

The Accuracy, Precision and Reliability of Measuring Ventilatory Rate and Detecting Ventilatory Pause by Rainbow Acoustic Monitoring and Capnometry

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Background

Current methods for monitoring ventilatory rate have limitations including poor accuracy and precision and low patient tolerance. In this study, we evaluated a new acoustic ventilatory rate monitoring technology for accuracy, precision, reliability, and the ability to detect pauses in ventilation, relative to capnometry and a reference method in postsurgical patients.

Methods

Adult patients presenting to the postanesthesia care unit were connected to a Pulse CO-Oximeter with acoustic monitoring technology (Rad-87, version 7804, Masimo, Irvine, CA) through an adhesive bioacoustic sensor (RAS-125, rev C) applied to the neck. Each subject also wore a nasal cannula connected to a bedside capnometer (Capnostream20, version 4.5, Oridion, Needham, MA). The acoustic monitor and capnometer were connected to a computer for continuous acoustic and expiratory carbon dioxide waveform recordings. Recordings were retrospectively analyzed by a trained technician in a setting that allowed for the simultaneous viewing of both waveforms while listening to the breathing sounds from the acoustic signal to determine inspiration and expiration reference markers within the ventilatory cycle without using the acoustic monitor- or capnometer-calculated ventilatory rate. This allowed the automatic calculation of a reference ventilatory rate for each device through a software program (TagEditor, Masimo). Accuracy (relative to the respective reference) and precision of each device were estimated and compared with each other. Sensitivity for detection of pauses in ventilation, defined as no inspiration or expiration activity in the reference ventilatory cycle for ≥ 30 seconds, was also determined. The devices were also evaluated for their reliability, i.e., the percentage of the time when each displayed a value and did not drop a measurement.

Results

Thirty-three adults (73% female) with age of 45 ± 14 years and weight 117 ± 42 kg were enrolled. A total of 3712 minutes of monitoring time (average 112 minutes per subject) were analyzed across the 2 devices, reference ventilatory rates ranged from 1.9 to 49.1 bpm. Acoustic monitoring showed significantly greater accuracy ($P = 0.0056$) and precision ($p = 0.0024$) for respiratory rate as compared with capnometry. On average, both devices displayed data over 97% of the monitored time. The (0.95, 0.95) lower tolerance limits for the acoustic monitor and capnometer were 94% and 84%, respectively. Acoustic monitoring was marginally more sensitive ($P = 0.0461$) to pauses in ventilation (81% vs 62%) in 21 apneic events.

Conclusions

In this study of a population of postsurgical patients, the acoustic monitor and capnometer both reliably monitored ventilatory rate. The acoustic monitor was statistically more accurate and more precise than the capnometer, but differences in performance were modest. It is not known whether the observed differences are clinically significant. The acoustic monitor was more sensitive to detecting pauses in ventilation. Acoustic monitoring may provide an effective and convenient means of monitoring ventilatory rate in postsurgical patients.