

Frequency-Domain EIT Features for Detecting Apnoea in Premature Neonates

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Abstract: Electrical impedance tomography (EIT) lung impedance signals from 15 premature neonates were analysed with fast Fourier transform and power spectral density before, during and after apnoea. Frequency features gave the best detection performance (AUC 0.981, sensitivity 85.96%, specificity 96.67%).

1 Introduction

Electrical impedance tomography (EIT) measures regional changes in thoracic impedance, enabling continuous, radiation-free bedside assessment of neonatal lung aeration and ventilation [1–3]. Apnoea of prematurity is frequent in preterm infants and is associated with oxygen desaturation, bradycardia and cardiorespiratory instability [4,5]. As apnoea alters the periodic structure of lung impedance waveforms, this study evaluated whether amplitude, dominant frequency, and power spectral density features can distinguish apnoea from non-apnoea periods.

2 Materials & Methods

Retrospective EIT lung impedance waveforms from 15 premature neonates (median gestational age 31 weeks) were segmented into pre-apnoea, apnoea and recovery windows. Signals were detrended and transformed using the fast Fourier transform (FFT); power spectral density (PSD) was calculated to quantify power across respiratory frequencies. Feature groups comprised time-domain amplitude descriptors, dominant-frequency/spectral descriptors and PSD-based power descriptors. Group differences were assessed using two-way ANOVA with Tukey's post hoc testing ($p < 0.05$). Classification performance was evaluated using ROC analysis and random forest models, where sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the curve (AUC) were calculated and reported.

3 Results

Apnoea produced a clear spectral redistribution of EIT lung impedance signals. Frequency features were the strongest single-feature group (AUC 0.981), outperforming amplitude (AUC 0.813) and power (AUC 0.923). Combined-feature models, although yielding lower AUC, improved discrimination across complementary metrics; amplitude + power achieved the highest specificity (98.33%) and PPV (96.00%), while power + frequency achieved the highest sensitivity (89.47%). Full performance metrics are listed in Tab. 1.

4 Conclusions

Apnoea can be detected in the time domain through reduced breathing-signal amplitude, but this may not reliably distinguish true apnoeic events from shallow or irregular respiration. Frequency-domain analysis is more sensitive because it captures shifts in the distribution of signal energy and disruptions to the normal respiratory rhythm. Therefore, spectral features from neonatal EIT signals provide a robust, clinically relevant basis for automated apnoea detection in preterm infants. Larger multicentre studies are needed to validate this approach against clinical annotations and assess real-time bedside implementation.

References

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Tab. 1: Diagnostic performance of EIT-derived feature groups for apnoea detection.

Feature	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	AUC
Amplitude	54.39	88.33	68.89	80.30	0.813
Frequency	85.96	96.67	92.45	93.55	0.981
Power	78.95	88.33	76.27	89.83	0.923
Amplitude + Frequency	71.93	92.50	82.00	87.40	0.928
Amplitude + Power	84.21	98.33	96.00	92.91	0.980
Power + Frequency	89.47	97.50	94.44	95.12	0.979