventilation. GCS, Glasgow coma scale. MDR, multi-drug-resistant. XDR, Extensively drug-resistant

[a]Included total parenteral and combined enteral-parenteral nutrition

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Table 3 Risk factors in association with 1-year survival
(univariate Cox Proportional Hazard analyses)

Risk factors	N	HR (95% CI) [a]	P value
Baseline characteristics			
Age (y)			
< 50	20	1.000	
50–64	25	1.06 (0.51–2.19)	0.89
≥ 65	79	1.48 (0.81–2.69)	0.20
Male sex	90	1.05 (0.66–1.66)	0.85
Stroke	16	1.09 (0.60–1.95)	0.78
Smoking [b]	31	1.18 (0.73–1.90)	0.51
Hypertension	66	1.09 (0.72–1.64)	0.69
Coronary heart disease	27	0.87 (0.54–1.40)	0.56
NYHA functional classification			
I + II	97	1.000	
III + IV	27	1.01 (0.62–1.66)	0.97
Diabetes	24	1.13 (0.89–1.44)	0.33
Cancer diagnosis	44	1.20 (0.98–1.48)	0.08
Location of surgery			
Others [c]	39	1.000	
Intra-thoracic/abdominal	85	1.73 (1.08–2.78)	0.02
SOFA score on ICU admission	124	1.09 (1.01–1.16)	0.02
APACHE II score on ICU admission	124	1.03 (1.00–1.06)	0.037
Situation on the 21st day of MV			
No tracheostomy	31	2.67 (1.70–4.17)	< 0.001
Consciousness (GCS = 15)	74	0.79 (0.52–1.20)	0.27
MDR/XDR bacterial infection	63	1.53 (1.02–2.32)	0.042
Intolerance of enteral nutrition [d]	43	1.90 (1.25–2.90)	< 0.01
Platelet $\leq 150 \times 10^9$/L	49	1.97 (1.30–2.97)	< 0.01
On vasopressors	41	1.70 (1.11–2.61)	0.02
On renal replacement therapy	24	1.59 (0.97–2.61)	0.068

HR, hazard ratio. CI, confidence interval. NYHA, the New York Heart
Association. ICU, intensive care unit. SOFA, sequential organ failure
assessment. APACHE, acute physiology and chronic health enquiry. MV,
mechanical ventilation. GCS, Glasgow coma scale. MDR, multi-drug-resistant.
XDR, Extensively drug-resistant
[a]Factors with number of events > 10 were included. [b] Smoking of more than
10 cigarettes per day for more than 1 year, including current or previous
smokers. [c] Included neurosurgery, thyroid surgery, and orthopedic surgery. [d]
Included total parenteral and combined enteral-parenteral nutrition

contents/37/69715.html), people older than 60 years will
be about 248 million by 2020 (17% of the present population in China). Along with an aging population is the
progression in medical technology and therapeutic theory, the number of PMV patients will also be increasing
in China with time. Thus, it is of great clinical significance to evaluate the prognosis of PMV patients in
ICUs.

Our results showed that, for patients requiring
PMV after surgery, cancer surgery, together with no
tracheostomy, enteral nutrition intolerance, platelet

count $\leq 150 \times 10^9$/L, use of vasopressors and renal replacement therapy on the 21st day of MV was associated with shortened 1-year survival. Since it is a
retrospective study, it is impossible to know whether
the factors associated with mortality are markers of
severity or determinants of death.

A study showed that low platelet count, use of vasopressors, and requirement of renal replacement
therapy on day 21 of MV are predictors of 1-year
mortality in PMV patients in a mixed ICU in the
United States [14], which is similar to our finding.
The same study showed that age was a predictor of
1-year mortality in PMV patients, but this was not
demonstrated in our study; this might have been
caused by the different study populations. In critically ill patients, thrombocytopenia is usually caused
by severe infections, side effect of medications, and
myelosuppression among others; which is regarded
as a sign of illness aggravation [15]. Requirement of
vasopressors implies an unstable circulation, which is
associated with higher occurrence of multiple organ
dysfunction syndrome (MODS) [16]. In patients with
sepsis and MODS, requirement of vasopressors is
also associated with increased 1-year and 5-year
mortality [17]. Requirement of renal replacement
therapy on the 21st day of MV is usually caused by
renal failure, and is also regarded as a sign of poor
prognosis [12].

A study showed that the overall 1-year survival rate in
PMV cancer patients was 14.3% [13], which was poorer
generally, than that in patients with other comorbidities
[18]. After cancer surgery, PMV patients showed poor
prognosis, which could be attributed to the cancer itself
as well as the development of cancer recurrence/metastasis after surgery [19, 20].

In a study involving 429 patients which evaluated
hospital and long-term outcome after tracheostomy
for respiratory failure, the results showed that those
who were weaned off MV and placed on tracheostomy tubes had lower 3-year mortality than
ventilator-dependent patients ($P < 0.001$) [21]. In the
present study, the patients not inserting tracheostomy might often meant with high risk of death, and
have increased the use of sedatives and opioids,
maybe dependence on MV ultimately, which was associated with prolonged 1-year mortality.

Critically ill patients on MV are at risk of underfeeding
and progressive malnutrition, and this population often
receives less than the required energy and protein [22].
Enteral nutrition (EN) is preferred over parenteral nutrition (PN) because it is more physiological and less likely
to result in hepatobiliary dysfunction and electrolyte imbalance [23]. In addition, when compared with EN, use
of PN has been linked to higher incidence of infection,

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Table 4 Predictors of 1-year survival (multivariate Cox Proportional Hazard analyses)

Predictors	Univariate analysis	Multivariate Analysis [a]	
	P value	HR (95% CI)	P value
Cancer diagnosis	0.083	2.14 (1.37–3.35)	< 0.01
Intra-thoracic/abdominal surgery (vs. others) [b]	0.023	–	–
SOFA score on ICU admission [c]	0.019	–	–
APACHE II score on ICU admission	0.037	–	–
No tracheostomy on day 21 of MV	< 0.001	2.01 (1.22–3.30)	< 0.01
MDR/XDR bacterial infection on day 21 of MV	0.042	–	–
Intolerance of enteral nutrition on day 21 of MV [d]	0.003	1.88 (1.19–2.97)	0.01
Platelet ≤150 × 10^9/L on day 21 of MV	0.001	1.77 (1.14–2.75)	0.01
On vasopressors on day 21 of MV	0.015	1.74 (1.11–2.74)	0.02
On renal replacement therapy on day 21 of MV	0.068	1.71 (1.01–2.91)	0.047

HR, hazard ratio. CI, confidence interval. ICU, intensive care unit. SOFA, sequential organ failure assessment. APACHE, acute physiology and chronic health evaluation. MV, mechanical ventilation. MDR, multi-drug-resistant. XDR, Extensively drug-resistant
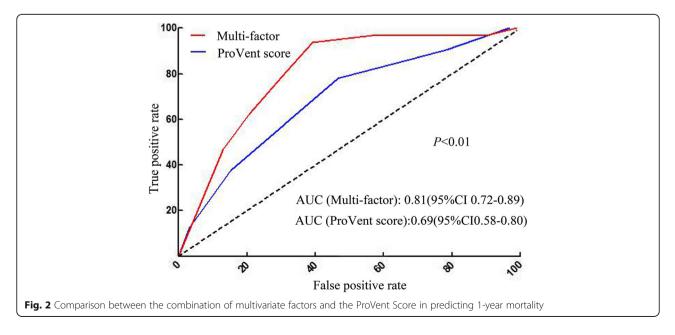[a]Factors with P < 0.10 and number of outcomes > 10 were included in the multivariate model (Backward). [b]Included neurosurgery, thyroid surgery, and orthopedic surgery. [c] Not included because of collinearity with APACHE II score. [d] Included total parenteral and combined enteral-parenteral nutrition

impaired wound healing, and gastrointestinal bleeding [24].

The multivariate Cox proportional model can be used as a prognostic assessment tool for critically ill patients after surgery in the future. Clinicians should not only pay attention to platelet count, use of vasopressors, and the need for renal replacement on the 21st day of MV in patients, but also to assess whether patients have malignant tumors, need tracheostomy, and enteral nutritional support.

The area under curve for the combination of our multivariate factors was more than the area for the ProVent score. There was significant difference between the

ProVent score and the combination of our multivariate factors in predicting 1-year survival using ROC curves, however, the sample size was relatively small and the comparison might be unconvincing.

This study had major limitations. First, the sample size was relatively small. Patients requiring PMV after surgery had a small sample size, with a percentage of only 0.5% in our study. A larger sample size is needed to develop a more accurate predictive model. Secondly, our study retrospectively analyzed patients' data over a long period. Clinical practice and, thus, patient characteristics might have changed during that period, which made it lack of validation.

Fig. 2 Comparison between the combination of multivariate factors and the ProVent Score in predicting 1-year mortality

Conclusions

For patients requiring PMV after surgery, cancer diagnosis, no tracheostomy, enteral nutrition intolerance, low platelet count, and dependence on vasopressors and renal replacement therapy on the 21st day of MV were associated with worse 1-year survival. The prognosis in PMV patients in ICUs can facilitate the decision that making process of the physicians and patients' family members on treatment schedule.

Abbreviations
APACHE: acute physiology and chronic health evaluation; CI: confidence interval; COPD: chronic obstructive pulmonary diseases; GCS: Glasgow coma scale; HR: hazard ratio; ICU: intensive care unit; MDR: multi-drug-resistant; MV: mechanical ventilation; NYHA: the New York Heart Association; POCs: postoperative complications; SOFA: sequential organ failure assessment; XDR: Extensively drug-resistant

Authors' contributions
YMS and SLL contributed to data interpretation, drafting of the manuscript and critical revision of the manuscript. SPW, CL, GL, JXX, HZW, FL, GQY, ZGC and YLL contributed to data collection and data interpretation. MXS contributed to data interpretation and performed statistical analysis. DXW contributed to interpretation and critical revision of the manuscript. SLL and DXW chaired the group, conceived and designed the study, performed statistical analysis and contributed to data collection, data interpretation and critical revision of the manuscript. All authors reviewed the manuscript. All authors read and approved the final manuscript.

Availability of data and materials
The datasets generated and/or analysed during the current study are not publicly available due to when individual privacy could be compromised but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate
The study protocol was approved by the Ethics Committee of Peking University First Hospital (2017[1422]). As the study was pure observational and retrospective in nature, the Ethics Committee agreed to exempt the written informed consent. However, all enrolled patients or their family members had verbally agreed to participate in the long-term follow-up before collecting data.

Consent for publication
The manuscript has been read and its submission approved by all coauthors.

Competing interests
The authors declare that they have no financial or non-financial competing of interest.

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