Estimation of the inspiratory mechanical muscle activation during breathing in healthy subjects and COPD patients

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1. Introduction and objective

Non-invasive assessment of respiratory muscle activation during the breathing cycle in people suffering from pulmonary diseases, remains a challenge due to the lack of accurate methods. The most direct measurements of the respiratory drive in humans are achieved using complex and invasive recordings such as: the diaphragm electromyographic activity recorded using an oesophageal electrode and transdiaphragmatic pressures obtained from oesophageal and gastric probes [1].

In the present work we characterized the amplitude of the mechanical activation of the inspiratory muscles using a novel method based on a non-linear multistate Lempel-Ziv index calculated over the inspiratory time of respiratory muscle mechanomyogram (MMG) of the lower chest wall (diaphragm and intercostal) [2], and we also have expressed the efficiency of the inspiratory muscle mechanical activation as the ratio between the peak inspiratory mouth pressure to the amplitude of the mechanical activation [3].

2. Methods

The current study involved 20 subjects, 13 patients with moderate-to-very severe chronic obstructive pulmonary disease (COPD) patients and 7 healthy subjects. The study was approved by the Local Ethics Committee (Hospital del Mar-IMIM, Barcelona).

3. Results and discussion

We found that the activation of inspiratory muscles correlated strongly with peak inspiratory mouth pressure in both COPD patients ($r=0.80$, $p<0.001$) and healthy ($r=0.82$, $p<0.001$). Moreover, the greater the COPD severity in patients (Figure 1), the greater the level of muscle activation ($r=-0.68$, $p=0.001$, between muscle activation and FEV_1). Furthermore, the efficiency of the mechanical activation of inspiratory muscle was lower in COPD patients than healthy subjects (7.61±2.06 vs 20.42±10.81, respectively, $p=0.0002$), and decreased with increasing COPD severity ($r=0.78$, $p<0.001$, between efficiency of the mechanical activation and FEV_1).

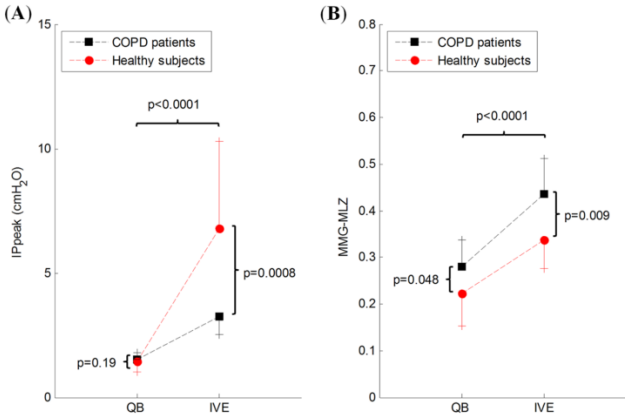

Figure 1. Value of mechanical activation measures at different ventilation levels. Representation (mean and SD) of (A) IPpeak and (B) MMG-MLZ, in COPD patients and healthy subjects. QB: quiet breathing; IVE: incremental ventilatory effort.

These results confirm that the respiratory muscle mechanomyogram is a good reflection of inspiratory effort and can be used to estimate the efficiency of the mechanical activation of the inspiratory muscles. This new non-invasive technique can improve the assessment of inspiratory muscle activation in clinical conditions, contributing to a better understanding of breathing in COPD patients.

Acknowledgments

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References

1. ATS/ERS Statement on Respiratory Muscle Testing. *Am J Respir Crit Care Med*. 2002 Aug 15; 166: 518–624.
2. Sarlabous L, Torres A, Fiz JA, Gea J, Martínez-Llorens JM, Jané R. Efficiency of mechanical activation of inspiratory muscles in COPD using sample entropy. *Eur Respir J*. 2015 Oct 22; 46(6): 1808–11.
3. Sarlabous L, Torres A, Fiz JA, Gea J, Martínez-Llorens JM, Jané R. Inspiratory muscle activation increases with COPD severity as confirmed by non-invasive mechanomyographic analysis. *PLoS ONE* 12(5): e0177730.