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EIT reconstruction parameters' impact on ventilation monitoring features

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Introduction

Electrical Impedance Tomography (EIT) enables continuous, non-invasive, real-time monitoring of pulmonary ventilation at the bedside, making it valuable for patients undergoing mechanical ventilation, where inhomogeneous ventilation distribution can contribute to ventilator-induced lung injury. EIT image reconstruction requires solving an ill-posed inverse problem governed by several algorithmic parameters. These involve regularisation type, noise thresholding, and mesh resolution, whose influence on clinically derived ventilation features, such as the Global Inhomogeneity index (GI), Centre of Ventilation (CoV) and regional ventilation delay (RVD), remain poorly characterised. This study systematically investigates how the reconstruction parameters of the GREIT algorithm, as implemented in the pyEIT framework, affect the ventilation monitoring features extracted from thoracic recordings.

Methods

Thoracic EIT recordings were acquired from 31 adult subjects using a Dräger PulmoVista 500 system with 16 electrodes, during volume-controlled mechanical ventilation. A maximal low flow manoeuvre (MAX-LFM, corresponding to the application of four litres per minute during inhalation, while keeping the exhalation spontaneous) was performed, and the inspiratory phase was retained for analysis. Five GREIT reconstruction parameters (*lambda*, *p*, *perm*, *s* and *ratio*) were each independently modulated at three perturbation levels ($\pm 10\%$, $\pm 25\%$, $\pm 50\%$) from the pyEIT v.,1.2.4 default baseline, yielding 31 reconstruction configurations. For each configuration, 19 functional ventilation features were extracted from the resulting image sequences, including statistical descriptors of RVD and fROI geometry, as well as impedance-based indices (GI, CoV). Parameter sensitivity was quantified using a normalised influence score combining effect magnitude and cross-record sign consistency via their product.

Results

The *ratio* parameter dominated all others by a wide margin, achieving a total influence score of 16.43, which is more than four times that of the next ranked parameter, *s* (3.64). The remaining three parameters (*lambda*, *p*, *perm*) showed comparatively lower influence scores. The parameters *lambda* and *perm* produced numerically identical results across all conditions, indicating that they modulate the reconstruction matrix through the same computational pathway, an implementation-specific consequence of Jacobian normalisation under a homogeneous background model in pyEIT. The magnitude of feature modulation scaled monotonically with the degree of parameter perturbation across all five parameters, confirmed by Spearman's rank correlations exceeding $|r| = 0.9$ for most feature-direction combinations.

Conclusion

These findings demonstrate that GREIT reconstruction parameters differ in the degree to which they influence EIT-derived features, with the *ratio* parameter exerting by far the strongest effect. The redundancy between *lambda* and *perm* suggests an underlying structural overlap in their roles within the reconstruction matrix computation. These results highlight the critical importance of standardising reconstruction settings, particularly the *ratio* parameter, prior to any fROI-dependent feature extraction, and suggest that reconstruction configurations should be explicitly reported in clinical and research applications of EIT-based ventilation monitoring.