Measurement of extravascular lung water in patients with pulmonary edema

Michael A. Matthay

Departments of Medicine and Anesthesia and The Cardiovascular Research Institute, University of California, San Francisco, San Francisco, California

MEASUREMENT OF EXTRAVASCULAR lung water has been a topic of major interest for more than two decades (1, 5, 19). In the recent article by Effros et al. (2), they provide a review of current and past efforts to measure extravascular lung water with thermal and osmotic dilution methods. The authors discuss several of the limitations of these methods, including problems related to early recirculation of the thermal indicator, as well as potential problems related to heterogeneous perfusion of edematous lungs. Although the authors have provided a thoughtful critique of some of the limitations of the transpulmonary thermodilution technique for measuring extravascular lung water, there is some recent evidence that this methodology may provide valuable insights into lung fluid balance in patients with acute pulmonary edema and acute lung injury.

In 2006, Perkins et al. (13) published the results of a randomized placebo-controlled clinical trial in which 40 patients with acute lung injury were treated with either intravenous salbutamol (a β2-agonist) or placebo. The primary objective of the trial was to determine if the β-agonist reduced extravascular lung water in these patients. β-agonist therapy has been proposed as a treatment that may accelerate the resolution of alveolar edema by upregulating salt and water transport mechanisms in the alveolar epithelium (3, 4). The results of this blinded trial showed that the patients who were treated with intravenous salbutamol had a 40% reduction in extravascular lung water compared with the controls. The reduction in extravascular lung water was matched by a reduction in the plateau airway pressure, a measure of quasistatic respiratory compliance that may reflect less pulmonary edema. In spite of the methodological concerns pointed out by Effros et al. (2), the results of this blinded trial seemed to indicate that the transpulmonary thermodilution technique (PiCCO; Pulsion Medical Systems, Munich, Germany) is able to detect a significant change in lung water with a treatment that might be expected to achieve this objective.

In addition, the results of a recent clinical trial published in April 2008 also support the conclusion that this methodology for measuring extravascular lung water is able to detect clinically significant changes in lung water (8). In this trial, the patients had their extravascular lung water measured before surgical resection of a lung lobe for cancer, and then the extravascular lung water was measured again every 6 h postoperatively. The patients were randomized in an elegant crossover design to receive every 6 h either 5 mg of inhaled salbutamol (β2-agonist) or 0.5 mg of inhaled ipratropium. When patients were treated with inhaled salbutamol, there was an 18% reduction in extravascular lung water (P = 0.019) and a corresponding improvement in oxygenation (P = 0.012). The results of this study provide further evidence that the measurement of extravascular lung water with this transpulmonary thermodilution technique is sensitive to detecting changes in the quantity of pulmonary edema in patients with pulmonary edema.

It should also be noted that several investigators have tested the reliability of the extravascular lung water measurement compared with gravimetric measurements in animal models and in patients (6, 7, 9, 15–18). Most of these studies have found a good correlation with gravimetric measurements. Also, a recent study from Phillips et al. (14) reported that the combined measurement of extravascular lung water and pulmonary dead space in patients with acute lung injury has prognostic value for identifying patients at the highest risk of nonsurvival. In fact, extravascular lung water that was greater than 16 ml/kg/predicted body weight predicted death with 100% specificity and 86% sensitivity. The use of predicted body weight for indexing extravascular lung water measurements may increase the accuracy of this method because of the prevalence of obesity in European and U.S. populations (11, 12).

In summary, the concerns expressed by Effros et al. (2) regarding the methodological issues with measurement of extravascular lung water are important to appreciate. However, the results of experimental studies, observational clinical studies, and two double-blind controlled trials indicate that significant changes in extravascular lung water can be detected in patients, and therefore measurements of lung water have research value (8, 13). The studies by the late Dr. Schuster and his colleagues (10) almost 20 years ago suggested the potential benefit of measuring extravascular lung water as a method for improving clinical outcomes. Thus, in my opinion, further studies are needed to assess extravascular lung water in patients at risk for developing pulmonary edema as well as in patients with established pulmonary edema from hydrostatic causes or from an increase in permeability (acute lung injury). Reliance on the chest radiograph or arterial oxygenation is not adequate for assessing the quantity of pulmonary edema. The transpulmonary thermodilution technique should be used to advance research into the mechanisms and potential therapeutic strategies in patients who are at risk for developing pulmonary edema from acute lung injury as well as in patients with established acute lung injury.

REFERENCES


