Use of a Respiratory Volume Monitor to Identify Opioid Induced Respiratory Depression in the Post-Anesthesia Care Unit

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Introduction
Adequate pain management is an essential component of postoperative patient care. Aggressive postoperative opioid therapy can lead to an increase in opioid-related respiratory complications. This has a profound impact on patient safety, length of stay and cost of postoperative care. Adequate respiratory monitoring could help physicians optimize pain management for both comfort and safety. Unfortunately, no current technology exists that provides a continuous, non-invasive, real-time objective assessment of respiratory competence in non-intubated patients. Most pain management and re-intubation decisions are based on oximetry data and subjective clinical assessment. However, oxygen saturation can be a late indicator of respiratory compromise as a patient fatigues or becomes overly sedated or narcotized, which can be confounded in patients receiving supplemental oxygen; a standard in post-operative care. Here we evaluated a novel, non-invasive, Respiratory Volume Monitor (RVM) that delivers accurate continuous, real-time measurements of minute ventilation (MV), tidal volume (TV) and respiratory rate (RR) in a post-operative setting. This study evaluated RVM’s ability to detect, quantify and predict severe respiratory depression occurring during conventional postoperative opioid pain management.

Methods
Respiratory traces were recorded from thoracic electrodes using an impedance-based RVM system (Exspirion, Respiratory Motion, Inc., Waltham, MA) from 56 non-intubated patients (mean age 66 ± 19 years; mean BMI 30 ± 19.4 kg/m²). The patients were enrolled in an IRB approved study prior to elective orthopedic surgery and were monitored in the pre-op setting, during surgery and during their PACU stay. Ten patients were placed under general anesthesia during surgery and all patients had regional anesthesia. RVM data collection was started in the preoperative setting and continued until discharge from the post-anesthesia care unit (PACU). Opioid analgesia administration (2-3mg hydromorphone PCA or 2-3mg PON morphine) times were recorded. Average respiratory values were calculated from 30-second segments within the 15 minutes before and after analgesic dosing. “Pre-op Baseline” respiratory parameters were calculated from periods of quiet breathing prior to transport to the operating room and were assumed to represent adequate ventilation.

Results

22 of the 56 patients (40%) (mean age 66.5 ± 19.82 years; mean BMI 28.8 ± 19.34 ± 3.93 kg/m²) received opioids in the PACU. Following initial opioid administration, MV for the entire group of 22 decreased significantly from pre-operative baseline of 3.5±9.19 to 4.0 L/min (decrease of 19.25±8.15, p<0.005). Interestingly, RR remained essentially unchanged (11.8±3.95 to 11.7±3.95, average decrease of 1.3±1, p=0.33), suggesting that one of the most reliable parameters most often monitored by clinical staff is a poor indicator of opioid-induced respiratory complications. Note that the patients respiratory status prior to opioid administration was a strong predictor for changes in respiratory depression resulting from a standard opioid dose; in 10 of the 22 patients, who received an opioid when already ≤100 below “Pre-op Baseline,” MV dropped to 55.5±2.7% of “Pre-op Baseline.” In the remaining 12 patients, MV prior to and following opioids remained near “Pre-op Baseline” (Figure 1). Also note that patient respiratory status on arrival at the PACU was also a strong predictor of opioid-induced respiratory complications. 7 of the 22 patients arrived at the PACU with MV ≤100 below “Pre-op Baseline.” In this group, the average total decreases in MV were 45.4±13.9% and RR was ≤100 below “Pre-op Baseline.” The remaining 15 patients arrived at the PACU with MV above “Pre-op Baseline” and had a 7-fold smaller decrease in MV (5.5±13.82, Figure 1). Figure 1 summarizes the predictive ability of patient’s MV on PACU arrival, which correlates strongly with subsequent post-narcotic respiratory depression (p<0.005).

Discussion
Reduction in MV from pre-operative baseline reliably quantifies respiratory status and may help titrate opioid dosing as well as provide an early warning of respiratory depression. Utilizing the RVM MV measurement changes before and after opioid dosing may lead to the development of protocols to assist with decision making regarding the use of opioids, discharge criteria, assessment of patient anxiety or the need for interventions. Protocols can be developed to deliver appropriate doses of opioids to patients that appear to demonstrate increased sensitivity to opioids. Use of RVM data collected in the PACU can stratify patients to adjust PCA dosing parameters. Potentially patients with MV or at near baseline might receive standard doses of narcotics, whereas those more than 20 below baseline might be given a half or quarter dose regimen, much as there are different insulin dosing protocols for diabetics.

Conclusions
- Continuous RVM provides continuous, accurate, non-invasive measurements of MV, TV and RR; respiratory data previously unavailable in the PACU.
- RVM has the potential to bridge the monitoring gap in non-intubated patients to help optimize pain management & improve patient safety.
- RVM data can be used to develop PCA or other opioid protocols to enhance patient safety in the PACU and on the hospital floor.
- RVM data can be used to develop appropriate discharge criteria and triage metrics to improve throughput and safety.

References: To be reviewed every year.

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