Letter

Measuring extravascular lung water: animals and humans are not the same

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The evolution of extravascular lung water (EVLW) monitoring is an important step forward in the hemodynamic assessment of critically ill patients.

The determination of EVLW with single transpulmonary thermodilution (STD) has shown an acceptable accuracy and reproducibility [1-4]. However, in the experimental setting the STD technique can overestimate EVLW compared with postmortem gravimetry as a reference method [1-3]. The calculation of EVLW is based on the assumption that EVLW = intrathoracic thermal volume (ITTV) − intrathoracic blood volume (ITBV). According to the STD algorithm (PiCCO; Pulsion Medical Systems, Munich, Germany), in humans ITBV = 1.25 × global end-diastolic volume (GEDV) − 28.4 (ml) [4]. However, in experimental studies the relationship between ITBV and GEDV differs significantly. It is still unsettled whether this depends on species differences or different body weights. In pigs weighing between 24.0 and 31.8 kg, the linear regression equation is ITBV = 1.52 × GEDV − 49.7 [1]. Replacing the default PiCCO algorithm by the latter equation, the overestimation was reduced to a level that was not significantly different from the gravimetric value.

Employing a thermal dye technique (TDD, Cold Z-021; Pulsion Medical Systems), we recently determined ITBV, GEDV, the ITBV:GEDV ratio, and pulmonary blood volume (PBV) in sheep. The measurements were performed during spontaneous breathing, during mechanical ventilation, and after pneumonectomy (Table 1). Our results confirm the close correlation between ITBV and GEDV in different states. They may also indicate a relationship between ventilation, perfusion and the ITBV/GEDV ratio [4]. Mechanical ventilation can decrease preloading, thus reducing GEDV, whereas ITBV continues to remain an accurate marker of preload. Most probably, ITBV reduces after pneumonectomy because of a decrease in PBV. We therefore suggest that the ITBV:GEDV

Table 1

Volumetric variables in sheep breathing spontaneously, or subjected to mechanical ventilation, or pneumonectomy

Parameter	SB ($n = 48$)	MV ($n = 51$)	PE ($n = 42$)
ITBVI (ml/m^2)	856 ± 106	804 ± 129	635 ± 116^{b,c}
GEDVI (ml/m^2)	654 ± 92	551 ± 91^b	461 ± 97^{b,c}
PBVI (ml/m^2)	202 ± 32	253 ± 56^b	176 ± 41^{b,c}
ITBV:GEDV ratio	1.313 ± 0.063	1.463 ± 0.089^b	1.389 ± 0.101^{b,c}
Correlation between ITBVI and GEDV^a	0.96	0.93	0.95
Regression equation	ITBVI = 1.16 × GEDVI + 92.45	ITBVI = 1.43 × GEDVI + 13.48	ITBVI = 1.21 × GEDVI + 73.72

SB, spontaneous breathing; MV, mechanical ventilation with tidal volumes of 6 to 8 ml/kg and positive end-expiratory pressure 2 cmH_2O; PE, pneumonectomy; ITBVI, intrathoracic blood volume index; GEDVI, global end-diastolic volume index; PBVI, pulmonary blood volume index; ITBV, intrathoracic blood volume; GEDV, global end-diastolic volume. All data are distributed normally and are presented as means ± SD. ^{a}Pearson coefficient, r ($p < 0.0001$). $^b p < 0.05$ compared with SB; $^c p < 0.05$ compared with MV (analysis of variance followed by Scheffe's test).

EVLW = extravascular lung water; GEDV = global end-diastolic volume; ITBV = intrathoracic blood volume; PBV = pulmonary blood volume; STD = single transpulmonary thermodilution.

ratio depends on relative and independent changes in ITBV and GEDV.

We agree with other investigators [1,2] that STD may be a useful tool for monitoring changes in EVLW over time. Our recent study [5] demonstrates that in patients with severe sepsis EVLW measured by STD has a prognostic role and is significantly correlated with lung injury score. Although we have to keep in mind the technical aspects of STD that can differ between experimental and clinical settings, EVLW has evolved as a key variable for evaluating pulmonary hemodynamics. Thus, monitoring of EVLW might be a valid dynamic measure of lung edema at the bedside, supporting therapeutical decisions on patients with a compromised cardiopulmonary function.

Key messages

- The calculation of extravascular lung water with the use of single transpulmonary thermodilution in the experimental animals requires a specific correction.

- The monitoring of extravascular lung water is a valid dynamic method for measuring lung edema at the bedside.

Competing interests

MYK and EF-M are members of the Medical Advisory Board, Pulsion Medical Systems. Approximately 25% of the total expenses to two of the studies upon which this letter is based has been reimbursed by Pulsion Medical Systems, Munich, Germany.

Authors' contributions

MYK and VVK participated in the design of the study, performed the statistical analysis, and drafted the manuscript. EF-M and LJB participated in the preparation of the draft. All authors read and approved the final version.

Acknowledgement

The studies in sheep described in this letter were approved by the Norwegian Experimental Animal Board and performed in compliance with the European Convention on Animal Care at the University of Tromsø, Norway.

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