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Electrical Impedance Tomography changes in regional tidal amplitude do not reflect changes in regional tidal volume

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Introduction

- Electrical Impedance Tomography (EIT) is a non-invasive bed-side technology offering real-time imaging of regional air volume changes in the lung
- It is assumed that the amplitude of changes on an EIT image is proportional to regional tidal volumes
- However, recent simulation studies suggest that amplitude of change in EIT for the same air volume change depends on regional aeration (Grychtol et al, *Phys Meas 2013*)

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Objective

Hypothesis: Volume changes in less aerated lung regions cause disproportionally large changes in EIT

Experimental test: Independent variation in aeration in the two lungs while keeping tidal volume constant

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Materials

- One anesthetized pig (27 kg)
- 2 x Servo 900C ventilator (Siemens)
- 2 x NICO monitoring system (Philips)
- Double-lumen tube
- Prototype EIT system (Swisstom)
- SOMATOM Flash CT scanner (Siemens)

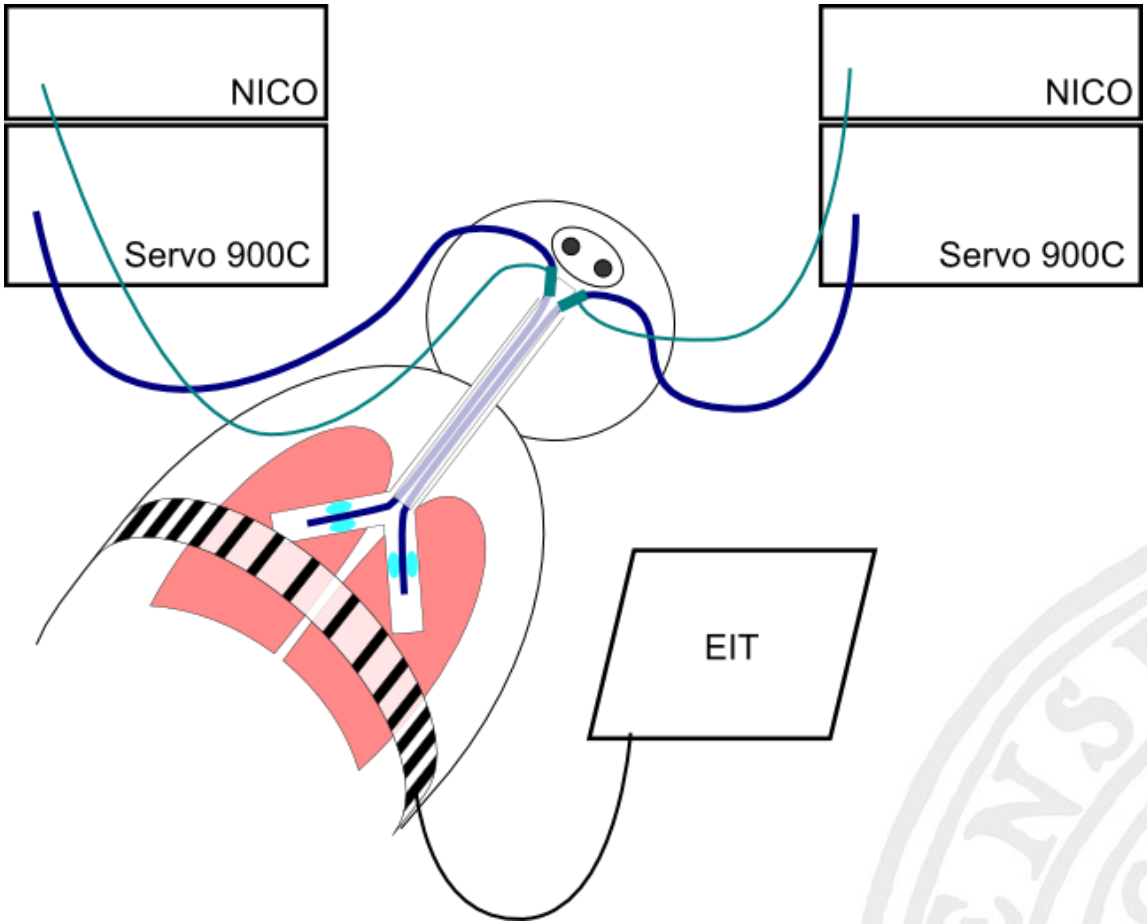

Figure 1: Experimental setup

The pig is tracheostomized and intubated with a double-lumen tube. Two synchronized Servo 900C were used to independently ventilate each lung. Each lung was monitored by an independent NICO system. The belt of EIT electrodes was placed at the level of 6th intercostal space.

Experiment

1. Ventilation: PCV, PEEP=10; PIP = 17 cmH_2O (6 ml/kg)
   - V_T in the left lung: 63 ml
   - V_T in the right lung: 107 ml
2. Ventilation: VCV with same V_T and PEEP
3. PEEP was increased in the right lung to 20 cmH_2O for 2 min while V_T in both lungs was kept constant
4. Baseline, same as 2
5. Repeat for the left lung

Simultaneous monitoring with EIT, NICO and dynamic CT acquired in a 3 cm band cranial of the EIT belt

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Analysis

- All data was manually synchronized
- EIT data was reconstructed with the GREIT algorithm
- CT data was automatically segmented to extract lungs via threshold, avoiding partial volume effects
- Air volume and tissue density in CT volume were calculated according to Gattinoni et al (*Am J Resp Crit Care Med 2001)*

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Results

- EIT overestimated tidal volume in the denser left lung throughout the experiment
- Increase in PEEP in a single lung caused an increase in volume and aeration and a drop in tidal volume of the affected lung in the thorax volume seen on CT
- The drop in tidal volume was stronger on EIT
- The actual global tidal volumes remained constant

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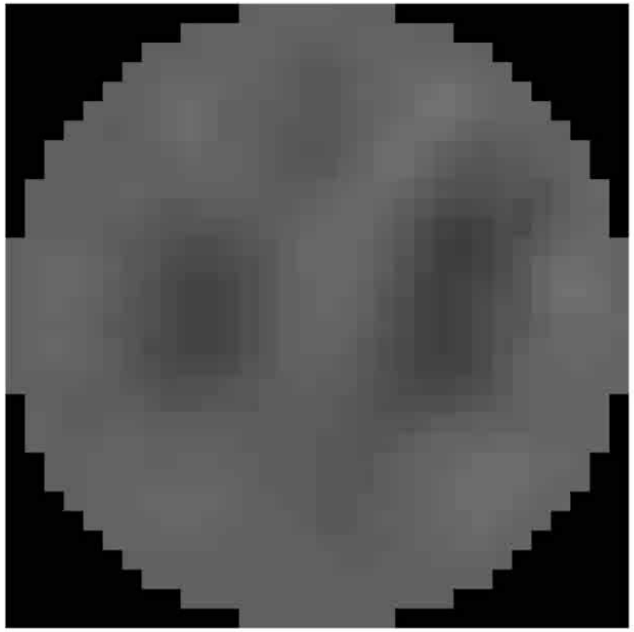
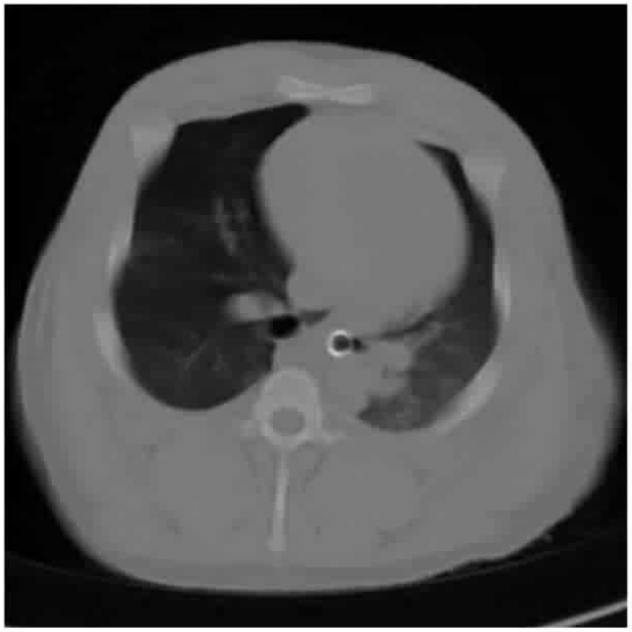
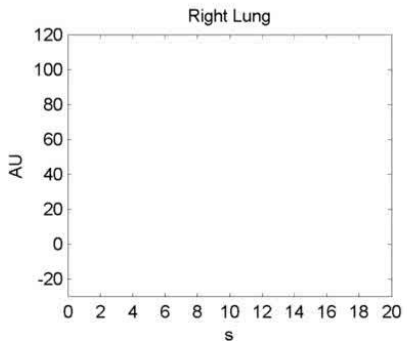
Results

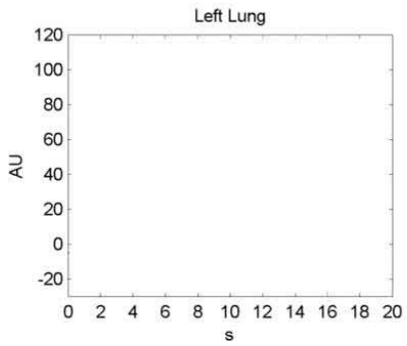
EIT

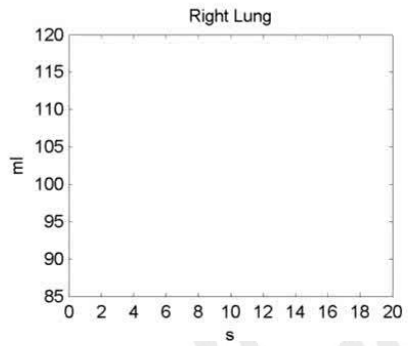


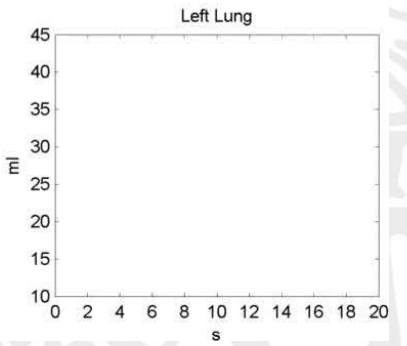
CT











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Results

Table 1: Tidal volumes

PEEP		EIT (AU)			CT (ml)			NICO (ml)	
LL	RL	LL	RL	L/R	LL	RL	L/R	LL	RL
10	10	25	**37 (100%)**	**.67**	2.5	**4.2 (100%)**	**.59**	58	108
10	20	25	**27 (73%)**	**.93**	2.7	**3.4 (80%)**	**.79**	57	101
10	20	**23 (100%)**	31	**.74**	**2.4 (100%)**	4.4	**.54**	56	104
20	10	**17 (69%)**	33	**.51**	**2.0 (83%)**	4.6	**.43**	53	104

LL: left lung; RL: right lung; L/R: left to right lung ratio; L20: PEEP 20 in Left lung

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Conclusion

- Air volume changes in denser lung areas cause greater changes in EIT images than equal volume changes in more aerated lung, confirming simulation results
- EIT tidal changes may be misleading, especially when the underlying lung aeration is non-homogeneous and changes over time
- This effect should be strongest for very dense lung areas