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APACHE II score predicts mortality in patients requiring prolonged ventilation in a weaning center

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Abstract

Background: Little is known about the diagnostic accuracy of the APACHE II scoring system in prolonged mechanical ventilation. The aim of this study was to assess the utility of APACHE II in order to predict in-hospital mortality, length of stay (LOS) and discharge destination of patients in a weaning centre.

Methods: The study group included 130 consecutive patients (median age 71 years; IQR 62–77). APACHE II was assessed based on the worst values taken during the first 24 hours post admission. The primary outcome was in-hospital mortality. LOS and discharge destination were considered secondary outcomes.

Results: The APACHE II median score was 11 points (IQR 9–14) while 15 patients (11.5%) died. Mortality was lower in men (10.3%) than in women (14%) ($P = 0.04$). APACHE II was higher in non-survivors (15; IQR 10.25–19.5) compared to survivors (11; 8.25–14) ($P < 0.001$). In a bivariate analysis, APACHE II predicted mortality with good diagnostic accuracy (AUROC = 0.714; $P = 0.007$). In a multivariate analysis APACHE II (OR = 1.22; 95% CI: 1.06–1.40 per 1 point) and mode of ventilation (OR = 0.28; 95% CI: 0.08–0.99; CPAP vs. BIPAP) only predicted mortality. The median length of stay (LOS) was 28 days (IQR 20–39). There was weak correlation between APACHE II and LOS (R = 0.23; $P = 0.01$). Most patients were transferred to a rehabilitation center (53.9%) or a geriatric ward (13.9%). APACHE II did not differ between patients discharged to different healthcare facilities ($P = 0.14$).

Conclusion: The APACHE II score is a powerful tool for predicting mortality of patients undergoing weaning from prolonged mechanical ventilation.

Key words: prolonged mechanical ventilation, weaning, APACHE II score, mortality, prediction

The number of patients requiring prolonged mechanical ventilation (PMV) is increasing worldwide [1]. There are multiple respiratory and non-respiratory risk factors of mechanical ventilation dependency [2]. Specialized weaning units have been established in order to facilitate the weaning of patients with continuing respiratory insufficiency who do not require an ICU level of treatment or monitoring [3]. Admission eligibility criteria usually require hemodynamic stability (no requirement for vasopressors or inotropes, no complex or life-threatening ar-

rhythmias, no risk of acute coronary ischemia), metabolic stability, stable renal function, proper acid-base balance and the absence of an infective process [4]. Potential advantages of these facilities are the increased attention given to patient-centered rehabilitation, greater expertise and improved patient outcomes (longer survival, higher ventilator independency, better quality of life).

Mechanical ventilation predisposes patients to numerous complications having a significant impact on LOS and

mortality that include pulmonary injury, pneumonia, other nosocomial infections, venous thromboembolism, dysphagia, increased catabolism with risk of malnutrition [5]. Therefore, a patient's condition on admission to a weaning unit can determine the outcome.

The Acute Physiology and Chronic Health Evaluation II (APACHE II) score was primarily designed to measure the severity of disease in patients admitted to intensive care units (ICU) and quickly became the most popular ICU mortality prediction score. Since APACHE II was exclusively studied in patients of multidisciplinary ICUs, little is known about its diagnostic utility in patients treated in high dependency units, including weaning units.

Thus, we sought to determine the value of the APACHE II score to predict in-hospital mortality in PMV patients admitted to a regional weaning center. We also investigated the association between baseline APACHE II and LOS, as well as discharge destination in survivors.

METHODS

Our observational study included 130 consecutive patients admitted to the weaning center between 1 January 2012 and 31 December 2013. All patients had been previously hospitalized in medical/surgical intensive care units and/or high dependency postoperative care units for a median period of 22 days (IQR 15–33). Indications for admission to a weaning center were based on the guidelines from the German Respiratory Society [4]. Weaning procedures were implemented according to the national recommendations [4].

Data including demographics and comorbidities was retrieved from medical records. Clinical and laboratory data were recorded on admission in all patients. Physiological data was recorded 3-hourly on day one. The Acute Physiology and Chronic Health Evaluation II score was calculated. The calculation was based on the worst values taken during the first 24 hours post admission. The Glasgow Coma Scale (GCS) was excluded from our calculations due to a possible confounding effect from analgesic and sedative agents (baseline median RASS = −1 points; IQR −2 to +1) [6]. Patient confidentiality was ensured as the dataset was fully anonymized. The Ethics Committee approved the study with waiver of consent as the project was non-interventional.

In-hospital mortality was the primary outcome. LOS (days) and discharge destinations were considered secondary outcomes.

STATISTICAL ANALYSIS

A statistical analysis was performed using MedCalc Statistical Software version 14.8.1 (MedCalc Software bvba, Ostend, Belgium). Continuous variables were expressed

Table 1. Subjects' characteristics

Variable	Median (IQR) or percentage
Men/Women	66.9%/33.1%
Age (years)	71 (62–77)
Coronary heart disease	64.6%
Arterial hypertension	92.3%
Previous cerebrovascular accident	16.9%
Diabetes	32.3%
Chronic kidney disease	25.4%
Chronic obstructive pulmonary disease	45.4%
Obesity (BMI > 30 kg m^{-2})	23.1%

Table 2. Etiology of underlying respiratory failure

Main condition	%
Postoperative	58.5
Pneumonia	13.8
COPD exacerbation	5.4
Post-cardiac arrest syndrome	5.4
Stroke/intracranial bleeding	5.3
Posttraumatic	4.7
Circulatory failure	3.1
Others	3.8

COPD — chronic obstructive pulmonary disease

as the median and interquartile range (IQR). Qualitative variables were expressed as a percentage. Between-group differences for quantitative variables were assessed using the Mann-Whitney U-test or the Kruskal-Wallis test. The type of distribution was verified with the Shapiro-Wilk test. The Mantel-Haenszel χ^2 or Fisher's exact test were applied to qualitative variables. All tests were two-tailed. Spearman rank coefficients of correlation were calculated for appropriate quantitative data.

The impact of clinical and demographic variables on mortality was initially evaluated using a bivariate analysis. ORs with 95% CIs were calculated. Variables with a P-value < 0.01 were consecutively subjected to a multivariate logistic stepwise regression model. Logistic ORs with 95% CIs were subsequently estimated. Receiver operating characteristic (ROC) curves were constructed and the area under the ROC curves (AUROC) was calculated to assess the predictive value of the APACHE II score on in-house mortality.

A P-value < 0.05 was considered significant.

RESULTS

Patients' characteristics are shown in Table 1. The APACHE II median score (excluding GCS) was 11 points (9–14). Baseline characteristics are shown in Table 1. The most frequent

Table 3. Discharge destination

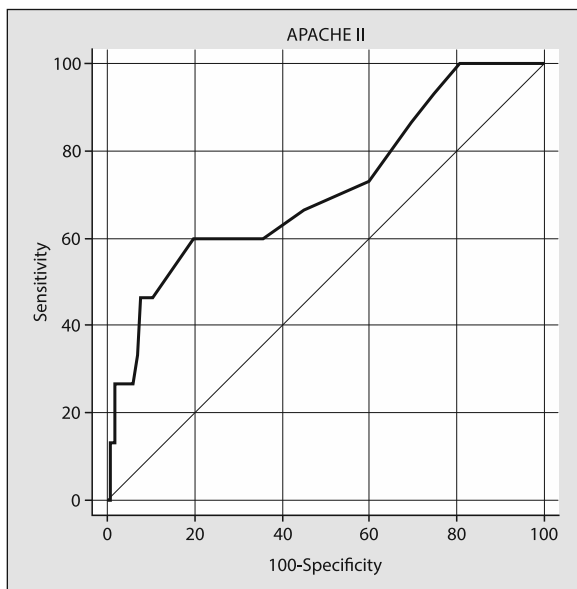| Place of discharge	%
Rehabilitation unit	53.9
Geriatric unit	13.9
Home	11.3
Surgical unit	7.8
Internal unit	7.0
Rest-home	5.2
Neurological unit	0.9

Figure 1. Receiver operating characteristic curve of APACHE II score for mortality prediction

admission diagnosis was postoperative respiratory failure (58.5%) (Table 2).

Median LOS in a weaning center was 28 days (20–39). Mortality reached 11.5% (10.3% in men, 14% in women; $P = 0.04$) and 115 patients (88.5%) were successfully discharged (Table 3). The majority of patients were transferred to a rehabilitation center (53.9%) or geriatric ward (13.9%) independent of gender ($P = 0.68$).

There was weak but statistically significant correlation between APACHE II score and LOS in a weaning center ($R = 0.23$; $P = 0.01$). APACHE II did not differ between patients discharged to different healthcare facilities ($P = 0.14$).

The APACHE II score was statistically higher in non-survivors (median = 15, IQR 10.25–19.5) compared to survivors (median = 11, IQR 8.25–14) ($P < 0.001$). The APACHE II predicted mortality with good diagnostic accuracy (AUROC = 0.714, 95% CI: 0.628–0.798, $P = 0.007$) (Fig. 1) optimal cut-off point being 14 points (sensitivity 60%; specificity 80%).

Although by using bivariate analysis we found six predictors of mortality, a multivariate analysis revealed only the APACHE II score and mode of mechanical ventilation on admission as playing a significant role (Table 4). Mortality increased by 22% per each APACHE II point while CPAP (compared to BIPAP) decreased mortality by 72%. This final 2-variable regression equation had very good diagnostic accuracy (AUROC = 0.829; 95% CI: 0.753–0.889; $P < 0.0001$). The etiology of respiratory failure had no impact on mortality ($P = 0.38$).

DISCUSSION

A multidisciplinary and collaborative approach to patients improves weaning outcomes. Adequate management of PMV requires ICU protocols regarding diagnosis and treatment, as well as the systematic screening of outcomes. An individual attitude is also necessary to understand the complexity and uniqueness of treated patients. Although mortality in PMV patients is at a satisfactory level, it remains multifactorial and not fully investigated [7].

In our study we explored outcomes in ventilator-dependent patients treated in a regional weaning unit with special attention given to the association between the baseline APACHE II score and mortality. Mortality of 11.5% seems quite low and is comparable to previous studies published, conducted also in Germany [6, 8]. Survival rates as low as 80% or less have also been reported [9]. Mortality in PMV patients is considerably high compared to simple and difficult weaning patients [10]. Damuth *et al.* in a systematic review and meta-analysis found that weaning outcomes were significantly worse in the USA than internationally ($P < 0.001$), with an in-hospital mortality difference of 13% (i.e. 18 vs. 31%) and 1-year mortality difference of 26% (i.e. 47 vs. 73%) [11].

Table 4. Statistically significant predictors of in-hospital mortality. Data given as ORs with 95% CIs

Variable	Bivariate analysis	Multivariate analysis
APACHE II (per point)	1.22 (1.08–1.39)	1.22 (1.06–1.40)
Gender (Women vs. Men)	3.03 (1.15–7.98)	
Pulmonary embolism (Yes = 1)	5.5 (1.17–25.9)	
Neoplastic disease (Yes = 1)	3.33 (1.001–11.1)	
Dysphagia (Yes = 1)	42.78 (1.95–938.54)	
Ventilation mode (CPAP vs. BIPAP)	0.24 (0.08–0.71)	0.28 (0.08–0.99)

The median APACHE II score in our patients was 11 points. Although this is comparable to some previous findings, it differs from most published data regarding PMV patients in weaning or ICU units [2, 9, 12]. There are 3 main reasons for this discrepancy. Firstly, the clinical profile of patients is changing, especially in terms of comorbidities and age [13]. Secondly, we excluded the GCS score from our calculations. Several studies have confirmed that although one's level of consciousness and mental status may influence the weaning outcome, this occurs only when they are unimpeded by analgesics and sedatives [6]. It was also confirmed that the GCS score cannot be used as a predictor of weaning outcomes [14].

The APACHE score is comprehensive and includes multiple abnormalities and chronic conditions that correspond to health status and ICU outcome. In our study, APACHE II, using the cut-off point of 14 points, predicted survival with good overall accuracy. The results are similar to the findings of Sapijaszko *et al.* [2] who showed that the APACHE II score was associated with mortality in PMV subjects. Sudarsanam *et al.* also found that mortality increased by 80% per 5-point increase in the APACHE II score in MV patients in India [15]. The APACHE II was useful in predicting mortality in pulmonary ICU patients with a cut-off point of 16 points (AUROC = = 0.81) [16]. In a comparison between tracheostomized and translaryngeally intubated patients, those with an APACHE II score < 18 points were more likely to be successfully weaned and be kept alive [17]. Jubran *et al.* confirmed that the comorbidity score might increase mortality by 24% [18]. Finally, APACHE II was found to be a better predictor of mortality compared to SAPS II in patients with respiratory disease in ICUs (AUCOC = 0.81) [19], as well as having a higher diagnostic accuracy compared to APACHE III and SAPS II in German interdisciplinary ICUs [20].

Contrary to the results of some authors we did not find an association between the etiology of respiratory failure and survival [8]. However, in our analysis the baseline mode of ventilation independently predicted the outcome.

STUDY LIMITATIONS

Our study possesses some limitations that prevent generalization of the obtained results. Firstly, this is a single-center study. A comprehensive review of the available data regarding patients requiring PMV suggests substantial variations across weaning units in terms of baseline characteristics, admission criteria and definitions used to describe PMV, as well as the diagnostic approach and treatment strategies during hospitalization [11]. Secondly, we performed a retrospective study, which may lead to researcher bias. However, we attempted to mitigate this bias by including consecutive patients during a specified time period. Thirdly, as the APACHE II includes only 14 variables, it is possible that

additional unmeasured parameters may become significant predictors of mortality. However, the AUROC of our final statistical model was 0.829 and confirms good diagnostic accuracy. Finally, we used a baseline APACHE II score for prediction. Therefore, we had no insight into trends in scoring during hospitalization (i.e. fluctuation of patients' health status). Last but not least, we did not collect follow-up data regarding survival.

CONCLUSIONS

The APACHE II score is a powerful tool for predicting mortality in patients requiring prolonged mechanical ventilation treated in a weaning unit. However, the APACHE II is not useful in order to predict length of stay or discharge destination.

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