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Wisse, J. J.; Goos, T. G.; Jonkman, A. H.

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BRIEF COMMUNICATION

Electrical impedance tomography causing interference on the electrocardiogram in neonatal ICU patients

J. J. Wisse[1,2] · T. G. Goos[2,3] · A. H. Jonkman[1]

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Electrical impedance tomography (EIT) is a non-invasive and continuous advanced respiratory monitoring tool for assessing regional lung ventilation distribution and aeration [1]. It generates images based on impedance differences in the intrathoracic area. Recently, its application has extended to monitoring of preterm neonates admitted to the intensive care unit (ICU), facilitated by the availability of EIT belts in small sizes, accommodating thorax circumferences ranging from 19 to 40 cm.

During observational measurements in neonatal ICU patients, we experienced interference of the EIT on the electrocardiogram (ECG) signal, for which an example is provided in Fig. 1. It is known that several sources of interference affect EIT examinations, including pulsatile air-mattresses, movement artefacts or cardiovascular impedance changes [2], however the generation of artefacts to the ECG signal has not been described earlier [3]. Figure 1 clearly illustrates that from the start of the EIT measurement the ECG signal is dominated by noise, hampering adequate continuous vital monitoring of heart rate and also ECG-derived respiratory rate. We explain the cause of this electrical interference and how it could potentially be resolved.

In our unit, EIT measurements were performed the LuMon system (Sentec AG, Switzerland) and the vital signal monitoring system was performed with Draeger M540 (Drägerwerk AG, Lübeck, Germany). EIT images are created using a fabric belt embedded with 32 electrodes that is placed around the thorax. A known current is injected through a pair of electrodes and the receiving electrodes measure the resulting voltage profile; for this specific device, the current injection (0.7–3.7 mA_{arms}; 200 kHz ± 10%) rotates around the chest at a frame rate of 50.8 Hz. Since the ECG also involves the use of electrodes placed on the neonate's thorax, the frequency of the generated voltages was measured by the ECG electrodes.

To minimize EIT interference on the ECG signal, we present two solutions:

1. Place the ECG electrodes as far away from the belt as possible, since interference appeared in the vicinity (1–2 cm) of the electrodes in our observation. However, we cannot rule out that interference does not occur with larger distances as the effect of absolute electrode distance on the signal-to-noise profile was not systematically studied. Nevertheless, this phenomenon was not recognized earlier in adult ICU patients, where there is a larger distance between ECG electrodes and the EIT belt. In extreme premature neonates (< 1000 g) the options for electrode positioning are, however, limited due to the small size of the neonate.
2. The Draeger M540 has the functionality to activate an Electrosurgical Unit (ESU) filter, which is an integrated filter designed to mitigate signal distortion during electrosurgery. Since the filter operates within a passband of 0.5–16 Hz, it effectively filters signals beyond this frequency range. Figure 1A illustrates the distinct impact of the ESU filter, clearly showing the prompt restoration of a clean ECG signal following its activation. Figure 1B illustrates the frequency spectra of the ECG signal. A drawback of the ESU filter is the risk of losing information related to the respiratory rate which is commonly derived from the ECG impedance.

With this work, describing accidental findings, we aim to create awareness of an EIT-ECG interference that has not

✉ J. J. Wisse
j.j.smit@erasmusmc.nl

1 Department of Adult Intensive Care, Erasmus Medical Centre, Rotterdam, The Netherlands

2 Department of Neonatal and Pediatric Intensive Care, Erasmus Medical Centre – Sophia Children's Hospital, Rotterdam, The Netherlands

3 Department of Biomechanical Engineering, Faculty of Mechanical, Maritime and Materials Engineering, Delft University of Technology, Delft, The Netherlands

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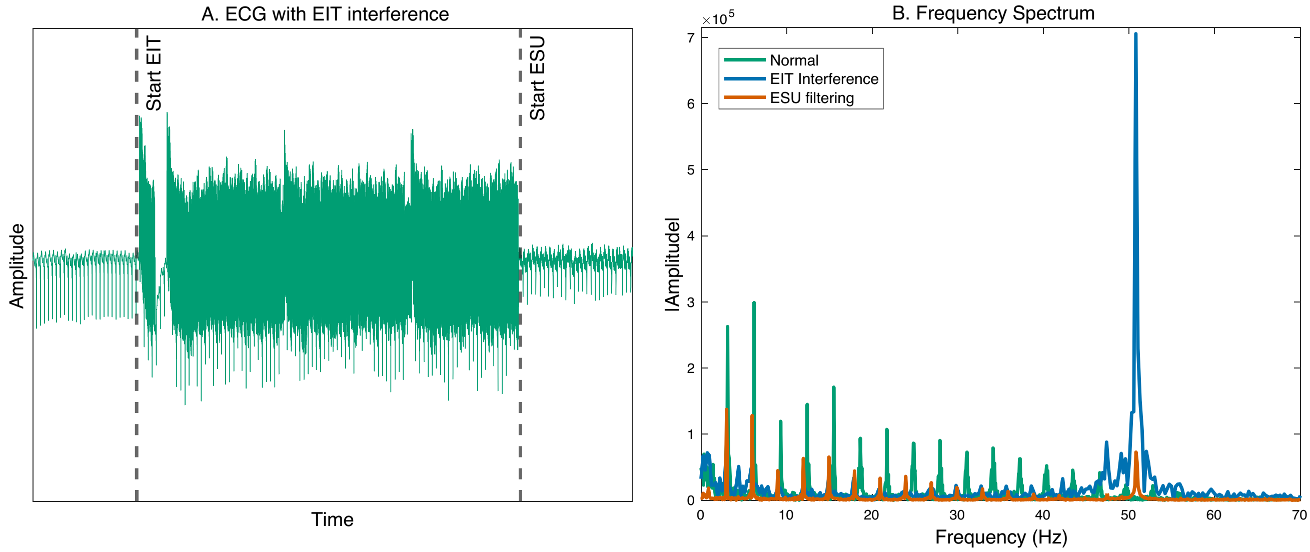

Fig. 1 **A** ECG recording in a premature born neonate. The recording start with a normal ECG with a heart rate frequency of 186 beats per minute. The first vertical line indicates the start of the EIT measurement. After the start of the EIT measurement the ECG signal is excessive dominated by artefacts. The second vertical line indicates the start of the ESU filter. The ESU filter removes the excessive artefacts and generates a clean ECG tracing. **B.** Frequency spectrum of the ECG signal: normal ECG signal (green) before the start of the EIT measurement, ECG signal with artifact (blue) during the EIT measurement, showing a prominent peak (artefact) at 50.8 Hz. The ECG signal with ESU filtering (orange), demonstrates a reduced artefact amplitude at 50.8 Hz

been reported before, and recommend to prioritize optimized electrode placement to enhance reliability of vital monitoring in the critically ill neonate.

Author contributions J.W. Collected the data. All authors wrote and reviewed the manuscript.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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