SINGLE BREATH DETECTION DURING SPONTANEOUS VENTILATION USING ALAR PHOTOPLETHYSMOGRAPHY

Presenting Author: Richard Melker, PhD, MD; Xhale, Inc. and Department of Anesthesiology, Gainesville, FL

Co-Authors: Michael Stahl, MS, Assurance Biosense, Gainesville, FL; Timothy Morey, MD; Mark Rice, MD; Judith Wishin, RN; Donn Dennis, MD (TM, MR, JW, DD Department of Anesthesiology, Gainesville, FL)

Introduction: Opioid-induced respiratory depression (ORD) is life-threatening and multifactorial. Many post-operative patients receive patient controlled analgesia. Accurate detection of ORD is challenging, prompting the APSF to highlight it and seek novel monitoring and intervention solutions.

Photoplethysmography (PPG) measures blood volume from at least one LED and a photodiode (PD) as in pulse oximeter sensors. Central PPG (cPPG) was coined to describe measurements above the thoracic inlet where intrathoracic pressure and thus cardiorespiratory changes are reflected.

We studied two hypotheses: 1) cPPG sensors placed on the nasal ala (NA), a site with a rich vascular supply with minimal-to-no sympathetic innervation, can accurately detect individual breaths in spontaneously breathing patients during minor surgery; and 2) the ability to detect individual breaths with NA PPG will be useful in designing technology for early detection of ORD.

Methods: With WIRB approval, 39 outpatients were studied with standard monitoring, and an NA sensor (Assurance Biosense, Gainesville, FL) placed on either ala and connected to an OxyPleth oximeter (Dixtal Medical, Wallingford, CT). High resolution raw data was collected for further analysis. The accuracy of breath detection from NA PPG was determined using one minute epochs of thermistor flow (TF) as the “gold standard.” (Respiratory rate [RR] in breaths per minute [BPM] from the NA PPG was compared to RR from the TF.)

21 hours of valid data was analyzed. NA PPG data was separated in the time domain into two components: one synchronous with heart rate, and the other containing low frequency events including individual breaths and 40 derived parameters of which 4 were selected to detect single breaths.

Results: Left figure - scatter plot of TF RR v. NA PPG RR. The Pearson coefficient between RR detected with TF and NA PPG was r=0.94, r²=0.88 (computed using Matlab, Natick, MA). Right figure - ROC curves for detecting when RR is <20 BPM (green) and <15 BPM (blue) for NA PPG. AUC=0.99 for 20 BPM; 0.96 for 15 BPM.
Conclusion: Because NA PPG correlates well with TF in detecting individual breaths in spontaneously breathing patients, this new technology holds the promise of reliable breath and respiratory rate detection with a low incidence of false alarms. We believe that future refinements in sensor design and processing algorithms will further improve the accuracy of alar PPG to detect respiratory events, including ORD.