

Assessment of tidal recruitment and overdistension by regional analysis of respiratory system compliance at different tidal volumes

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Abstract: In this pilot clinical study, we assessed the effects of positive end-expiratory pressure (PEEP) on tidal recruitment and overdistension in mechanically ventilated patients. Changes in EIT-derived regional respiratory system compliance (C_{rs}) induced by variation of tidal volume (V_T) were analysed in the chest cross-section and identified the simultaneous occurrence of tidal recruitment and overdistension in the examined patients.

1 Introduction

Tidal recruitment associated with cyclic opening and closing of alveoli and alveolar overdistension are important mechanisms in the genesis of ventilator-induced lung injury [1]. One promising method for detection of these phenomena is the calculation of regional C_{rs} in individual image pixels [2] or as profiles in 32 horizontal chest layers [3].

When a patient is ventilated with two different values of V_T and regional C_{rs} is calculated in each setting, the differences in regional C_{rs} induced by the V_T variation can be determined. In the present paper, we used this approach to quantify the amount of tidal recruitment and overdistension by calculating the V_T -dependent changes in C_{rs} at two PEEP values on a pixel-by-pixel basis.

2 Methods

We performed a retrospective analysis of data from five critically ill patients (4 male, 1 female, 74 ± 6 years (mean age \pm SD)) with acute respiratory distress syndrome (ARDS). The patients were ventilated in a volume-controlled mode at two different PEEP values (PEEP_{high}, PEEP_{low}). As described in [2], PEEP_{high} and PEEP_{low} were set individually in each patient based on the analysis of a quasi-static pressure-volume manoeuvre. For the diagnosis of tidal recruitment and overdistension, a variation of V_T between a high value of 10 ml/kg ideal body weight (IBW) and low value of 6 ml/kg IBW was performed at both PEEP values.

EIT measurements were carried out with the Goe-MF II device (CareFusion, Höchberg, Germany) using a set of 16 electrodes (L-00-S, Ambu, Ballerup, Denmark). EIT images were generated using the back-projection algorithm.

Regional C_{rs} was calculated by dividing the individual pixel values of tidal amplitude of relative impedance change (rel. ΔZ) by the sum of all these values and by multiplying them with the global C_{rs} . The regional C_{rs} values at low V_T were subtracted from the respective values with high V_T to generate difference images, visualising ΔC_{rs} between high and low V_T in every pixel (Fig.1). For quantitative estimation of tidal recruitment and overdistension, we calculated the sum of pixels with positive values of ΔC_{rs} and divided the resulting value by

the global C_{rs} at high V_T . This analysis rendered a dimensionless index value of the amount of tidal recruitment that was finally multiplied by 100 to yield a value in %. This was performed similarly for all pixels with negative values of ΔC_{rs} to create an index value of alveolar overdistension.

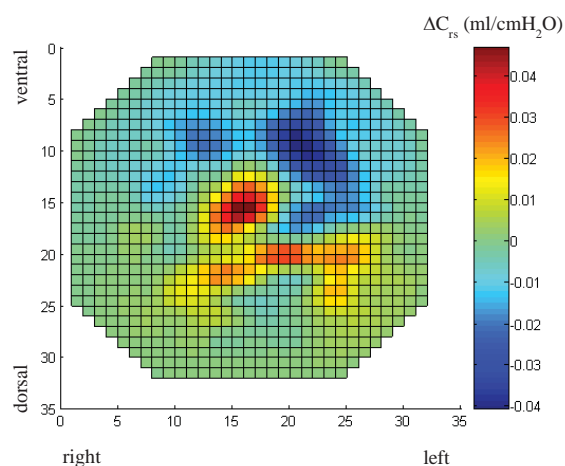


Figure 1: Map of regional differences in respiratory system compliance (ΔC_{rs}) between high and low V_T at the high positive end-expiratory pressure (PEEP_{high}) in one of the examined patients. Positive values imply tidal recruitment, whereas negative values show overdistension. At this PEEP level, 10% overdistension and 6% tidal recruitment were identified in this patient.

3 Results

Tidal recruitment and alveolar overdistension occurred simultaneously at both PEEP levels in all studied patients. At PEEP_{high}, we found a non-significant reduction in tidal recruitment (11% vs 14%; $p = n.s.$) and a non-significant increase in overdistension (18% vs 11%; $p = n.s.$) in comparison with PEEP_{low}.

4 Conclusions

Analysis of changes in EIT-derived regional C_{rs} between high and low V_T is feasible in mechanically ventilated patients and may be used to quantify the overall amount of tidal recruitment and overdistension at a given PEEP. This might be used for an individualized optimization of PEEP and V_T setting adapted to the regional respiratory system mechanics.

References

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