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A Signal Quality Index for the Impedance Respiratory Signal

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Introduction

Respiratory rate (RR) is an important physiological marker, often increasing prior to acute clinical deteriorations such as cardiac arrests. Consequently, RR is often monitored using thoracic impedance pneumography (IP), since the IP signal can be easily acquired with ECG electrodes. However, IP is highly susceptible to motion artifact, reducing signal quality and resulting in inaccurate RRs. Our aim was to design a signal quality index (SQI) to discriminate between low and high quality periods of IP, and to estimate RR accurately from high quality periods.

Methods

We designed an SQI to quality assess segments of IP of 32 seconds, based on [1]. It consists of: (i) filtering the IP signal to eliminate non-respiratory frequencies; (ii) detecting individual breaths; (iii) assessing the plausibility of breath-to-breath timings; and (iv) assessing the similarity of breath morphologies using template matching. Performance was assessed using IP signals from 59 hospital patients recovering from cardiac surgery, each of one hour duration. Each segment was manually annotated as high or low quality, and individual breaths were annotated. Performance was compared to an existing SQI [2], and the RRs provided by the clinical monitor.

Results & Discussion

See table. The novel SQI had improved discriminatory performance compared to a technique from the literature [2]. RRs had a lower mean absolute error, more accurate estimates (error < 2 bpm), and fewer inaccurate estimates (error > 5 bpm), than this technique or the clinical monitor.

Performance metric	Novel SQI	Technique from literature	Monitor
SQI Sensitivity [%]	76.7	45.0	-
SQI Specificity [%]	84.9	77.4	-
Mean absolute error of RRs [bpm]	0.20	1.34	1.27
Proportion RR error < 2 bpm [%]	97.8	79.5	83.0
Proportion RR error > 5 bpm [%]	0.0	4.7	4.7

Conclusion

The novel SQI can be used to improve the accuracy of RRs estimated from IP. It has applications in both tethered and wearable monitors, and in hospital and home settings.

References

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