VENTILATION WITH LOWER TIDAL VOLUMES AS COMPARED WITH TRADITIONAL TIDAL VOLUMES FOR ACUTE LUNG INJURY AND THE ACUTE RESPIRATORY DISTRESS SYNDROME

THE ACUTE RESPIRATORY DISTRESS SYNDROME NETWORK*

ABSTRACT

Background Traditional approaches to mechanical ventilation use tidal volumes of 10 to 15 ml per kilogram of body weight and may cause stretch-induced lung injury in patients with acute lung injury and the acute respiratory distress syndrome. We therefore conducted a trial to determine whether ventilation with lower tidal volumes would improve the clinical outcomes in these patients.

Methods Patients with acute lung injury and the acute respiratory distress syndrome were enrolled in a multicenter, randomized trial. The trial compared traditional ventilation treatment, which involved an initial tidal volume of 12 ml per kilogram of predicted body weight and an airway pressure measured after a 0.5-second pause at the end of inspiration (plateau pressure) of 50 cm of water or less, with ventilation with a lower tidal volume, which involved an initial tidal volume of 6 ml per kilogram of predicted body weight and a plateau pressure of 30 cm of water or less. The first primary outcome was death before a patient was discharged home and was breathing without assistance. The second primary outcome was the number of days without ventilator use. (N Engl J Med 2000;342:1301-8.)

Results The trial was stopped after the enrollment of 861 patients because mortality was lower in the group treated with lower tidal volumes than in the group treated with traditional tidal volumes (31.0 percent vs. 39.8 percent, P=0.007), and the number of days without ventilator use during the first 28 days after randomization was greater in this group (mean [±SD], 12±11 vs. 10±11; P=0.007). The mean tidal volumes on days 1 to 3 were 6.2±0.8 and 11.8±0.8 ml per kilogram of predicted body weight (P<0.001), respectively, and the mean plateau pressures were 25±6 and 33±8 cm of water (P<0.001), respectively.

Conclusions In patients with acute lung injury and the acute respiratory distress syndrome, mechanical ventilation with a lower tidal volume than is traditionally used results in decreased mortality and increases the number of days without ventilator use. (N Engl J Med 2000;342:1301-8.)

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THE mortality rate from acute lung injury and the acute respiratory distress syndrome is approximately 40 to 50 percent. Although substantial progress has been made in elucidating the mechanisms of acute lung injury, there has been little progress in developing effective treatments.

Traditional approaches to mechanical ventilation use tidal volumes of 10 to 15 ml per kilogram of body weight. These volumes are larger than those in normal subjects at rest (range, 7 to 8 ml per kilogram), but they are frequently necessary to achieve normal values for the partial pressure of arterial carbon dioxide and pH. Since atelectasis and edema reduce aerated lung volumes in patients with acute lung injury and the acute respiratory distress syndrome, inspiratory airway pressures are often high, suggesting the presence of excessive distention, or “stretch,” of the aerated lung. In animals, ventilation with the use of large tidal volumes caused the disruption of pulmonary epithelium and endothelium, lung inflammation, atelectasis, hypoxemia, and the release of inflammatory mediators. The release of inflammatory mediators could increase lung inflammation and cause injury to other organs. Thus, the traditional approach to mechanical ventilation may exacerbate or perpetuate lung injury in patients with acute lung injury and the acute respiratory distress syndrome and increase the risk of nonpulmonary organ or system failure.

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*Members of the Acute Respiratory Distress Syndrome (ARDS) Network are listed in the Appendix.
The use of lower tidal volumes during ventilation in patients with acute lung injury and the acute respiratory distress syndrome may reduce mortality in patients with acute lung injury and the acute respiratory distress syndrome,16–18 however, this approach may cause respiratory acidosis16,17 and decrease arterial oxygenation19,20 and may therefore require changes in the priority of some objectives in the care of these patients. With the traditional approach, the attainment of normal partial pressure of arterial carbon dioxide and pH is given a higher priority than is protection of the lung from excessive stretch. With an approach that involves lower tidal volumes, the reverse is true. Uncontrolled studies suggested that the use of a lower tidal volume would reduce mortality in patients with acute lung injury and the acute respiratory distress syndrome,17 but the results of four randomized trials of lung-protecting ventilation strategies have been conflicting.21–24 The present trial was conducted to determine whether the use of a lower tidal volume with mechanical ventilation would improve important clinical outcomes in such patients.

METHODS

Patients

Patients were recruited from March 1996 through March 1999 at the 10 university centers of the Acute Respiratory Distress Syndrome Network of the National Heart, Lung, and Blood Institute (the centers are listed in the Appendix). The protocol was approved by the institutional review board at each hospital, and informed consent was obtained from the patients or surrogates at all but one hospital, where this requirement was waived. A complete description of the methods is available on the World Wide Web (at www.arndnet.org) or from the National Auxiliary Publications Service (NAPS).* Patients who were intubated and receiving mechanical ventilation were eligible for the study if they had an acute decrease in respiratory acidosis, and decrease arterial oxygenation and may therefore require changes in the priority of some objectives in the care of these patients. With the traditional approach, the attainment of normal partial pressure of arterial carbon dioxide and pH is given a higher priority than is protection of the lung from excessive stretch. With an approach that involves lower tidal volumes, the reverse is true. Uncontrolled studies suggested that the use of a lower tidal volume would reduce mortality in patients with acute lung injury and the acute respiratory distress syndrome, but the results of four randomized trials of lung-protecting ventilation strategies have been conflicting. The present trial was conducted to determine whether the use of a lower tidal volume with mechanical ventilation would improve important clinical outcomes in such patients.

METHODS

Patients

Patients were recruited from March 1996 through March 1999 at the 10 university centers of the Acute Respiratory Distress Syndrome Network of the National Heart, Lung, and Blood Institute (the centers are listed in the Appendix). The protocol was approved by the institutional review board at each hospital, and informed consent was obtained from the patients or surrogates at all but one hospital, where this requirement was waived. A complete description of the methods is available on the World Wide Web (at www.arndnet.org) or from the National Auxiliary Publications Service (NAPS).* Patients who were intubated and receiving mechanical ventilation were eligible for the study if they had an acute decrease in the ratio of partial pressure of arterial oxygen to fraction of inspired oxygen to 300 or less (indicating the onset of hypoxemia; values were adjusted for altitude in Denver and Salt Lake City), bilateral pulmonary infiltrates on a chest radiograph consistent with the presence of edema, and no clinical evidence of left atrial hypertension or (if measured) a pulmonary-capillary wedge pressure of more than 18 mm Hg or less.1 Patients were excluded if 36 hours had elapsed since they met the first three criteria; they were younger than 18 years of age; they had participated in other trials within 30 days before the first three criteria were met; they were pregnant; they had increased intracranial pressure, neuromuscular disease that could impair spontaneous breathing, sickle cell disease, or severe chronic respiratory disease; they weighed more than 1 kg per centimeter of height; they had burns over more than 30 percent of their body-surface area; they had other conditions with an estimated 6-month mortality rate of more than 50 percent; they had undergone bone marrow or lung transplantation; they had chronic liver disease (as defined by Child–Pugh class C);25 or their attending physician refused or was unwilling to agree to the use of full life support.

A centralized interactive voice system was used for randomization. Patients were randomly assigned to receive mechanical ventilation involving either traditional tidal volumes or lower tidal volumes.

*See NAPS document no. 05542 for 15 pages of supplementary material. To order, contact NAPS, c/o Microfiche Publications, 248 Hempstead Tpke., West Hempstead, NY 11552.
in four hours before the ventilator settings were changed on day 0. Physiologic and radiographic data, medication use, and use of other investigational treatments were recorded between 6 and 10 a.m. on days 1, 2, 3, 4, 7, 14, 21, and 28. Data were transmitted weekly to the network coordinating center. Patients were followed until day 180 or until they were breathing on their own at home.

**Assessment of Compliance**

Randomly selected ventilator and blood gas variables were analyzed for compatibility with the protocol. Quarterly reports of these data from each of the 10 centers were used by investigators to assess compliance.

**Statistical Analysis**

The first primary outcome was death before a patient was discharged from the hospital and to be breathing without assistance. Patients who were in other types of health care facilities at 180 days were considered to have been discharged from the hospital and to be breathing without assistance. The second primary outcome was ventilator-free days, defined as the number of days from day 1 to day 28 on which a patient breathed without assistance, if the period of unassisted breathing lasted at least 48 consecutive hours. A difference in ventilator-free days could reflect a difference in mortality, ventilator days among survivors, or both. Other outcomes were the number of days without organ or system failure and the occurrence of barotrauma, defined as any new pneumothorax, pneumomediastinum, or subcutaneous emphysema, or a pneumatocele that was more than 2 cm in diameter. Interim analyses were conducted by an independent data and safety monitoring board after the enrollment of each successive group of approximately 200 patients. Stopping boundaries (with a two-sided level of 0.05) were designed to allow early termination of the study if the use of lower tidal volumes was found to be either efficacious or ineffective.

The comparison of traditional with lower tidal volumes was one of two trials conducted simultaneously in the same patients in a factorial experimental design. Ketoconazole was compared with placebo in the last 194 patients, and lisofylline was compared with placebo in the first 234 patients, and lisofylline was compared with placebo in the last 194 patients; no drugs were assessed in the middle 433 patients. We used Student’s t-test or Fisher’s exact test to compare base-line variables. We used analysis of covariance to compare log-transformed plasma interleukin-6 values. We used Wilcoxon’s test to compare the day 0 and day 3 plasma interleukin-6 concentrations, ventilator-free days, and organ-failure–free days, which had skewed distributions. We used the 180-day cumulative incidence of mor-

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**Table 1. Summary of Ventilator Procedures.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group Receiving Traditional Tidal Volumes</th>
<th>Group Receiving Lower Tidal Volumes</th>
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<tbody>
<tr>
<td>Ventilator mode</td>
<td>Volume assist–control</td>
<td>Volume assist–control</td>
</tr>
<tr>
<td>Initial tidal volume (ml/kg of predicted body weight)†</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Plateau pressure (cm of water)</td>
<td>≤50</td>
<td>≤30</td>
</tr>
<tr>
<td>Ventilator rate setting needed to achieve a pH goal of 7.3 to 7.45 (breaths/min)</td>
<td>6–35</td>
<td>6–35</td>
</tr>
<tr>
<td>Ratio of the duration of inspiration to the duration of expiration</td>
<td>1:1–1:3</td>
<td>1:1–1:3</td>
</tr>
<tr>
<td>Oxygenation goal</td>
<td>PaO₂, 55–80 mm Hg, or SpO₂, 88–95%</td>
<td>PaO₂, 55–80 mm Hg, or SpO₂, 88–95%</td>
</tr>
<tr>
<td>Allowable combinations of FiO₂ and PEEP (cm of water)‡</td>
<td>0.3 and 5</td>
<td>0.3 and 5</td>
</tr>
<tr>
<td></td>
<td>0.4 and 5</td>
<td>0.4 and 5</td>
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<td>0.4 and 8</td>
<td>0.4 and 8</td>
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<td>0.5 and 8</td>
<td>0.5 and 8</td>
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<td></td>
<td>0.5 and 10</td>
<td>0.5 and 10</td>
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<tr>
<td></td>
<td>0.6 and 10</td>
<td>0.6 and 10</td>
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<tr>
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<td>0.7 and 10</td>
<td>0.7 and 10</td>
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<tr>
<td></td>
<td>0.7 and 12</td>
<td>0.7 and 12</td>
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<tr>
<td></td>
<td>0.7 and 14</td>
<td>0.7 and 14</td>
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<tr>
<td></td>
<td>0.8 and 14</td>
<td>0.8 and 14</td>
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<tr>
<td></td>
<td>0.9 and 14</td>
<td>0.9 and 14</td>
</tr>
<tr>
<td></td>
<td>0.9 and 16</td>
<td>0.9 and 16</td>
</tr>
<tr>
<td></td>
<td>0.9 and 18</td>
<td>0.9 and 18</td>
</tr>
<tr>
<td></td>
<td>1.0 and 18</td>
<td>1.0 and 18</td>
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<td></td>
<td>1.0 and 20</td>
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<td>1.0 and 22</td>
<td>1.0 and 22</td>
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<tr>
<td></td>
<td>1.0 and 24</td>
<td>1.0 and 24</td>
</tr>
</tbody>
</table>

*PaO₂ denotes partial pressure of arterial oxygen, SpO₂ oxyhemoglobin saturation measured by pulse oximetry, FiO₂ fraction of inspired oxygen, and PEEP positive end-expiratory pressure.

†Subsequent adjustments in tidal volume were made to maintain a plateau pressure of ≤50 cm of water in the group receiving traditional tidal volumes and ≤30 cm of water in the group receiving lower tidal volumes.

‡Further increases in PEEP, to 34 cm of water, were allowed but were not required.
tality to compare the proportion of patients in each group who died before being discharged from the hospital and breathing without assistance, after stratification for other experimental interventions; treatment with ketocazole, the ketocazole placebo, lisofylline, the lisofylline placebo, or no other agent. We used a chi-square test to determine whether there was an interaction between the study group and the other experimental interventions with respect to the mean (±SE) mortality rates at 180 days. All P values are two-sided.

RESULTS

The trial was stopped after the fourth interim analysis because the use of lower tidal volumes was found to be efficacious (P=0.005 for the difference in mortality between groups; P value for the stopping boundary, 0.023). The base-line characteristics of the 861 patients who were enrolled were similar, except that minute ventilation was slightly but significantly higher (P=0.01) in the group treated with lower tidal volumes (Table 2).

The tidal volumes and plateau pressures were significantly lower on days 1, 3, and 7 in the group treated with lower tidal volumes than in the group treated with traditional tidal volumes (Table 3). The mean (±SD) tidal volumes on days 1 to 3 were 6.2±0.8 and 11.8±0.8 ml per kilogram of predicted body weight (P<0.001), respectively, and the mean plateau pressures were 25±6 and 33±8 cm of water (P<0.001), respectively. The partial pressure of arterial oxygen was similar in the two groups at all three times, but the positive end-expiratory pressure and fraction of inspired oxygen were significantly higher and the ratio of partial pressure of arterial oxygen to fraction of inspired oxygen was significantly lower in the group treated with lower tidal volumes on days 1 and 3. On day 7, positive end-expiratory pressure and the fraction of inspired oxygen were significantly higher in the group treated with traditional tidal volumes. The respiratory rate was significantly higher in the group treated with lower tidal volumes on days 1 and 3, but minute ventilation was similar in the two groups on these days. The partial pressure of arterial carbon dioxide was significantly higher on days 1, 3, and 7 and arterial pH was significantly lower on days 1 and 3 in the group treated with lower tidal volumes.

The probability of survival and of being discharged home and breathing without assistance during the first 180 days after randomization is shown in Figure 1. The mortality rate was 39.8 percent in the group treated with traditional tidal volumes and 31.0 percent in the group treated with lower tidal volumes (P=0.007; 95 percent confidence interval for the difference between groups, 2.4 to 15.3 percent). The interaction between the study group and stratification for other experimental interventions was not significant (P=0.16).

Data were available to calculate the static compliance of the respiratory system at base line in 517 patients (Fig. 2). The interaction between the quartile of static compliance at base line and the study group with respect to the risk of death was not significant (P=0.49).

The number of ventilator-free days was significantly higher in the group treated with lower tidal volumes than in the group treated with traditional tidal volumes (Table 4). The median duration of ventilation was 8 days among patients in both groups who were discharged from the hospital after weaning and 10.5 and 10 days, respectively, among those who died in the group treated with lower tidal volumes and the group treated with traditional tidal volumes. The number of days without nonpulmonary organ or system failure was significantly higher in the group treated with lower tidal volumes (P=0.006). This group had more days without circulatory failure (mean [±SD], 19±10 vs. 17±11 days; P=0.004), coagulation failure (21±10 vs. 19±11 days, P=0.004), and renal failure (20±11 vs. 18±11 days, P=0.005) than did the group treated with traditional tidal volumes.

**Table 2. Base-Line Characteristics of the Patients.**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Group Receiving Lower Tidal Volumes (N=432)</th>
<th>Group Receiving Traditional Tidal Volumes (N=429)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>51±17</td>
<td>52±18</td>
</tr>
<tr>
<td>Female sex (%)</td>
<td>40</td>
<td>41</td>
</tr>
<tr>
<td>Race or ethnic group (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>75</td>
<td>71</td>
</tr>
<tr>
<td>Black</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Hispanic</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Other or unknown</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>APACHE III score†</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>81±28</td>
<td>84±28</td>
</tr>
<tr>
<td>PaO2, PaCO2, PaO2, PaCO2 (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>138±64</td>
<td>134±58‡</td>
</tr>
<tr>
<td>PaO2, PaCO2, PaO2, PaCO2 (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>82</td>
<td>85</td>
</tr>
<tr>
<td>Tidal volume (ml)§</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>676±119</td>
<td>665±125</td>
</tr>
<tr>
<td>Minute ventilation (l/min)§</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13.4±4.3§</td>
<td>12.7±4.3</td>
</tr>
<tr>
<td>No. of nonpulmonary organ or system failures¶</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.8±1.1</td>
<td>1.8±1.0</td>
</tr>
</tbody>
</table>

*Plus-minus values are means ±SD. Because of rounding, not all percentages total 100. PaO2 denotes partial pressure of arterial oxygen, and PaCO2, fraction of inspired oxygen.
†APACHE III denotes Acute Physiology, Age, and Chronic Health Evaluation. Scores can range from 0 to 299, with higher scores indicating more severe illness.
‡Data were missing for one patient.
§Data were available for 300 patients in the group treated with lower tidal volumes and for 290 patients in the group treated with traditional tidal volumes.
¶P=0.01.
†Organ and system failures were defined as described in the Methods section.
Experimental interventions were given to 15 patients who died (73±24 percent and 71±28 percent, respectively), or those who were discharged home and breathing without assistance (65±24 percent, respectively), or in the percentages of days on which sedatives were used among patients who were discharged home and breathing without assistance (65±26 percent and 65±24 percent, respectively) or those who died (73±24 percent and 71±28 percent, respectively).

Investigational treatments for acute lung injury and the acute respiratory distress syndrome that were not included in the factorial design of the experimental interventions were given to 15 patients in the group treated with lower tidal volumes and 12 patients in the group treated with traditional tidal volumes. These included prone positioning in 14 and 9 patients, respectively.

The mean log-transformed plasma interleukin-6 values decreased from 2.5±0.7 pg per milliliter on day 0 to 2.3±0.7 pg per milliliter on day 3 in the group treated with traditional tidal volumes and from 2.5±0.7 pg per milliliter to 2.0±0.5 pg per milliliter in the group treated with lower tidal volumes. The decrease was greater in the group treated with lower tidal volumes (P<0.001), and the day 3 plasma interleukin-6 concentrations were also lower in this group (P=0.002).

**DISCUSSION**

In this large study of patients with acute lung injury and the acute respiratory distress syndrome, mortality was reduced by 22 percent and the number of ventilator-free days was greater in the group treated with lower tidal volumes than in the group treated with traditional tidal volumes.
with traditional tidal volumes. These results are consistent with the results of experiments in animals\textsuperscript{9-14} and observational studies in humans.\textsuperscript{16,17}

These benefits occurred despite the higher requirements for positive end-expiratory pressure and fraction of inspired oxygen and the lower ratio of partial pressure of arterial oxygen to fraction of inspired oxygen in the group treated with lower tidal volumes on days 1 and 3. These results, coupled with the greater reductions in plasma interleukin-6 concentrations, suggest that the group treated with lower tidal volumes had less lung inflammation.\textsuperscript{35} The greater reductions in plasma interleukin-6 concentrations may also reflect a reduced systemic inflammatory response to lung injury, which could contribute to the higher number of days without organ or system failure and the lower mortality in the group treated with lower tidal volumes.\textsuperscript{15}

Several factors could explain the difference in results between our trial and other trials of ventilation using lower tidal volumes in patients with acute lung injury and the acute respiratory distress syndrome.\textsuperscript{22-24} First, our study had a greater difference in tidal volumes between groups. In one earlier trial, the traditional tidal volume was equivalent to approximately 12.2 ml per kilogram of predicted body weight and the lower tidal volume was equivalent to approximately 8.1 ml per kilogram of predicted body weight.\textsuperscript{23} In a second study, the traditional and lower tidal volumes were approximately 10.3 and 7.1 ml per kilogram of dry body weight (calculated as the measured weight minus the estimated weight gain from fluid retention), respectively.\textsuperscript{22} In the present trial, measured weight exceeded predicted body weight by approximately 20 percent. Assuming a similar difference, and assuming that half the difference was dry weight in excess of predicted body weight, tidal volumes in the second trial would have been approximately 11.3 and 7.8 ml per kilogram of predicted body weight. Therefore, the traditional tidal volume of 11.8 ml per kilogram of predicted body weight in our study was similar to the values in the previous two trials.
However, the tidal volume of 6.2 ml per kilogram of predicted body weight in the group receiving lower tidal volumes was lower than the values in the previous two trials.

If one assumes that measured weights also exceeded predicted body weights by 20 percent in the earlier trials, the tidal volumes in the traditional groups were approximately 10.2 and 9.4 ml per kilogram of measured weight, respectively, as compared with 9.9 ml per kilogram of measured weight in our study. Therefore, the tidal volumes in the traditional groups in each of the three trials were consistent with traditional recommendations.6,36

A second possible explanation for the different results is that the previous trials were designed to detect larger differences in mortality between groups.22-24 Hence, they lacked the statistical power to demonstrate the moderate effects of lower tidal volumes that we found.

A third difference in the trials was in the treatment of acidosis. Increases in the ventilator rate were required and bicarbonate infusions were allowed to correct mild-to-moderate acidosis in our study, which resulted in smaller differences in the partial pressure of arterial carbon dioxide and pH between the study groups than in the previous trials.22-24 The deleterious effects of acidosis in the previous studies may have counteracted a protective effect of the lower tidal volumes.

In addition to being caused by excessive stretch, lung injury may also result from repeated opening and closing of small airways or from excessive stress at margins between aerated and atelectatic regions of the lungs.37 These types of lung injury may be prevented by the use of a higher positive end-expiratory pressure.10,13,37,38 A slightly higher positive end-expiratory pressure was necessary in the group treated with lower tidal volumes during the first few days to maintain arterial oxygenation at a level similar to that in the group treated with traditional tidal volumes, but positive end-expiratory pressure was not increased as a means of protecting the lungs.

In a recent trial in 53 patients with acute respiratory distress syndrome, 28-day mortality was significantly lower with a ventilation strategy that used a higher positive end-expiratory pressure combined with limited peak inspiratory pressure than with a strategy of traditional ventilation.21 These results suggest that both increased positive end-expiratory pressure and reduced inspiratory stretch could have beneficial effects.

Stretch-induced lung injury may not occur if lung compliance is not greatly reduced. However, the benefit of ventilation with a lower tidal volume was independent of the static compliance of the respiratory system at base line, suggesting that the lower tidal volume was advantageous regardless of lung compliance. Variations in chest-wall compliance, which contributes to compliance of the respiratory system and is reduced in many patients with acute lung injury and the acute respiratory distress syndrome,39 may have obscured a true interaction between tidal volume and base-line lung compliance.

Barotrauma occurred with similar frequency in the two study groups, a finding consistent with the results of other studies in which the incidence of barotrauma was independent of airway pressures.22-24,40,41 The most common manifestation of barotrauma was pneumothorax, which could have been the result of invasive procedures. Pneumothorax is not a sensitive or specific marker of stretch-induced injury with the tidal volumes used in this study.

The similarity in the number of days of ventilator use among the survivors in both groups suggests that the higher number of ventilator-free days in the group treated with lower tidal volumes resulted from reduced mortality rather than from a reduced number of days of ventilation among the survivors. However, the comparison of the number of days of ventilator use among the survivors could be misleading.22 Some patients who would have survived in the group treated with traditional tidal volumes might have needed the ventilator on fewer days had they been in the group treated with lower tidal volumes. This beneficial effect would have been obscured if prolonged ventilation was required before recovery among patients who otherwise would have died in the group treated with traditional tidal volumes. For similar reasons, it is also difficult to compare the number of days with organ or system failure among the survivors in the two study groups.

We found that treatment with a ventilation approach designed to protect the lungs from excessive stretch resulted in improvements in several important clinical outcomes in patients with acute lung injury and the acute respiratory distress syndrome. On the basis of these results, high priority should be given to preventing excessive lung stretch during adjustments to mechanical ventilation, and this lower-tidal-volume protocol should be used in patients with acute lung injury and the acute respiratory distress syndrome.

Supported by contracts (NO1-HR 46054, 46055, 46056, 46057, 46058, 46059, 46060, 46061, 46062, 46063, and 46064) with the National Heart, Lung, and Blood Institute.


We are indebted to the intensive care unit nurses, respiratory therapists, and physicians, as well as our patients and their families, who supported this trial.

APPENDIX

In addition to the members of the Writing Committee, the members of the National Heart, Lung, and Blood Institute ARDS Network were as follows: Network Participants: Cleveland Clinic Foundation — H.P. Wiedemann, A.C. Arroliga, C.J. Fisher, Jr., J.J. Komara, Jr., P. Perez-Trelpchio;
REFERENCES


