Acute Respiratory Distress Syndrome in the Trauma Intensive Care Unit

Morbid but Not Mortal

Ali Salim, MD; Matthew Martin, MD; Constantinos Constantinou, MD; Burapat Sangthong, MD; Carlos Brown, MD; George Kasotakis, MD; Demetrios Demetriades, MD; Howard Belzberg, MD

Hypothesis: The diagnosis of acute respiratory distress syndrome (ARDS) carries significant additional morbidity and mortality among critically injured patients.

Design: Retrospective case-control study using a prospectively maintained ARDS database.

Setting: Surgical intensive care unit (ICU) in an academic county hospital.

Patients: All trauma patients admitted to the ICU from January 1, 2000, to December 31, 2003, who developed ARDS as defined by (1) acute onset, (2) a partial pressure of arterial oxygen–fraction of inspired oxygen ratio of 200 or less, (3) bilateral pulmonary infiltrates on chest radiographs, and (4) absence of left-sided heart failure. Each patient with ARDS was matched with 2 control patients without ARDS on the basis of sex, age (±5 years), mechanism of injury (blunt or penetrating), Injury Severity Score (±3), and chest Abbreviated Injury Score (±1).

Main Outcome Measures: Mortality, hospital charges, hospital and ICU lengths of stay, and complications (defined as pneumonia, deep venous thrombosis, pulmonary embolism, acute renal failure, and disseminated intravascular coagulopathy).

Results: Of 2042 trauma ICU admissions, 216 patients (10.6%) met criteria for ARDS. We identified 432 similarly injured control patients. Compared with controls, trauma patients with ARDS had more complications (43.1% vs 9.5%), longer hospital (32.2 vs 17.9 days) and ICU (22.1 vs 8.4 days) lengths of stay, and higher hospital charges ($267,037 vs $136,680) (P < .01 for all), but mortality was similar (27.8% vs 25.0%, P = .48).

Conclusion: Although ARDS is associated with increased morbidity, hospital and ICU length of stay, and costs, it does not increase overall mortality among critically ill trauma patients.

Arch Surg. 2006;141:655-658

ACUTE RESPIRATORY DISTRESS syndrome (ARDS) is a well-known complication of major trauma, occurring in 8% to 82% of selected patient populations.1-7 These subgroups include patients with pulmonary contusions,7,8 severe trauma (Injury Severity Score, > 25),2,8 head injury (Injury Severity Score, > 25),2,8 head injury,3,9 notable base deficit,10,11 notable blood transfusion requirement,8,12 and notable orthopedic injuries such as long-bone and pelvic fractures.3 The presence of ARDS is associated with a significant increase in morbidity, an increased use of hospital resources, and up to a 4.3-fold increase in mortality.2,13-15

The additional mortality effect of ARDS among trauma patients has recently come into question. Findings from studies5,16 have suggested that the mortality may be explained by injury severity alone and not by the presence of ARDS. The overall mortality from ARDS is decreasing, and the mortality from trauma-related ARDS is lower than that associated with ARDS from other causes.4,5,17,18 However, whether ARDS contributes to the mortality remains controversial, with few studies16,17 having adequate control mechanisms that address this issue. The objective of this study was to examine the contribution of ARDS on the mortality among trauma patients by comparing the mortality among a similarly injured group of patients without ARDS.

METHODS

Data for this study were obtained from a prospectively maintained database from January 1, 2000, through December 31, 2003, of all admissions to the surgical intensive care unit (ICU) at the Los Angeles County–University of Southern California Medical Center, a level I academic trauma center. This database was established in January 2000 to track the incidence of organ system failures, including ARDS.
only trauma patients who required ICU admission for longer than 24 hours were included in the study. Patients with isolated head trauma were excluded. Data regarding mortality, hospital charges, complications, demographics, Injury Severity Score, Abbreviated Injury Score, and hospital and ICU lengths of stay were obtained from our trauma registry. Complications included pneumonia, deep venous thrombosis, pulmonary embolism, acute renal failure, and disseminated intravascular coagulopathy. For each trauma patient who developed ARDS, 2 control subjects were matched on the basis of the following 5 criteria: sex, age (±5 years), mechanism of injury (blunt or penetrating), Injury Severity Score (±3), and chest Abbreviated Injury Score (±1). When more than 2 controls were identified for a case, 2 were randomly selected from the pool using a random number table.

Using Fisher exact test or χ² test, data were tested for equality between the ARDS group and the control group. Paired differences in age, Glasgow Coma Scale score, and Injury Severity Score were tested using Wilcoxon signed rank test. Outcomes (survival and complications) between the 2 groups were compared using conditional logistic analysis, an analytic method for matched studies with more than 1 control. The odds ratio with a 93% confidence interval and the P value for its significance between the 2 groups were derived. Statistical significance was set at P<.05. All statistical analysis was performed using STATA version 7.0 (StataCorp LP, College Station, Tex).

This study was approved by the institutional review board, and the need for informed consent was waived because the study involved collection of existing data in such a manner that subjects could not be identified.

**RESULTS**

During the 4-year study period, there were 2042 trauma-related ICU admissions. Two hundred sixteen patients met criteria for ARDS, for an incidence of 10.6%. The patients with ARDS were then matched with 432 similarly injured controls. **Table 1** gives the characteristics of the ARDS and control groups. There was no difference for overall mortality between the ARDS group (60/216 [27.8%]) and the control group (108/432 [25.0%]) (odds ratio, 1.11; 95% confidence interval, 0.85-1.45; P=.48) (**Table 2**).

Table 2 compares specific and overall complications between the 2 groups. There were significantly more overall complications in the ARDS group (43.1%) compared with the control group (9.5%) (odds ratio, 4.53; 95% confidence interval, 3.26-6.30; P<.01). The most common

---

### Table 1. Demographic and Admission Characteristics Among Patients With and Without Acute Respiratory Distress Syndrome (ARDS)*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>ARDS Group (n = 216)</th>
<th>Control Group (n = 432)</th>
<th>P Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD, y</td>
<td>42 ± 19</td>
<td>41 ± 19</td>
<td>.57</td>
</tr>
<tr>
<td>Age group, y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-14</td>
<td>5 (2.3)</td>
<td>9 (2.1)</td>
<td>.85</td>
</tr>
<tr>
<td>15-55</td>
<td>157 (72.7)</td>
<td>322 (74.5)</td>
<td>.61</td>
</tr>
<tr>
<td>&gt;55</td>
<td>54 (25.0)</td>
<td>101 (23.4)</td>
<td>.65</td>
</tr>
<tr>
<td>Male sex</td>
<td>169 (78.2)</td>
<td>327 (75.7)</td>
<td>.47</td>
</tr>
<tr>
<td>Mechanism of injury</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blunt</td>
<td>157 (72.7)</td>
<td>313 (72.5)</td>
<td>.95</td>
</tr>
<tr>
<td>Penetrating</td>
<td>59 (27.3)</td>
<td>119 (27.5)</td>
<td>.95</td>
</tr>
<tr>
<td>Glasgow Coma Scale score, mean ± SD</td>
<td>11 ± 5</td>
<td>11 ± 5</td>
<td>.12</td>
</tr>
</tbody>
</table>

Abbreviated Injury Score ≥3‡:
- Chest: 80 (37.0) vs 157 (36.3) (P=.86)
- Abdomen: 67 (31.0) vs 125 (28.9) (P=.58)
- Extremity: 55 (25.5) vs 124 (28.7) (P=.38)
- External: 2 (0.9) vs 3 (0.7) (P=.75)
- Injury Severity Score, mean ± SD:
  - ≤15: 47 (21.8) vs 91 (21.1) (P=.84)
  - 16-25: 61 (28.2) vs 126 (29.2) (P=.81)
  - >25: 108 (50.0) vs 215 (49.8) (P=.96)

*Data are given as number (percentage) unless otherwise indicated.
†Equality in proportions by Fisher exact test or by χ² test as appropriate.
‡The numbers of patients do not sum to the sample totals because of missing data.

### Table 2. Complications or Death Among Patients With Acute Respiratory Distress Syndrome (ARDS) and Control Subjects

<table>
<thead>
<tr>
<th>Outcome</th>
<th>No. (%)</th>
<th>ARDS Group (n = 216)</th>
<th>Control Group (n = 432)</th>
<th>Odds Ratio (95% Confidence Interval)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonia</td>
<td>43 (19.9)</td>
<td>23 (5.3)</td>
<td>3.74 (2.32-7.56)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>Acute renal failure</td>
<td>25 (11.6)</td>
<td>8 (1.9)</td>
<td>6.25 (2.87-13.60)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>Disseminated intravascular coagulopathy</td>
<td>9 (4.2)</td>
<td>9 (2.1)</td>
<td>2.00 (0.81-4.87)</td>
<td>&lt;.13</td>
<td></td>
</tr>
<tr>
<td>Deep venous thrombosis</td>
<td>6 (2.6)</td>
<td>1 (0.2)</td>
<td>12.00 (1.45-99.05)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>6 (2.6)</td>
<td>1 (0.2)</td>
<td>12.00 (1.45-99.05)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>Any complications†</td>
<td>93 (43.1)</td>
<td>41 (9.5)</td>
<td>4.53 (2.36-6.30)</td>
<td>&lt;.01</td>
<td></td>
</tr>
<tr>
<td>Death</td>
<td>60 (27.8)</td>
<td>108 (25.0)</td>
<td>1.11 (0.85-1.45)</td>
<td>.48</td>
<td></td>
</tr>
</tbody>
</table>

*Derived by conditional logistic analysis.
†Some patients had more than 1 complication.
complication in the ARDS group was pneumonia (19.9%), followed by acute renal failure (11.6%).

Table 3 compares the hospital charges and the hospital and ICU lengths of stay between the 2 groups. The ARDS group had an overall mean ICU length of stay of 22.1 days vs 8.4 days in the control group ($P=.01$). When only survivors were examined, the mean ICU length of stay was 24.0 days in the ARDS group vs 9.9 days in the control group ($P=.01$). As expected, the ARDS group had significantly higher hospital charges than the control group ($267,037 vs $136,680, P=.01$) (Table 3).

The overall mortality from ARDS has decreased during the past few years. This decrease seems more pronounced in trauma patients, among whom the mortality rates associated with ARDS are consistently lower than those associated with non–trauma-related ARDS. Improved critical care management and the use of lower tidal volume ventilation in patients with ARDS may explain some of this decline. There also seems to be less endothelial and alveolar epithelial injury in trauma-related ARDS compared with non–trauma-related ARDS, which may also help explain the lower mortality rates seen with trauma-related ARDS.

Despite the notable decline in ARDS-related mortality among all populations, its presence is still associated with a significant increase in morbidity and mortality. In a prospective study performed 10 years ago, Hudson et al found that mortality among trauma patients increased 4.3-fold if they developed ARDS. In another study by Miller et al, trauma patients who developed ARDS experienced 36% mortality compared with 5% mortality if ARDS was not present ($P=.001$). Similarly, Johnston et al reported 20% mortality among trauma patients with ARDS compared with 12% among trauma patients without ARDS ($P=.001$). Despite these higher raw mortality rates among trauma patients who develop ARDS, comparisons between the 2 groups may

Major trauma is a well-known risk factor for the development of ARDS. Its presence is associated with higher morbidity and with higher raw mortality rates. However, attributable mortality from ARDS among trauma patients is not well defined. By matching a group of trauma patients who developed ARDS with an equally injured group of patients who did not develop ARDS, we sought to determine if the presence of ARDS affected for mortality (27.8% in the ARDS group vs 25.0% in the control group, $P=.48$). In contrast, the ARDS group had notably more complications, longer hospital and ICU lengths of stays, and higher hospital costs.

Table 3. Hospital Charges and Hospital and Intensive Care Unit (ICU) Lengths of Stay Among Patients With Acute Respiratory Distress Syndrome (ARDS) and Control Subjects*

<table>
<thead>
<tr>
<th>Variable</th>
<th>ARDS Group (n = 216)</th>
<th>Control Group (n = 432)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital charges, $</td>
<td>267,037 ± 256,548†</td>
<td>136,680 ± 170,764‡</td>
<td>128,668 ± 19,363</td>
</tr>
<tr>
<td>Length of stay, d</td>
<td>Hospital</td>
<td>32.2 ± 28.2§</td>
<td>17.9 ± 19.7</td>
</tr>
<tr>
<td>ICU</td>
<td>22.1 ± 21.1¶</td>
<td></td>
<td>13.9 ± 2.1</td>
</tr>
</tbody>
</table>

*Data are given as mean ± SD. $P<.01$ for all comparisons (Wilcoxon signed rank test).
†Minimum, median, and maximum are $10,967, $190,405, and $1,921,002, respectively.
‡Minimum, median, and maximum are $5207, $85,390, and $1,475,604, respectively.
§Minimum, median, and maximum are 2, 26, and 217 days, respectively.
¶Minimum, median, and maximum are 1, 12, and 212 days, respectively.
#Minimum, median, and maximum are 1, 17, and 124 days, respectively.

Table 4. Hospital Charges and Hospital and Intensive Care Unit (ICU) Lengths of Stay Among Survivors*

<table>
<thead>
<tr>
<th>Variable</th>
<th>ARDS Group (n = 156)</th>
<th>Control Group (n = 324)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital charges, $</td>
<td>295,335 ± 241,469†</td>
<td>164,028 ± 179,783‡</td>
<td>131,307 ± 21,837</td>
</tr>
<tr>
<td>Length of stay, d</td>
<td>Hospital</td>
<td>36.9 ± 27.1§</td>
<td>21.9 ± 20.5</td>
</tr>
<tr>
<td>ICU</td>
<td>24.0 ± 19.5¶</td>
<td></td>
<td>14.9 ± 2.4</td>
</tr>
</tbody>
</table>

*Data are given as mean ± SD. $P<.01$ for all comparisons (Wilcoxon signed rank test).
†Minimum, median, and maximum are $243,28, $239,992, and $1,921,002, respectively.
‡Minimum, median, and maximum are $10,704, $116,064, and $1,475,604, respectively.
§Minimum, median, and maximum are 5, 31, and 217 days, respectively.
¶Minimum, median, and maximum are 2, 17, and 212 days, respectively.
#Minimum, median, and maximum are 2, 140, and 134 days, respectively.

Abbreviation: ARDS, acute respiratory distress syndrome.
be problematic. Patients who develop ARDS often have higher injury severity, more physiologic disturbances, and increased comorbidities. Some argue that the presence of ARDS is not a complication of trauma but rather is a marker of the severity of trauma. What remains unanswered is whether the higher mortality rates are a result of the ARDS or a result of patient factors such as injury severity and preexisting disease. Unfortunately, there is a scarcity of studies that adequately define the attributable mortality from ARDS among trauma patients.

In the only study (to our knowledge) in the literature that attempted to examine the independent contribution of ARDS on mortality among trauma patients, Treggiari et al in a prospective cohort study found that there was no association of mortality with ARDS (relative risk, 1.23; 95% confidence interval, 0.63-2.43) after adjustment for age, Injury Severity Score, and Acute Physiology Score. Our study findings seem to support this in that mortality among similarly injured trauma patients with and without ARDS was similar (27.8% vs 25.0%; odds ratio, 1.11; 95% confidence interval, 0.85-1.45).

It is not surprising that complications, hospital and ICU lengths of stay, and hospital costs were significantly higher in the ARDS group compared with the control group. The presence of any complication has been shown to increase the length of stay and costs. Other studies have documented similar findings and emphasize the overall burden of ARDS on the health care system.

CONCLUSIONS

Trauma patients who develop ARDS have no increased mortality compared with an equally injured group of patients who did not develop ARDS. However, ARDS was associated with increased complication rates, hospital and ICU lengths of stay, and hospital charges. Because mortality is predicted more from injury severity and not the subsequent development of ARDS, future studies regarding effective treatment of ARDS may need to target outcomes other than mortality among trauma patients.

Accepted for Publication: June 14, 2005.
Correspondence: Ali Salim, MD, Los Angeles County–University of Southern California Medical Center, 1200 N State St, Room 9900, Los Angeles, CA 90033 (asalim@surgery.usc.edu).

REFERENCES