Mechanical Ventilation Guided by Electrical Impedance Tomography in Experimental Acute Lung Injury

Wolf GK, Gómez-Laberge C, Rettig JS, Vargas SO, Smallwood CD, Prabhu SP, Vitali SH, Zurakowski D, Arnold JH.

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Objective: To utilize real-time electrical impedance tomography to guide lung protective ventilation in an animal model of acute respiratory distress syndrome.

Design: Prospective animal study.

Setting: Animal research center.

Subjects: Twelve Yorkshire swine (15 kg).

Interventions: Lung injury was induced with saline lavage and augmented using large tidal volumes. The control group (n = 6) was ventilated using ARDSnet guidelines, and the electrical impedance tomography-guided group (n = 6) was ventilated using guidance with real-time electrical impedance tomography lung imaging. Regional electrical impedance tomography-derived compliance was used to maximize the recruitment of dependent lung and minimize overdistension of nondependent lung areas. Tidal volume was 6 mL/kg in both groups. Computed tomography was performed in a subset of animals to define the anatomic correlates of electrical impedance tomography imaging (n = 5). Interleukin-8 was quantified in serum and bronchoalveolar lavage samples. Sections of dependent and nondependent regions of the lung were fixed in formalin for histopathologic analysis.

Measurements and Main Results: Positive end-expiratory pressure levels were higher in the electrical impedance tomography-guided group (14.3 cm H2O vs. 8.6 cm H2O; $p < 0.0001$), whereas plateau pressures did not differ. Global respiratory system compliance was improved in the electrical impedance tomography-guided group (6.9 mL/cm H2O vs. 4.7 mL/cm H2O; $p = 0.013$). Regional electrical impedance tomography-derived compliance of the most dependent lung region was increased in the electrical impedance tomography group (1.78 mL/cm H2O vs. 0.99 mL/cm H2O; $p = 0.001$).

Pao2/FIO2 ratio was higher and oxygenation index was lower in the electrical impedance tomography-guided group (Pao2/FIO2: 388 mm Hg vs. 113 mm Hg, $p < 0.0001$; oxygentation index, 6.4 vs. 15.7; $p = 0.02$) (all averages over the 6-hr time course).
The presence of hyaline membranes (HM) and airway fibrin (AF) was significantly reduced in the electrical impedance tomography-guided group (HMEIT 42% samples vs. HMCONTROL 67% samples, $p < 0.01$; AFEIT 75% samples vs. AFCONTROL 100% samples, $p < 0.01$). Interleukin-8 level (bronchoalveolar lavage) did not differ between the groups. The upper and lower 95% limits of agreement between electrical impedance tomography and computed tomography were ± 16%.

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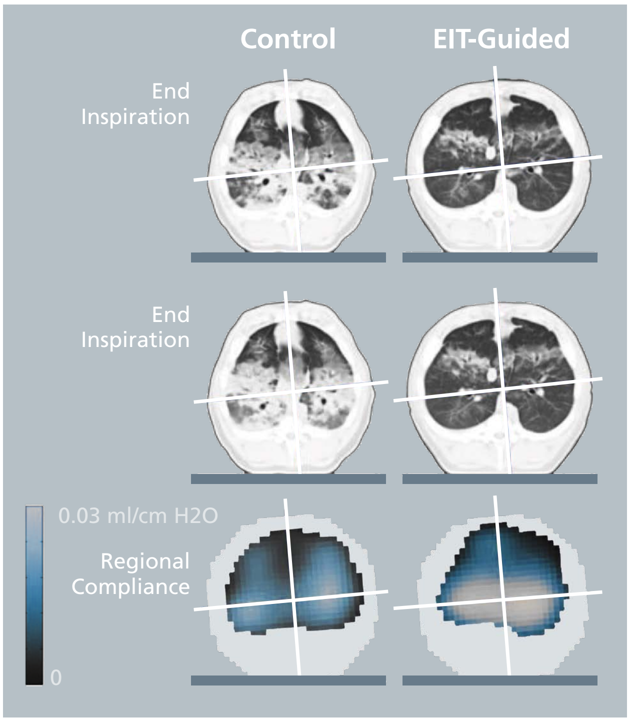

* *modified from the article*

Conclusions: Electrical impedance tomography-guided ventilation resulted in improved respiratory mechanics, improved gas exchange, and reduced histologic evidence of ventilator-induced lung injury in an animal model. This is the first prospective use of electrical impedance tomography-derived variables to improve outcomes in the setting of acute lung injury.

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Figure*: *Electrical impedance tomography (EIT) and CT images of a control and EIT-guided animal. Larger areas of lung collapse are seen especially in dorsal (dependent) lung areas in the CT image of the control group* ***(two upper left images)****. This corresponds to a lesser degree of ventilation-induced impedance change in the EIT image of the control group* ***(bottom left)****. The EIT-guided animal displays better aeration on CT* ***(two upper right images)*** *and increased impedance change (indicated by white color) especially in the dependent lung areas* ***(bottom right)****.*

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eit inside
electrical impedance tomography