

RecruitmEnt Assessed by eleCtRical Impedance Tomography (RECRUIT study). A Multicentre study

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Introduction

Defining the potential for lung recruitment is a crucial aspect of safe PEEP selection in mechanically ventilated patients, but no valid method exists to define the best PEEP. By using electrical impedance tomography (EIT), we aim to quantify recruitability and determine the potential beneficial and harmful physiological effects of PEEP in patients with COVID-19 related acute respiratory distress syndrome (ARDS).

Method

In this observational international study from the PLUG group (NCT04460859) COVID-19 patients with moderate and severe ARDS were enrolled within the first week of ARDS diagnosis. EIT recordings, ventilator data, hemodynamics and arterial blood gases were obtained during lung (de)recruitment maneuvers. PEEP was set to 6, 16 and 24 cmH₂O for 5-min per step, after which a decremental PEEP titration from 24 to 6 cmH₂O (in steps of 2 cmH₂O) was performed. Recruitment-to-inflation (R/I) ratio was assessed with a single-breath maneuver during a 16 to 6 cmH₂O PEEP drop, and an EIT-based R/I ratio was calculated for these same breaths. Lung collapse, overdistension and respiratory system compliance were calculated for each step, and we determined the PEEP level at the intercept of the relative overdistention and collapse curves during a decremental PEEP trial (Costa et al. approach). Recruitability was defined based on the amount of recruitable collapse when increasing PEEP 6 (at start protocol) to PEEP 24 cmH₂O, further referred to as $\Delta\text{Collapse}_{6-24}$. To facilitate the presentation, patients were defined as lower, medium or higher recruiters based on the tertiles of $\Delta\text{Collapse}_{6-24}$. Differences in parameters between groups were assessed with the Wilcoxon rank sum test or per a linear mixed effects model for continuous parameters to test for the interaction effect of PEEP and group.

Results

108 COVID-19 patients were enrolled. Patients with $\Delta\text{Collapse}_{6-24} < 25.3\%$, between 25.4–39.6%, or $> 39.6\%$ were categorized as lower, medium, or higher recruitability. Higher recruitable patients were younger and had higher BMI, but did not differ in ARDS severity on ICU admission (Table 1). R/I ratio correlated with the $\Delta\text{Collapse}_{6-24}$ ($r=0.52$, $p=0.001$). Collapse and overdistention during the decremental PEEP trial for the groups is shown in Fig.1, resulting in different optimal PEEP levels as per the crossing point: 10 [7.5; 13.5] vs. 13.5 [12; 15] vs. 15.5 [13.8; 17] cmH₂O for patients with lower vs. medium vs. higher recruitability, respectively ($p<0.05$). At the crossing point, the amount of collapse and overdistention, and respiratory mechanics were similar between groups, with medians for collapse and overdistention below 5% and 10%, respectively (Table.1).

Conclusion

Recruitability varies widely among COVID-19 patients; most do not require very high PEEP levels. EIT seems useful to identify recruitability and to support selecting a personalized PEEP.

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Table 1. Characteristics of recruiters and non-recruiters, and their response to increases in PEEP

Values are presented as median with interquartile range [IQR]. ¹ p-value for the interaction effect of PEEP level

	Lower recruitability (n=36)	Medium recruitability (n=36)	Higher recruitability (n=36)	p-value
Patient characteristics				
BMI, kg/m ²	28.4 [24.8; 31.5]	30.1 [26.6; 31.9]	32.9** [27.2; 39.4]	0.0134
Age, years	65 [57.6; 70]	61 [54; 65]	55* [46; 63.5]	0.0051
PaO ₂ /FiO ₂ , ICU admission	113 [97; 134]	120 [100; 142]	113 [99; 141]	0.9070
Recruitability				
Ventilator-based R/I ratio	0.59 [0.43; 0.75] (n=30)	0.82 [0.54; 0.95]* (n=34)	0.83 [0.68; 1.04]* (n=29)	0.0034
EIT-based R/I ratio	0.79 [0.59; 1.02] (n=23)	0.92 [0.83; 1.10] (n=30)	1.08 [0.95; 1.35]* (n=22)	0.0026
ΔCollapse ₆₋₂₄ , %	16.9 [11.1; 22.2]	32 [27.3; 34.9]	46.4 [42.5; 51.6]	<0.001
PEEP titration				
Costa PEEP level (cmH ₂ O)	10 [7.5; 13.5]	13.5* [12; 15]	15.5** [13.8; 17]	<0.001
<i>Mechanics at Costa PEEP level</i>				
Crs, ml/cmH ₂ O	29.2 [24.4; 38.4]	37.4 [28.2; 46.6]	35.6 [30.8; 39.5]	0.054
ΔPaw, cmH ₂ O ¹	8.2 [7.5; 9.7]	8.6 [7.1; 10.1]	8.4 [7.1; 10.9]	0.923
Collapse, %	4.8 [3.1; 7.2]	6.0 [4.4; 7.3]	4.5 [3.2; 5.8]	0.216
Overdistention, %	8.3 [4.9; 9.9]	8.0 [7.0; 10.1]	6.3 [4.8; 7.9]	0.053

x group, as assessed per a linear mixed effects model. Abbreviations: Crs, respiratory system compliance; EIT, electrical impedance tomography; FiO₂, fraction of inspired oxygen; ICU, intensive care unit; PaO₂, partial arterial oxygen pressure; ΔPaw, airway driving pressure (calculated from Crs and the set tidal volume); PEEP, positive end-expiratory pressure; R/I ratio, recruitment-to-inflation ratio

Figure 1 - Collapse and overdistention during PEEP trial and comparison of crossing point

