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ACCURACY OF ESOPHAGEAL PRESSURE TO ASSESS TRANS-PULMONARY PRESSURE DURING MECHANICAL VENTILATION^{1,2}

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The difference in pressure inside (airway pressure) minus outside (pleural pressure) the lungs represents trans-pulmonary pressure. Esophageal pressure (P_{ES}) is a surrogate for pleural pressure but controversies exist on how derive the values of P_{ES} to calculate trans-pulmonary pressure [1,2].

Ex-vivo lung perfusion (EVLP) followed by transplant may allow the comparison of trans-pulmonary pressure values obtained outside the thorax with the values obtained from the same lungs inside the thorax after transplantation [3]. We identified the method to derive P_{ES} values that provide the best agreement between “in-vivo” and “ex-vivo” assessment of trans-pulmonary.

Institutional review board approved the study and written informed consent was obtained from transplanted patients. Lungs referred for EVLP and patients receiving bilateral transplant were included. Measurements were performed if the best PaO_2/FiO_2 during 4 hours of EVLP was ≥ 350 [3] and if patients had a $PaO_2/FiO_2 \geq 350$ with a level of PEEP ≤ 10 cmH₂O. Patients were excluded and measurement not performed in the presence of pleural effusion at the chest x-ray, if ECMO or a chest tube was needed, if $PaO_2/FiO_2 < 350$ or PEEP > 10 cmH₂O.

“Ex-vivo” and “in-vivo” measurements were performed with a respiratory rate of 7 breaths/min, a tidal volume of 10 ml/kg donor PBW, and an FiO_2 of 1.0 [3]. “In-vivo” measurements were obtained in the semi-recumbent position and 24 hours after ICU admission. To match lung volume between “ex-vivo” and “in-vivo”, PEEP was set at 5 cmH₂O in the former and 0 cmH₂O in the latter [4].

Trans-pulmonary pressure at end-inspiration and end-expiration were calculated using values of P_{ES} referred to atmosphere ($P_{ES_ABSOLUTE}$), or assuming that pleural pressure is 5 cmH₂O lower than $P_{ES_ABSOLUTE}$ ($P_{ES_CORRECTED}$), or referring P_{ES} to the value at end-expiration (ΔP_{ES}) [1].

Elastance of the lung ($EST_{,l}$) was calculated [1,2].

Inferential analysis was based on the computation of the two-tailed 95% confidence intervals (CI) of the mean (one-sample t distribution) of the differences between alternative methods.

Measurements were performed in 15 cases. $P_{ES_ABSOLUTE}$ and $P_{ES_CORRECTED}$ provided the best agreement between “in vitro” and “in vivo” measurements of $EST_{,l}$. The best agreement between “ex-vivo” and “in-vivo” values of end inspiratory and end-expiratory trans-pulmonary pressure was observed using $P_{ES_CORRECTED}$. On the other hand, the way how values of trans-pulmonary pressure were derived from esophageal pressure had little impact on the result of $EST_{,l}$ as this calculation is based on the difference between end-inspiratory and end-expiratory transpulmonary pressures (**Table**).

Our study presents these limitations: (a) although “ex-vivo” and “in-vivo” PaO_2/FiO_2 values were similar (444 ± 70 vs. 432 ± 64 , respectively) these conditions conditions are very different and the time between the two measurements of trans-pulmonary pressure is relatively long; (b) we did not assess absolute lung volumes; (c) the correction factor to calculate was fixed at 5 cmH₂O [1] but other studies showed it may vary among subjects [5].

Despite these limitations, our data seem to suggest that the assumption that pleural pressure is 5 cmH₂O lower than the absolute value of P_{ES} may be valid.

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On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Table. Comparative analysis of different approaches to estimate “in-vivo EST, L , $P_{PLAT, L}$ and $PEEP, L$ from measurements of esophageal pressure.

		“EX-VIVO”	“IN-VIVO”		
			$P_{ES_ABSOLUTE}$	ΔP_{ES}	$P_{ES_CORRECTED}$
EST, L (L/cmH ₂ O)		5.86±2.09	6.00±1.78	6.53±1.71	6.00±1.78
$TRANS-PULMONARY PRESSURE$ (cmH ₂ O)	END-EXPIRATORY	5.02±0.03	0.56±0.34	0.21±0.14	5.56±0.31
	END-INSPIRATORY	9.18±1.60	4.88±1.38	4.91±1.37	9.88±1.38
BIAS “EX-VIVO” vs. “IN-VIVO” (95% CI)					
		$P_{ES_ABSOLUTE}$	ΔP_{ES}	$P_{ES_CORRECTED}$	
EST, L (L/cmH ₂ O)		-0.01 (-1.37; 1.21)	-0.61 (-1.85; 0.67)	-0.01 (-1.37; 1.21)	
$TRANS-PULMONARY PRESSURE$ (cmH ₂ O)	END-EXPIRATORY	5.30 (4.98; 5.63)	4.85 (4.76; 4.93)	0.35 (-0.04; 0.66)	
	END-INSPIRATORY	4.845 (3.846; 5.848)	3.946 (2.914; 4.978)	-0.153 (-1.154; 0.848)	

Data are mean ± standard deviation. Definitions of abbreviations: EST, L : Elastance of the lung; P_{ES} : esophageal pressure; CI : confidence interval. BIAS is the difference between “ex-vivo” and “in-vivo” measurements.