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Clinical predictors of early acute respiratory distress syndrome in trauma patients



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Abstract

BACKGROUND: The objectives of this study were to examine the incidence and severity of early acute respiratory distress syndrome (ARDS) according to the Berlin Definition and to identify risk factors associated with the development of early post-traumatic ARDS.

METHODS: A 2.5-year retrospective database of adult trauma patients who required mechanical ventilation for greater than 48 hours at a level 1 trauma center was analyzed for variables predictive of early (<48 hours after injury), mild, moderate, and severe ARDS and in-hospital mortality.

RESULTS: Of 305 patients, 59 (19.3%) developed early ARDS: mild, 27 (45.8%); moderate, 26 (44.1%); and severe, 6 (10.1%). Performance of an emergent thoracotomy, blunt mechanism, and fresh frozen plasma administration were independently associated with the development of early ARDS. ARDS was not predictive of mortality.

CONCLUSIONS: Trauma patients with blunt mechanism, who receive fresh frozen plasma, or undergo thoracotomy, are at risk of developing early ARDS.

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Acute respiratory distress syndrome (ARDS) is associated with significant morbidity and mortality.¹ Historically, mortality was as high as 70%. More recently mortality rates between 24% and 46% have been reported.^{2–4} Despite advances in the understanding of the pathophysiology of ARDS, management remains challenging.

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In 2012, a new consensus definition of ARDS known as the Berlin Criteria was implemented. This divides ARDS into three categories based on the degree of hypoxemia using the ratio of partial pressure of arterial oxygen and fraction of inspired oxygen ($\text{PaO}_2/\text{FiO}_2$). Previously, an overarching category of acute lung injury was used to define those patients with mild-moderate hypoxemia. ARDS was reserved for those patients with severe disease. With increasing disease severity there is an increasing risk of mortality.³

It is well established that low-tidal volume ventilation is associated with improved survival among patients who develop ARDS. More recently, there has been an increasing emphasis on early identification and prevention of ARDS as

evidenced by the establishment of the National Institutes of Health Prevention and Early Treatment of Acute Lung Injury Network.⁵

To date, most of studies examining risk factors for development of ARDS have been performed in heterogeneous patient populations. Variables associated with the development of ARDS in trauma patients specifically include advanced age, injury severity score (ISS), transfusion of more than units of packed red blood cells (PRBCs), and increasing crystalloid resuscitation.^{6,7} The objectives of this study were to examine the incidence and severity of early (<48 hours) ARDS among trauma patients according to the Berlin definition and to identify risk factors associated with the development of early post-traumatic ARDS.

Methods

We performed a 30-month retrospective review of adult trauma patients admitted to the surgical intensive care unit at our level 1 trauma center who required mechanical ventilation for greater than 48 hours. Variables analyzed included demographics, ISS, APACHE II score, injury patterns, operative interventions, and the type as well as volume of blood products and crystalloids administered over the first 24 hours of admission.

Additional variables included mode of ventilation, arterial blood gases (admission, 24 and 48 hours after admission), and chest radiographs during the first 48 hours of admission. These were used to determine if patients met criteria for ARDS and to determine the severity of their disease. Patients requiring mechanical ventilation with a PEEP of 5 or greater were reviewed. Each patient’s ABG was reviewed and if the ratio of PaO₂/FiO₂ (P/F) was less than or equal to 300-mm Hg, the patient’s chest x-rays were reviewed for evidence of ARDS. If bilateral infiltrates were present and the patient met hypoxemic criteria, they were identified as having ARDS.

The main outcome measure was the development of early ARDS (≤48 hours of injury). Secondary endpoints included severity of ARDS, mild (P/F ratio ≤300-mm Hg); moderate (P/F ≤200-mm Hg); severe (P/F ≤100-mm Hg), and in-hospital mortality. Continuous numerical variables were summarized using means and standard deviations and compared using the Wilcoxon rank-sum test. Categorical data were compared using Fisher’s exact test or chi-square as appropriate or as odds ratios (ORs) with 95% confidence intervals. Multivariate logistic regression was performed to identify independent predictors of ARDS and mortality. This study was approved by the institutional review board. Statistical analysis was performed with Epi Info 7 and Stata 12 (StataCorp. 2013).

Results

Over the 30-month study period, 305 patients met inclusion criteria. Of these, 59 (19.3%) developed early

ARDS. Twenty-seven patients (45.7%) developed mild ARDS, 26 (44.1%) developed moderate ARDS, and 6 (10.1%) developed severe ARDS. The mean age for the entire study cohort was 44 ± 18 years and 82% of the patients were male. Average body mass index (BMI) was 26.8 ± 6.9 kg/m² (Table 1). Patients received an average of 7.5 ± 4.7 L intravenous fluids over the first 24 hours of their hospitalization.

There were no significant differences in age, sex, ISS, or APACHE II scores between patients who developed ARDS and those who did not (Table 2). Patients with ARDS had a higher BMI (29 vs 26 kg/m², *P* = .003). Those patients who developed ARDS received a greater volume of total blood products, including PRBC (*P* = .01) and fresh frozen plasma (FFP; *P* = .007; Table 2). There was no significant difference in cumulative volume of crystalloids administered between groups (Table 2).

Patients with ARDS had a longer ICU length of stay (*P* = .023) and longer duration of mechanical ventilation (*P* = .006). However, at the time of discharge there was no difference in the incidence of discharge to home or supported care facilities between groups (Table 3). Mortality was also similar between groups (17.0% vs 12.2%, *P* = .27).

On multivariate logistic regression analysis, performance of a thoracotomy (OR = 8.0; 95% CI = 1.3 to 47.9, *P* = .02), blunt mechanism (OR = 5.6; 95% CI = 1.4 to 21.6, *P* = .01), and FFP administration (OR = 1.3; 95% CI = 1.02 to 1.73, *P* = .04) were independently associated with the development of early ARDS (Table 4). On adjusted analysis, ARDS was not predictive of mortality.

Comments

Despite advances in treatment strategies for ARDS, mortality remains high, ranging from 24% to 45%.^{5,6,8–10} In addition, ARDS continues to be under-recognized and undertreated. For example, in the LUNG SAFE prospective cohort study, low-tidal volume ventilation was initiated in less than two-thirds of the patients with ARDS, 80% of the patients were on PEEP less than 12-mm Hg, and prone positioning was only used in 16.3% of the patients.⁴

Table 1 Baseline characteristics of study population	
Demographics	Adult trauma patients
Age (median)	45 (28–57)
Male	82%
BMI	26 (22–30)
Hispanic	36.1%
Black	23%
Caucasian	32%
ISS	22 (13–29)
APACHE II	12 (7–17)

APACHE II = Acute Physiology and Chronic Health Evaluation II; BMI = body mass index; ISS = injury severity score.

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