3D EIT Improves Detection of Ventilation Inhomogeneity in Obstructive Lung Disease

Lana Chen[1], Andy Adler[2], Jean-Pierre Lavoie[3], Martina Mosing[4], Maokun Li[1], David Byrne[5]

[1]Department of Electronic Engineering, Tsinghua University, Beijing, China
[2]Department of Systems and Computer Engineering, Carleton University, Ottawa, Canada
[3]Université de Montréal Faculty of Veterinary Medicine,3200 Sicotte, Saint-Hyacinthe, QC J2S 2M2, Canada
[4]Anaesthesiology and Intensive Care, Veterinary University Vienna, Austria
[5]School of Veterinary Medicine, Murdoch University, Perth, WA, Australia D.Byrne@murdoch.edu.au

Abstract: Obstructive lung diseases are highly heterogeneous. Using measurements of equine asthma, we compared 2D and 3D EIT metrics against lung mechanics. 3D EIT showed greater sensitivity to treatment effects, indicating improved detection of ventilation heterogeneity.

1 Introduction

Traditional 2D EIT uses a single electrode plane, reconstructing a transverse slice, but obstructive lung diseases (OLD) exhibit heterogeneity along the craniocaudal axis, potentially missed by 2D imaging. 3D EIT, using multiple electrode planes, provides volumetric reconstructions, capturing a larger fragment of lung geometry.

We compare 2D and 3D EIT in assessing ventilation inhomogeneity in OLD, using an equine asthma model, and hypothesize that 3D EIT offers superior sensitivity.

2 Materials & Methods

Data were acquired from ten horses with severe equine asthma during exacerbation and remission phases, as described in [1, 2]. EIT images were reconstructed in 2D- and 3D (example Figure 1) and EIT metrics computed: Global Inhomogeneity (GI) [3], Regional Ventilation Delay (RVD) standard deviation [4], and Global Asynchrony Index (GAI) from Pixel Asynchrony Value (PAV) [5].

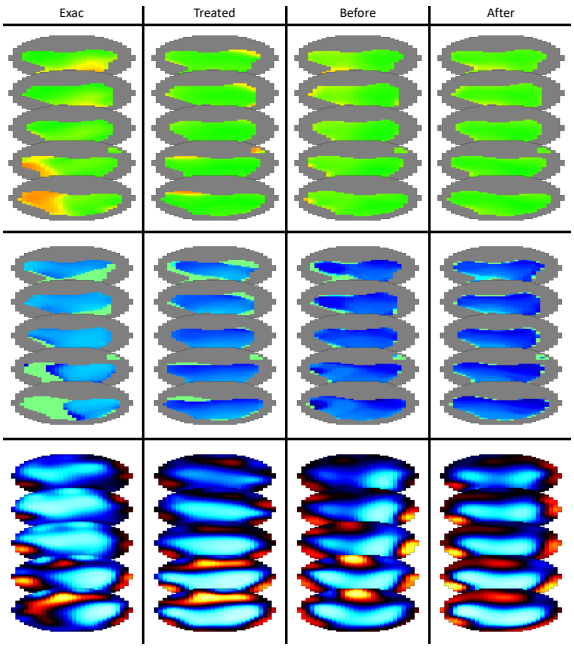

Fig. 1: 3D EIT functional maps of Pixel Asynchrony Value (PAV, top), Regional Ventilation Delay (RVD, middle), and Tidal Impedance Variation (TIV, bottom) from one horse with equine asthma under four conditions: exacerbation (Exac.), corticosteroid-treated remission (Treated), and pre-/post-salbutamol administration. Each panel contains five reconstructed coronal slices from the 3D EIT volume.

All metrics were calculated for 2D and 3D ROIs defined by 20% ventilation threshold. Paired t-tests compared metric changes against lung resistance R_L reductions.

3 Results

Paired comparisons (Exacerbated-Treated, n=10; Before-After salbutamol, n=9) showed R_L decreases ($p < 0.001$).

Tab. 1: Paired t-test p-values for 2D and 3D EIT metrics.

Metric	E-T (2D / 3D)	B-A (2D / 3D)
GAI	0.003 / 0.002	0.019 / 0.002
SD_{RVD}	0.627 / 0.042	0.614 / 0.058
GI	0.848 / 0.435	0.671 / 0.001

Paired t-test results for 2D and 3D EIT metrics (Table 1) show 3D metrics consistently have higher significance than 2D, especially for GAI and GI, while 2D SD-RVD failed to detect consistent changes. Figure 2 presents the paired 2D/3D comparisons for GAI, SD_{RVD} and GI.

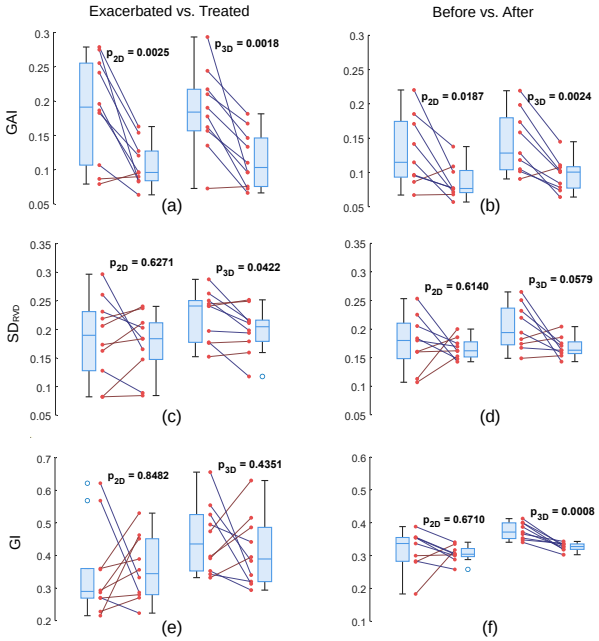

Fig. 2: Paired 2D/3D comparison of EIT metrics for the Exacerbated-Treated and Before-After salbutamol datasets.

4 Conclusions

3D EIT reconstruction better captures craniocaudal ventilation variations in obstructive lung disease and aligns more closely with lung mechanics represented by R_L.

References

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