Acute respiratory distress syndrome among trauma patients: trends in ICU mortality, risk factors, complications and resource utilization

Abstract  
Objectives: To evaluate trends in mortality and related factors among trauma patients who developed acute respiratory distress syndrome (ARDS).  
Study: Observational study based on data prospectively gathered in computerized trauma registry.  
Setting: Trauma intensive care unit (ICU) of 48 beds in level I trauma center.  
Patients: All trauma patients with ARDS admitted during 1985–87 (486, group 1 [G1]) and 1993–95 (552, group 2 [G2]).  
Methods: ARDS was defined by American-European Consensus Conference criteria and the need for 48 h or more on mechanical ventilation with FIO2 greater than 0.50 and PEEP of more than 5 cmH2O. Demographics, severity score, injury-admission delay time, first 24-h transfusion and septic and organ system failure complications were independent variables. ICU mortality was the dependent variable. ICU length of stay (LOS) and life support techniques were considered. Respiratory and renal support strategies were different in the two time periods.  
Results: Mortality decreased over the period (G1: 29.2% vs G2: 21.4%, p < 0.04), in patients aged both over and under 65 years. Multivariate analysis showed mortality was related to age, severity and time period (G1 1.68-fold that in G2) and that the greater G1 mortality was related to more renal failure and hematologic failure/dysfunction. ICU LOS decreased from 31.7 ± 26.7 days (G1) to 27.3 ± 22 days (G2) (p < 0.003).  
Conclusions: Mortality among trauma patients with ARDS declined over the 8 years studied and was associated with less organ failure. This reduction was probably the result of new approaches to mechanical ventilation, renal failure replacement and vasoactive drug therapy.  
Keywords Trauma · Acute respiratory distress syndrome (ARDS) · Epidemiology · Septic complications · Mortality · Risk factors · Predictors · Resource utilization · Length of stay · Active life support

Introduction

Ever since the acute respiratory distress syndrome (ARDS) was first described in 1967 [1] it has continued to pose a major challenge to intensivists. ARDS is characterized by severe hypoxemia and bilateral lung infiltrates of non-cardiac origin. Its defining oxygenation, radiologic and hemodynamic criteria were proposed at the American-European Consensus Conference (AECC) in 1994 [2], although they are currently under revision after reports that the AECC definition does not correlate with the severity and outcome of patients with acute lung injury and ARDS [3].

The pathophysiologic injuries of ARDS can start on the capillary or alveolar level, complicating other severe conditions of different etiologies including sepsis, pneu-
monia, pancreatitis, drug overdose or trauma. ARDS outcomes vary widely, depending on the underlying disease, and the ARDS concept includes different population groups and outcomes with very varied clinical and epidemiologic characteristics [4]. In the trauma patient, ARDS is classically associated with musculoskeletal injuries, a high injury severity score (ISS > 40) and a delay in the stabilization of major fractures [5].

During the past 30 years, ARDS treatment has evolved around different mechanical ventilation modalities and chiefly through “best-PEEP” concepts, whose definition has ranged from low/medium [6] to high PEEP levels and back to protective lung ventilation strategies [7]. New concepts such as volutrauma and end-alveolar transpulmonary pressure seem reasonable [8]. Although various efforts have been made to develop pharmacologic approaches, including recent research on interleukin/cytokine cascade modulation responses, their clinical correlation or application has yet to be established [9].

During all this time, and particularly over the past 10 years, the mortality rate among ARDS patients appears to have decreased. Most reports on this topic are based on not very large samples, take limited consideration of severity or complications and are mainly on patients with ARDS of septic or pulmonary origin or injured patients, with very varied comorbidities [10, 11, 12]. It appears from these studies that the mortality is related to the etiology of the ARDS. In this context, trauma patients can be regarded as a considerably more homogeneous ARDS sub-population in terms of age and comorbidities, although particular subsets of these patients can show different behaviors. The most typical example of the latter would be severe head injuries, which are not adequately weighted in the usual score systems (ISS, APACHE, RTS) and can constitute a bias in severe trauma mortality studies, above all in small samples [13].

The aim of the present study was to compare two large and homogeneous populations of trauma patients who developed ARDS and were treated at the same institution 8 years apart. We studied their complications, outcomes, mortality-related factors and resource utilization. This analysis was intended to elucidate trends in patient outcomes and to document resource utilization, in order to analyze the effectiveness and efficiency of our performance [14].

**Materials and methods**

**Data source**

The trauma registry of the Shock Trauma Center (STC) of the University of Maryland Medical Systems [15] has prospectively stored information on the patients admitted to this institution since July 1983. The STC is the level 1 referral center for a population of around seven million in Maryland, Delaware and part of the District of Columbia. The data base captures the following: (1) demographic data; (2) etiology of the injury; (3) pre-hospital assessment, interventions and times; (4) data on injury severity, anatomic and physiologic indexes; (5) initial treatment (resuscitation/surgery); (6) anatomic, physiologic and infectious complications; (7) outcome, including mortality, length of stay (LOS) and brain and extremity function characteristics.

**Data collection**

We analyzed the prospectively gathered records of all patients over 14 years old at the time of admission to our institution who met criteria of ARDS during their stay in the ICU. Two different time periods were studied: 1985–87 (G1) and 1993–95 (G2). These were selected as offering the longest time span for which there were adequate data for our study.

The following independent variables were recorded in each group: age; gender; type of trauma (blunt/penetrating); injury-to-admission time; amounts of total fluids and blood administered during the first 24 h; severity of injury measured by Revised Trauma Score (RTS) and lowest Glasgow Coma Scale (GCS) (for severity of head injury) during the first 24 h, and by Injury Severity Score (ISS) and long bone and pelvis fractures. We also recorded complications, including infections (pneumonia, bacteremia, severe sepsis and septic shock) and organ system failure (renal, hepatic, cardiovascular and hematologic). The dependent variable studied was ICU mortality in the two time periods.

Resource utilization and life support treatments in the two groups were assessed by the following parameters: ICU length of stay (LOS), average days on mechanical ventilation, total parenteral nutrition (TPN), dialysis and vasoactive drug infusion, and number of intravenous central, pulmonary (PA) catheters and arterial lines.

The predicted mortality for each patient was calculated using the TISS formula for blunt and penetrating trauma [13] and the results were expressed separately for G1 and G2. The standard mortality rate (SMR) was the observed mortality as a ratio of the predicted mortality.

**Definitions**

Acute respiratory distress syndrome was defined according to the criteria established by the AECC [2] as respiratory failure of acute onset in the ICU, with a PaO₂/FIO₂ less than 200 mmHg and presence of bilateral radiologic pulmonary infiltrates with a pulmonary wedge pressure (PCwP) below 18 mmHg or no clinical or radiologic evidence of elevated pressure in the left atrium. To be included in the present study, the patient must also have been more than 48 h on a mechanical ventilation regimen that required FiO₂ more than 0.50 and PEEP above 5 cmH₂O to reach a PaO₂ higher than 60 mmHg.

Pneumonia was defined as evidence of primary lung infection from clinical criteria (fever, purulent secretions, deterioration of gas exchange) and evidence of bacterial or fungal infection diagnosed by tracheal aspirate or from bronchoalveolar lavage specimens.

Bacteremia: presence of any pathogen bacteria in blood culture.

Sepsis: presence of hyperdynamic circulation, hyperventilation, elevated or reduced temperature, elevated/reduced or left-shifted white blood cell count in addition to a potential source of infection.

Septic shock: attribution of a shock state to sepsis.