CRITICAL CARE

COMMENTARY

Extravascular lung water in acute respiratory distress syndrome: potential clinical value, assumptions and limitations

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See related research by Chew *et al.*, http://ccforum.com/content/16/1/R1

Abstract

Extravascular lung water has been proposed as a marker of disease severity, response to treatment and mortality in patients with acute respiratory distress syndrome. Here, we discuss its potential value and limitations in clinical practice.

Acute respiratory distress syndrome (ARDS) is characterised by diffuse alveolar damage and increased extravascular lung water (EVLW), clinically measured by the trans-pulmonary single-indicator thermo-dilution method. Although not part of the diagnostic criteria for ARDS, increased EVLW is central to the pathophysiology of the syndrome and correlates with the severity of lung injury, response to treatment and clinical outcome. In this issue of *Critical Care*, Chew and colleagues [1], in an observational study involving an heterogeneous population of patients with shock, report the role of EVLW in the context of two themes: its ability to predict disease severity and outcome and its added value as a diagnostic criterion of ARDS.

On the first theme, Chew and colleagues [1] report that patients with higher EVLW indices (EVLWIs) had more severe disease with greater Lung Injury Score, and were less likely to survive ICU [1]. These findings are in accordance with the available literature [2-4], which suggests that EVLW is a good predictor of mortality with an odds ratio of 8.8 [5]. However, there is still no firm consensus on its range of normal values and the best indexing parameter (for example, actual or predicted body weight or pulmonary blood volume) against which EVLW should be normalised. Chew and colleagues [1] found that EVLW indexed to absolute body weight resulted in a stronger association with outcome. This result differs from previous clinical studies showing that EVLW indexed to predicted body weight (PBW) is a superior predictor of mortality [6], of developing multiple organ failure [2] and for the diagnosis of ARDS [4,6-8]. The physiologic rationale for using predicted body weight is that lung size and lung weight depend on height and gender - and therefore predicted body weight - whereas adjusting EVLW for absolute body weight may lead to erroneous estimations of EVLW in obese patients. However, obesity may be an explanatory variable rather than a confounding one. Obesity may directly affect EVLW - for example, by decreasing the intra-thoracic blood volume (ITBV) or the lymphatic clearance of EVLW through increased intra-abdominal and pleural pressures. As EVLW is calculated as the difference between the intra-thoracic thermal volume and ITBV, any change in pulmonary perfusion and ITBV will affect EVLW.

In addition, the relationship between EVLW and disease severity, and EVLW and outcome, may reflect three independent but concurrent possibilities.

First, EVLWI may measure the amount of inflammatory oedema (high permeability). The ratio of EVLW to the pulmonary blood volume has been used as an indirect index of pulmonary vascular permeability in critically ill patients with, or at risk of, ARDS [9], with normal ratios helping to exclude high pulmonary permeability [10]. Chew and colleagues [1] show that this ratio seems a better marker of disease severity in patients with a Lung Injury Score >2.5, perhaps implying that patients with severe ARDS have greater lung oedema, possibly due to greater pulmonary permeability, and greater mortality. Computed tomography studies of patients with ARDS have suggested that patients with severe ARDS have greater inflammatory oedema and lung weight, a greater response to lung recruitment and higher positive

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end-expiratory pressure (PEEP) together with higher mortality [11]. Considering the reported limitations of this index to truly distinguish high permeability from hydrostatic oedema [9], however, this relationship is here only suggested and warrants further clinical confirmation.

Second, EVLWI may reflect a higher fluid balance (hydrostatic pulmonary oedema), which is an independent determinant of mortality and is associated with worse oxygenation and lower compliance [12]. The lack of correlation with other oxygenation parameters and compliance suggests that EVLW may provide additional information not available in other parameters.

Third, EVLW may be a reflection of other physiological processes that are associated with disease severity but independent from oedema formation (linked to the technique). Pathologic factors leading to an increase in dead space, shunt fraction and loss of hypoxic pulmonary vasoconstriction in severe ARDS cause redistribution of pulmonary blood flow in parallel with the distribution of the perfused thermal volume. Since the thermal signal can only diffuse into perfused lung tissue, the increased perfusion of previously thermally silent tissue causes an apparent increase of EVLW independently of true changes in pulmonary oedema [13].

On the second theme of the inclusion of EVLWI as a diagnostic criterion of ARDS, the current definition of ARDS has been challenged on the basis of its limited predictive value, large inter-observer variability and the lack, among its defining criteria, of an objective physiological marker that possesses diagnostic, prognostic and concurrent validity (that is, the ability to distinguish ARDS from other forms of hypoxaemic respiratory failure). Elevated EVLWI can identify patients with ARDS and predicts progression to ARDS in patients with risk factors 2 to 3 days before the patients meet current ARDS criteria, increasing the opportunity of delivering therapeutic intervention proven to improve outcome [14]. Chew and colleagues [1] show that EVLW used as an additional diagnostic test leads to a two- to three-fold increase in the post-test odds ratio for the diagnosis of ARDS, and the authors argue for its inclusion in a revised definition of ARDS. This argument is justified in view of the clear pathophysiological and prognostic plausibility of EVLW in ARDS [2-4,8,15,16]. In our opinion, however, physiological and methodological assumptions required for its estimation, the still arbitrary cutoff values and the still limited availability worldwide currently restrict its general applicability as a diagnostic criterion in the definition of ARDS until its prognostic and concurrent validity are prospectively validated and confirmed in larger scale clinical trials.

Abbreviations

ARDS, acute respiratory distress syndrome; EVLW, extravascular lung water; EVLWI, extravascular lung water index; ITBV, intra-thoracic blood volume.

Competing interests

The authors declare that they have no competing interests.

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