

Airway driving pressure and lung stress in ARDS patients

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Additional file 1

Table S1. Patients characteristic according to intensive care unit outcome.

	Survivors (N=102)	Non-survivors (N=48)	P value
Age (years)	61.0 [45.0 – 74.0]	65.5 [52.5 – 72.5]	0.17
Male sex, N (%)	73 (71.6)	29 (60.4)	0.239
Body mass index (kg/m²)	24.7 [22.9 – 27.7]	24.6 [22.6 – 30.1]	0.64
PaO₂/FiO₂ ratio	211 [156 – 257]	160 [117 – 170]	< 0.0001
PaCO₂ (mmHg)*	38.1 [35.0 – 43.6]	43.1 [36 – 48.3]	0.019
Respiratory system elastance (cmH₂O/L)[°]	22.9 [20.0 – 28.7]	28.1 [23.2 – 35.2]	0.016
Tidal volume (mL/kg_{IBW})*	8.3 [7.1 – 9.3]	7.8 [6.7 – 8.6]	0.22
PEEP (cmH₂O)*	10.0 [10.0 – 12.5]	10.0 [10.0 – 14.0]	0.055
Respiratory rate (breaths/min)*	13.0 [11.0 – 16.5]	16.5 [14.0 – 20.0]	< 0.01
Airway driving pressure at PEEP 5 cmH₂O (cmH₂O)	12.2 [10.2 – 14.3]	13.8 [10.7 – 16.4]	0.047
Transpulmonary driving pressure at PEEP 5 cmH₂O (cmH₂O)	8.9 [7.0 – 10.9]	10.0 [7.7 – 13.2]	0.057
Lung stress at PEEP 5 cmH₂O (cmH₂O)	12.9 [10.7 – 15.5]	14.0 [11.0 – 16.4]	0.32
Airway driving pressure at PEEP 15 cmH₂O (cmH₂O)	13.0 [11.2 – 16.5]	14.1 [11.4 – 17.1]	0.37
Transpulmonary driving pressure at PEEP 15 cmH₂O (cmH₂O)	9.3 [7.3 – 12.2]	10.0 [8.2 – 12.0]	0.19
Lung stress at PEEP 15 cmH₂O (cmH₂O)	20.4 [18.0 – 23.1]	21.1 [17.8 – 23.6]	0.57
Total gas at PEEP 5 cmH₂O (mL)[#]	1133 [783 – 1662]	933 [662 – 1701]	0.20
Total tissue at PEEP 5 cmH₂O (g)[§]	1391 [1199 – 1670]	1395 [1074 – 1686]	0.58
• Not inflated tissue (%)[§]	44.9 [38.4 – 57.3]	47.5 [31.2 – 56.1]	0.80
• Poorly inflated tissue (%)[§]	27.9 [20.1 – 38.3]	29.1 [20.4 – 39.7]	0.51
• Well inflated tissue (%)[§]	25.7 [13.8 – 34.3]	22.6 [14.2 – 32.7]	0.42
• Over inflated tissue (%)[§]	0.01 [0.00 – 0.10]	0.02 [0.00 – 0.24]	0.24
Lung recruitability (%)[§]	12.6 [7.0 – 21.9]	16.3 [8.6 – 25.9]	0.268

Statistical Analysis: Student 's t –test, Mann-Whitney Rank sum Test, Chi-Square, as appropriate.

Abbreviations: PaO₂: arterial partial pressure of oxygen; FiO₂: inspired fraction of oxygen; PaCO₂: arterial partial pressure of carbon dioxide; PEEP: positive end-expiratory pressure.

* Data available for 97 patients in the “survivors” group and for 46 patients in the “non-survivors” group.

° Data available for 42 patients in the “survivors” group and for 30 patients in the “non-survivors” group.

Total gas was computed by CT scan analysis (for 53 in the “survivor” group, and for 38 patients in the “non-survivors” group, respectively), or by helium dilution technique (for 48 in the “survivor” group, and for 10 patients in the “non-survivors” group, respectively).

§ Data available for 53 patients in the “survivors” group and for 38 patients in the “non-survivors” group.

Table S2. Baseline characteristics of the study population divided according to lower or higher airway driving pressure at PEEP 5 cmH₂O.

Characteristics	Overall population (N=150)	Lower airway driving pressure (<15 cmH ₂ O) (N=108)	Higher airway driving pressure (≥15 cmH ₂ O) (N=42)	P value
Age (years)	62 [47 – 74]	64 [49 – 74]	57 [45 – 75]	0.339
Male sex, N (%)	102 (68.0)	75 (69.4)	27 (51.9)	0.679
Body Mass Index (kg/m ²)	24.7 [22.8 – 27.7]	24.2 [22.5 – 27.5]	25.9 [23.9 – 29.0]	0.041
ICU mortality, N (%)	48 (32.0)	29 (26.9)	19 (45.2)	0.049
Cause of lung injury, N (%):				
• Sepsis	46 (30.7)	36 (33.3)	10 (23.8)	0.739
• Penumonia	56 (37.3)	40 (37.0)	16 (38.1)	
• Trauma	15 (10.0)	10 (9.3)	5 (11.9)	
• Aspiration	7 (4.7)	4 (3.7)	3 (7.1)	
• Other	26 (17.3)	18 (16.7)	8 (19.0)	
ARDS category at PEEP 5 cmH ₂ O, N(%):	(n=91)	(n=59)	(n=32)	
• Mild	16 (17.6)	11 (18.6)	5 (15.6)	0.553
• Moderate	50 (54.9)	34 (57.6)	16 (50.0)	
• Severe	25 (27.5)	14 (23.7)	11 (34.4)	

Statistical Analysis: Mann-Whitney Rank Sum Test, Chi-Square, as appropriate.

Abbreviations: ICU: intensive care unit; ARDS: acute respiratory distress syndrome; PEEP: positive end-expiratory pressure.

Table S3. Respiratory mechanics, gas exchange, CT scan variables and outcome of the patients divided according to lower or higher airway driving pressure at PEEP 5 cmH₂O and 15 cmH₂O.

	Variable	Lower airway driving pressure (<15 cmH ₂ O) at PEEP 15 cmH ₂ O	Higher airway driving pressure (≥15 cmH ₂ O) at PEEP 15 cmH ₂ O	P value
Lower airway driving pressure (<15 cmH ₂ O) at PEEP 5 cmH ₂ O	Number of patients	85	23	
	Airway driving pressure (cmH ₂ O)	11.0 [9.7 – 12.4]	13.5 [12.2 – 14.0]	<0.001
	Transpulmonary driving pressure (cmH ₂ O)	7.8 [6.2 – 9.2]	9.7 [7.7 – 10.7]	0.002 [§]
	End-Inspiratory airway plateau pressure (cmH ₂ O)	16.7 [15.1 – 18.0]	20.0 [18.0 – 21.1]	<0.001
	Lung stress (cmH ₂ O)	11.5 [9.8 – 13.7]	13.8 [11.5 – 15.5]	0.003 [§]
	Respiratory system elastance (cmH ₂ O/L)	21.3 [17.8 – 25.5]	26.5 [21.3 – 27.7]	0.011
	Lung elastance (cmH ₂ O/L)	14.8 [12.6 – 18.0]	19.8 [14.7 – 21.0]	0.028
	Chest wall elastance (cmH ₂ O/L)	5.6 [4.1 – 8.8]	6.2 [4.9 – 8.4]	0.467
	PaCO ₂ (mmHg)*	43.9 [39.5 – 50.6]	42.0 [36.9 – 48.2]	0.467
	PaO ₂ /FiO ₂ ratio*	143 [99 – 170]	212 [136 – 300]	0.004 [§]
	Total lung gas (mL) ^o	1236 [839 – 1912]	1210 [944 – 1669]	0.900
	Total lung tissue weight (g)*	1397 [1212 – 1832]	1200 [1115 – 1338]	0.077
	• Not-aerated lung tissue (%)*	45.9 [35.9 – 56.2]	39.4 [37.0 – 42.2]	0.167 [§]
	• Poorly-aerated lung tissue (%)*	27.1 [20.0 – 37.3]	29.9 [21.7 – 34.0]	0.950
	• Well-aerated lung tissue (%)*	27.4 [15.9 – 34.4]	31.5 [29.8 – 39.3]	0.066 [§]
	• Over-aerated lung tissue (%)*	0.03 [0.00 – 0.29]	0.08 [0.01 – 0.11]	0.716
Lung recruitability (%)*	12.6 [7.9 – 23.4]	5.6 [2.5 – 18.3]	0.123	
ICU mortality N (%)	24 (28.2)	5 (21.7)	0.720	
Higher airway driving pressure (≥15 cmH ₂ O) at PEEP 5 cmH ₂ O	Number of patients	12	30	
	Airway driving pressure (cmH ₂ O)	15.6 [15.4 – 16.6]	17.4 [16.4 – 19.1]	0.013
	Transpulmonary driving pressure (cmH ₂ O)	12.8 [10.8 – 14.0]	14.2 [11.8 – 15.1]	0.215 [§]
	End-Inspiratory airway plateau pressure (cmH ₂ O)	21.0 [20.3 – 21.8]	23.0 [21.4 – 24.3]	0.010
	Lung stress (cmH ₂ O)	16.9 [15.4 – 18.9]	17.7 [15.4 – 19.8]	0.389 [§]
	Respiratory system elastance (cmH ₂ O/L)	33.4 [28.4 – 38.0]	33.8 [29.8 – 40.4]	0.707
	Lung elastance (cmH ₂ O/L)	27.4 [20.4 – 32.7]	27.1 [21.8 – 31.6]	0.967
	Chest wall elastance (cmH ₂ O/L)	7.0 [4.6 – 9.5]	8.2 [4.5 – 11.6]	0.646
	PaCO ₂ (mmHg) [#]	41.6 [40.1 – 47.6]	50.0 [43.2 – 53.3]	0.016 [§]
	PaO ₂ /FiO ₂ ratio [#]	113 [80 – 210]	134 [82 – 176]	0.958 [§]
	Total lung gas (mL) ⁺	665 [471 – 812]	726 [562 – 960]	0.351
	Total lung tissue weight (g) [#]	1449 [1107 – 1649]	1466 [1046 – 1702]	0.685 [§]
	• Not-aerated lung tissue (%) [#]	52.4 [26.9 – 64.7]	48.7 [33.5 – 58.9]	0.886 [§]
	• Poorly-aerated lung tissue (%) [#]	27.3 [21.1 – 43.6]	38.0 [20.2 – 42.5]	0.466 [§]
	• Well-aerated lung tissue (%) [#]	16.8 [9.3 – 27.2]	15.0 [8.1 – 26.3]	0.704 [§]
	• Over-aerated lung tissue (%) [#]	0.00 [0.00 – 0.01]	0.00 [0.00 – 0.04]	0.905
Lung recruitability (%) [#]	17.2 [6.1 – 28.6]	19.9 [10.4 – 26.2]	0.550 [§]	
ICU mortality N (%)	4 (33.3)	15 (50.0)	0.524	

Lung mechanics, gas exchange, CT-related variables and lung total gas were determined at PEEP 5 cmH₂O.

Statistical Analysis: Student's t-test[§], Mann-Whitney Rank Sum Test, Chi-Square, as appropriate.

Abbreviations: PaO₂: arterial partial pressure of oxygen; FiO₂: inspired fraction of oxygen; PaCO₂: arterial partial pressure of carbon dioxide; ICU: intensive care unit; PEEP: positive end-expiratory pressure.

* Data available for 53 patients in the “lower airway driving pressure at PEEP 15 cmH₂O” group and for 6 patients in the “higher airway driving pressure at PEEP 15 cmH₂O” group.

° Total gas was computed either by CT scan analysis (in 53 patients of the “lower airway driving pressure at PEEP 15 cmH₂O” group, and in 6 patients of the “higher airway driving pressure at PEEP 15 cmH₂O” group, respectively), or by helium dilution technique (in 31 patients of the “lower airway driving pressure at PEEP 15 cmH₂O” group, and in 17 patients of the “higher airway driving pressure at PEEP 15 cmH₂O” group, respectively).

Data available for 11 patients in the “lower airway driving pressure at PEEP 15 cmH₂O” group and for 21 patients in the “higher airway driving pressure at PEEP 15 cmH₂O” group.

+ Total gas was computed either by CT scan analysis (in 11 patients of the “lower airway driving pressure at PEEP 15 cmH₂O” group, and in 21 patients of the “higher airway driving pressure at PEEP 15 cmH₂O” group, respectively), or by helium dilution technique (in one patient of the “lower airway driving pressure at PEEP 15 cmH₂O” group, and in 9 patients of the “higher airway driving pressure at PEEP 15 cmH₂O” group, respectively).

Table S4. Sensibility, specificity, positive and negative predictive values of optimal cut off for airway and transpulmonary driving pressure to predict a lung stress equal or above 24 or 26 cmH₂O.

	Sensitivity	Specificity	Positive predictive value	Negative predictive value
<i>Lung stress equal or above 24 cmH₂O</i>				
Airway driving pressure (cut off 15.0 cmH₂O)	0.90	0.78	0.80	0.88
Transpulmonary driving pressure (cut off 11.7 cmH₂O)	0.97	0.89	0.90	0.96
<i>Lung stress equal or above 26 cmH₂O</i>				
Airway driving pressure (cut off 16.6 cmH₂O)	0.81	0.80	0.80	0.81
Transpulmonary driving pressure (cut off 11.8 cmH₂O)	0.94	0.82	0.84	0.93

Figure S1. Linear regression between respiratory system elastance (cmH₂O/L) and lung gas volume at PEEP 5 cmH₂O (mL).

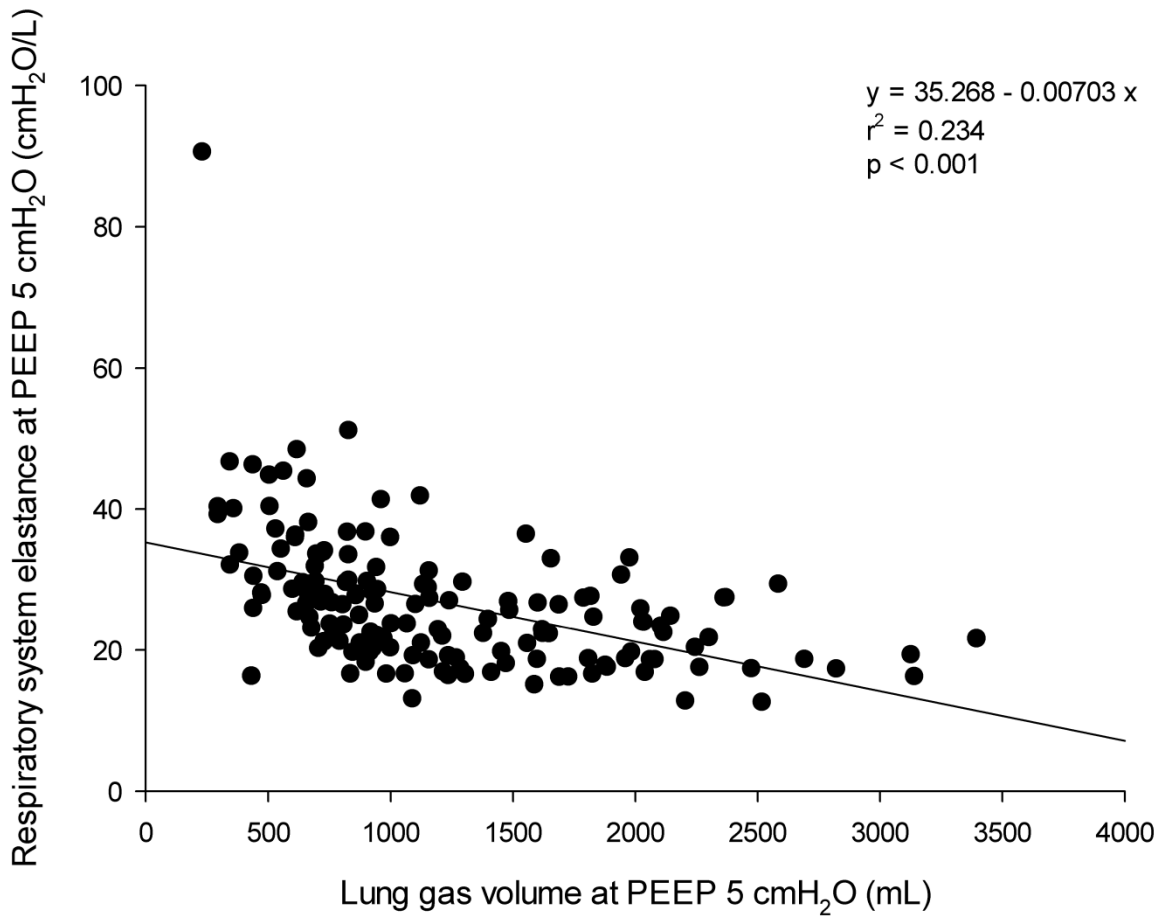


Figure S2. Linear regression between respiratory system elastance (cmH₂O/L) and well-aerated lung tissue weight at PEEP 5 cmH₂O (g).

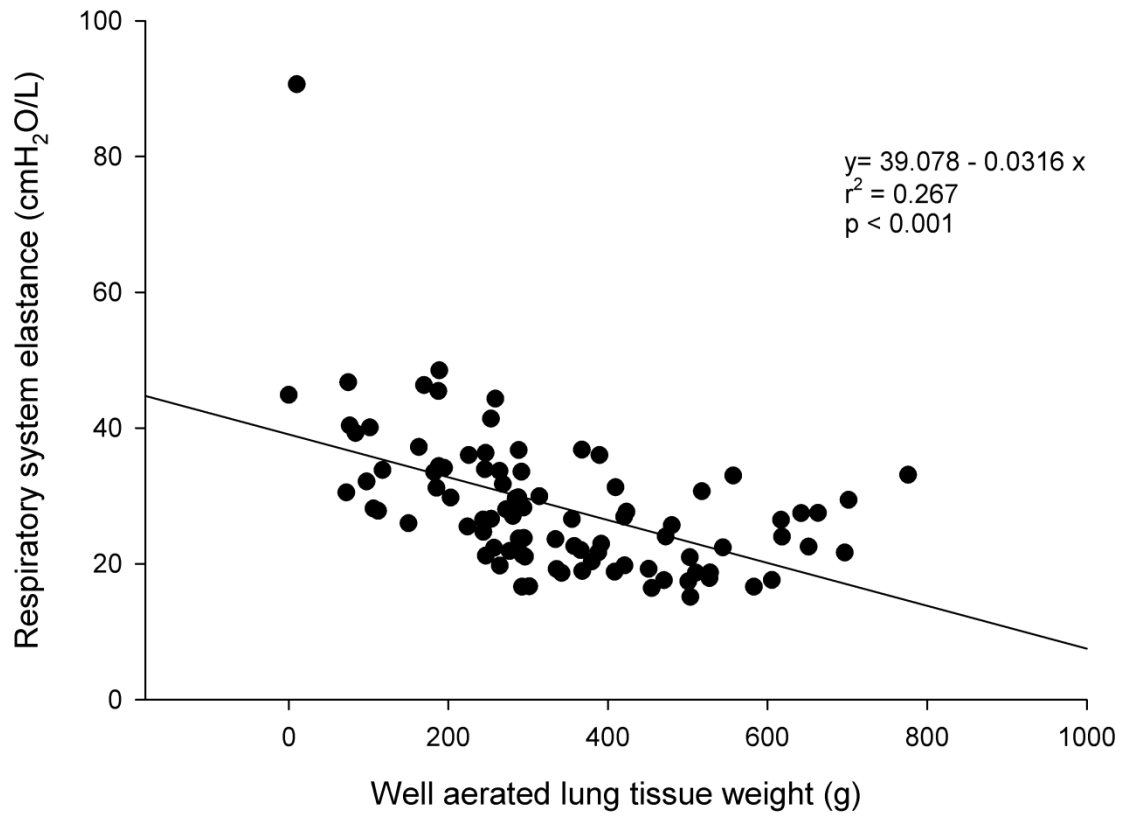


Figure S3. Linear regression between transpulmonary driving pressure (cmH₂O) and lung stress (cmH₂O) at PEEP 5 (upper panel) and 15 cmH₂O (lower panel).

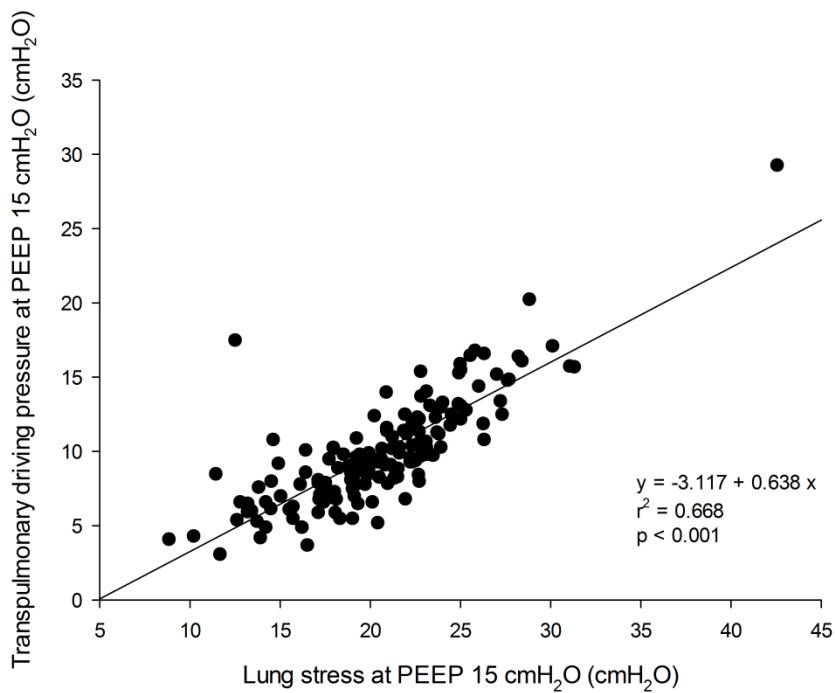
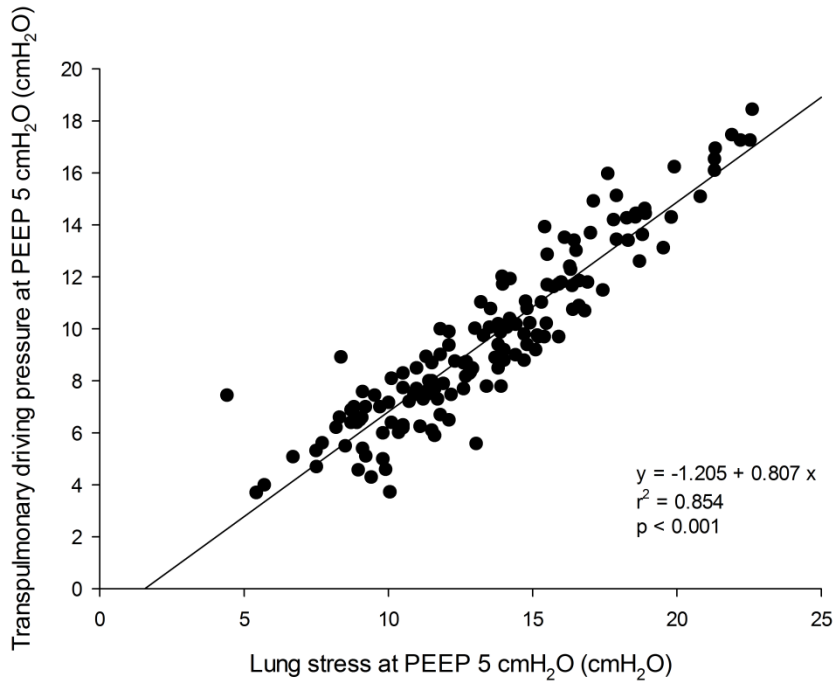


Figure S4. Linear regression between lung stress (cmH₂O) and airway end-inspiratory plateau pressure (cmH₂O).

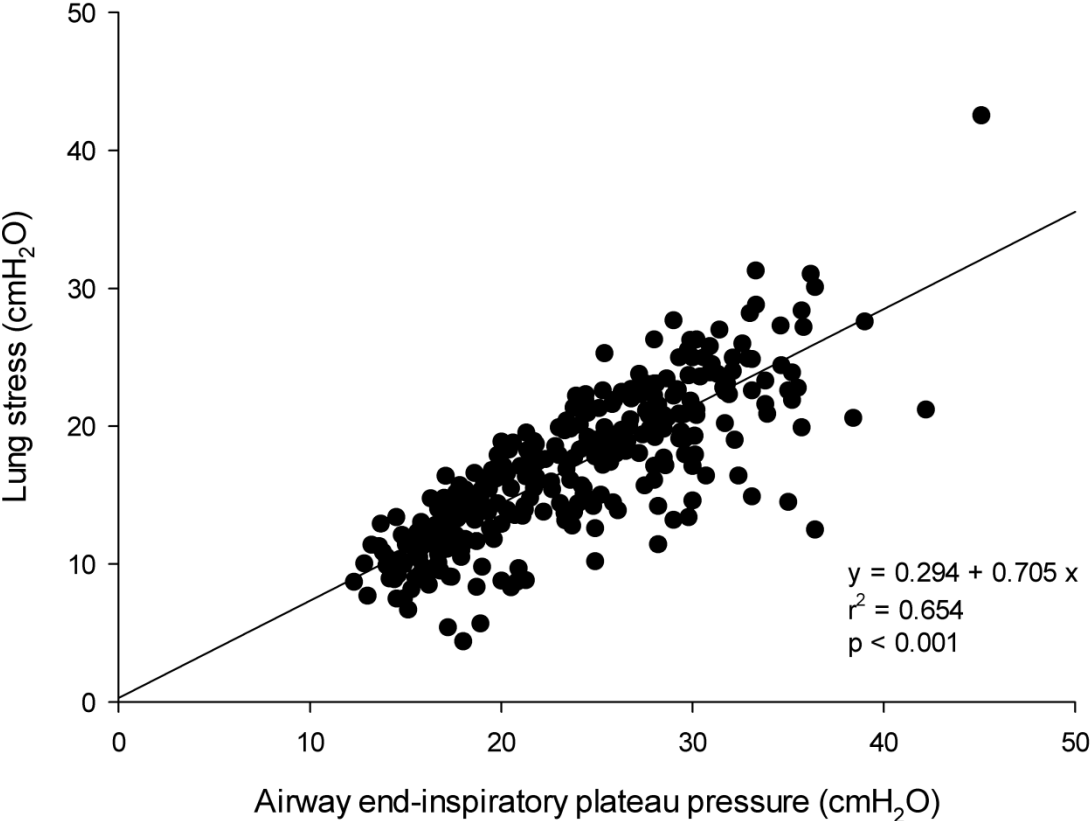


Figure S5. Linear regression between airway driving pressure (cmH₂O) and lung gas volume (mL) at PEEP 5 cmH₂O.

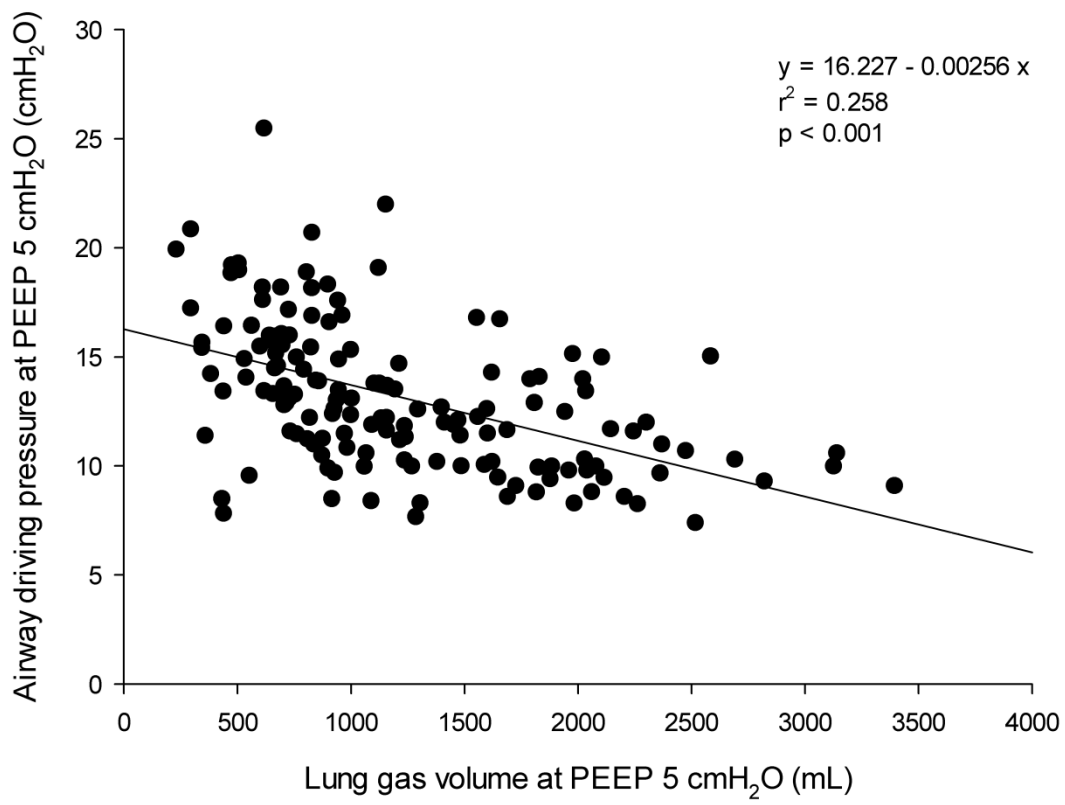


Figure S6. Receiver operator characteristic (ROC) curve for transpulmonary driving pressure as a predictor of lung stress above 24 (left panel) or 26 cmH₂O (right panel).

