# Shock on Admission Day Is the Best Predictor of Prolonged Mechanical Ventilation in the ICU*

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***Study objectives:*** **To determine the incidence of prolonged mechanical ventilation (PMV), which is associated with increased health-care costs and risks of adverse events, and to identify its early predictors.**
***Design:*** **Retrospective cohort.**
***Setting:*** **A medical-surgical ICU in a university-affiliated hospital.**
***Patients or participants:*** **All patients admitted to the ICU over 3 years who received mechanical ventilation (MV) for > 12 h.**
***Interventions:*** **None.**
***Measurements:*** **PMV was defined as MV lasting > 21 days. We recorded epidemiologic data, severity scores, worst $Pa_{O_2}/F_{IO_2}$, presence of shock on ICU admission day, cause for MV, length of MV, ICU length of stay (LOS), and hospital LOS. PMV patients were compared to patients weaned before 21 days (non-PMV group) to determine predictors of PMV.**
***Results:*** **Of 551 hospital admissions, 319 patients (58%) required MV > 12 h. One hundred thirty patients died early and were excluded. Seventy-nine patients (14%) required PMV. The non-PMV group consisted of 110 patients. Simplified acute physiology score (SAPS) II, APACHE (acute physiology and chronic health evaluation) II, therapeutic intervention scoring system, $Pa_{O_2}/F_{IO_2}$, shock, ICU LOS, and hospital LOS differed significantly between groups. However, logistic regression identified shock on ICU admission day as the only independent predictor of PMV (odds ratio, 3.10; p = 0.001). SAPS II and $Pa_{O_2}/F_{IO_2}$ had the nearest coefficients and were used to build the predictive model. Sensitivity analysis was performed including the 130 patients who died early, and shock remained the most powerful predictor.**
***Conclusions:*** **PMV was a frequent event in this cohort. The presence of shock on ICU admission day was the only prognostic factor, even adjusting for severity of illness and hypoxemia.**
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**Key words:** duration; intensive care; long-term outcomes; mechanical ventilation; prediction; shock

**Abbreviations:** APACHE = acute physiology and chronic health evaluation; CI = confidence interval; CIPNM = critical illness polyneuropathy and myopathy; $F_{IO_2}$ = fraction of inspired oxygen; IQR = interquartile range; LOS = length of stay; MV = mechanical ventilation; OR = odds ratio; PMV = prolonged mechanical ventilation; SAPS = simplified acute physiology score

Prolonged mechanical ventilation (PMV) can increase mechanical ventilation (MV) morbidity and costs.[1] Although many definitions of PMV are available, most experts use the one provided by the Health Care Financing Administration (now the Center for Medicare and Medicaid Services), which characterizes PMV as MV lasting for > 21 days.[1,2] Up to 7 to 15% of patients may become ventilator dependent in the ICU.[3] These figures are expected to increase, since more patients with complex diseases survive due to advances in resuscitation techniques, MV protocols, metabolic control, and treatment of sepsis.[4–7]

PMV patients account for > 37% of ICU costs.[8] Estimation of the incidence of PMV could help allocate health-care resources more efficiently, allowing to rationally plan the number of long-term

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acute care facilities where weaning of chronic, critically ill patients is performed at lower costs.[9] In addition, recognizing the early predictive factors of PMV also allows their prompt correction. Therefore, we performed this study to answer two questions: what is the incidence of PMV in our ICU, and which variables during the first 24 h in the ICU predict PMV?

## Materials and Methods

This retrospective cohort study took place in an eight-bed, mixed medical-surgical ICU in a university-affiliated hospital in La Plata, Buenos Aires, Argentina. Patients were admitted to the hospital from November 1, 1999, to October 31, 2002, and received MV for > 12 h. Patients were included only if intubation was performed in our ICU or in the operative room within a few hours after ICU admission. All data on these patients were prospectively collected as part of our ICU database.

On the day of ICU admission, we recorded age, gender, severity-of-illness scores (APACHE [acute physiology and chronic health evaluation] II, simplified acute physiology score [SAPS] II), comorbidities (McCabe score), level of interventions during the first day (therapeutic intervention scoring system), and presence of shock. Shock was defined as systolic BP < 90 mm Hg or a reduction of > 40 mm Hg of systolic BP from baseline despite adequate fluid resuscitation, along with presence of perfusion abnormalities that might include oliguria, lactic acidosis, or acute altered mental status.[10] We also registered underlying diagnoses and causes for initiation of MV. These last were considered as postoperative ventilation, hemodynamic, respiratory, and neurologic disorders.[11]

At ICU discharge, the day of tracheostomy, length of MV, ICU length of stay (LOS), and hospital LOS (in days) were recorded. In-hospital mortality was considered. The main outcome measure was the occurrence of PMV, defined as MV lasting > 21 days.[1,2] Effective days of MV were considered, whether continuous or with interruptions. Days of failed weaning were included in the total sum.

### *Data Analysis*

Patients with PMV were compared to patients surviving 21 days after ICU admission who were no longer receiving MV (non-PMV group). In the non-PMV group, patients who died before 21 days (early death group) were excluded from our main comparison, since they were not able to reach the primary outcome measure, which requires 21 days of survival. Nevertheless, to avoid selection bias, epidemiologic and severity-of-illness data of the early death group are also presented and compared to those of the PMV and non-PMV groups.

Continuous variables of parametric distribution were analyzed with one-way analysis of variance, and nonparametric continuous data were analyzed with the Kruskal-Wallis test. If the result of any test was $p < 0.05$, a *t* test or Mann-Whitney test adjusted for multiple comparisons were performed to identify differences between groups. $\chi^2$ was used for categorical data, with values adjusted for multiple comparisons.

We explored differences of variables that could act as possible PMV predictors in PMV and non-PMV groups. Variables presenting significant differences between groups ($p < 0.10$) were entered in stepwise logistic regression analysis, with the presence of PMV as the dependent variable. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. A predictive model of PMV was constructed with the first two thirds of patients (developmental sample) and validated in the remaining third (validation sample).

The Hosmer-Lemeshow goodness-of-fit test was performed on the developmental and validation sample to evaluate model calibration. This test compares observed with predicted mortality, and $p > 0.1$ indicates a good agreement between them.[12]

A sensitivity analysis was conducted for each of the variables of the predictive model, to assess the behavior of the model when the patients who died before 21 days were included in the PMV group. We assigned to these early death patients the worst outcome of our study, the evolution to PMV (21 days of MV). Using this new grouping of patients, we rebuilt the regression model. Statistical analysis was performed with statistical software (Stata 7.0; Stata Corporation; College Station, TX).

## Results

During the 3 years of our study, 551 patients were admitted to the ICU. Their mean age was 41 ± 17 years (± SD); 53% were men. Mean APACHE II and SAPS II scores were 18 ± 9 and 32 ± 18, respectively. The expected mortality rates were 31% and 28%, respectively, and the observed mortality rate was 31%.

Of the entire cohort, 348 patients (63%) received MV, and 319 patients (58%) received MV for > 12 h. Median length of MV was 7 days (interquartile range [IQR], 2 to 19 days). One hundred thirty patients died before day 21 (early death group). Of the 189 patients who survived at day 21, 110 patients had been weaned and most of them were discharged from the ICU (non-PMV group), while 79 patients were still receiving MV (PMV group). Epidemiologic, severity-of-illness, and main physiologic variables; length of MV; ICU LOS; hospital LOS; general causes of admission to the ICU; causes of initiation of MV; and underlying diagnoses of the three groups are displayed in Tables 1–3.

The PMV group represented 14% of ICU admissions. Survival and discharge from the ICU of this population was 73%. Mean time for tracheostomy was 15 ± 5 days (± SD), and median time was 16 days (IQR, 12 to 21 days). Fifty-four PMV patients (68%) received MV for > 30 days, and 8 patients (10%) received MV for > 90 days (mean, 136 ± 53 days). Half of these last eight patients could be weaned and discharged from the ICU.

Early death patients were older and had significantly higher acuity scores and comorbidities than PMV patients. However, physiologic alterations, assessed by $Pao_2$/fraction of inspired oxygen ($Fio_2$) and presence of shock, were similar in both groups. The intensity of treatment did not differ.

PMV patients were significantly sicker than non-PMV patients, according to severity-of-illness scores. The most striking difference with non-PMV patients resided in the incidence of shock on ICU admission