Developing a Protocol Utilizing Non-Invasive Respiratory Volume Monitoring to Identify Patients at Risk for Opioid-Induced Respiratory Depression

C. Marshall MacNabb, MS1, Jordan Braymano, PhD1, Jenny Freeman, MD1, Edward George, MD, PhD1

1Respiratory Motion, Inc., Waltham, MA, 2Massachusetts General Hospital, Harvard Medical School, Boston, MA

Introduction

Respiratory compromise, often due to opioid administration, is a contributor or main cause of ≥1/3 of hospital cardiopulmonary arrests. Opioids are routinely used for post-operative pain management, and adequate respiratory monitoring remains a major challenge. Opioid-induced respiratory depression (OIRD) and post-operative apnea (POA) often remain unnoticed with current resuscitation and often lead to increased monitoring and no modification in therapy. Currently, no technology provides continuous, non-invasive, real-time, measurements of respiratory competence in non-intubated patients. Opioid-induced respiratory compromise, a significant respiratory compromise, leading to a delay in interventions, increased recovery times, adverse outcomes, and associated healthcare costs. A non-invasive Respiratory Volume Monitor (RVM) that displays continuous, real-time, minute ventilation (MV), tidal volume (TV) and respiratory rate (RR) measurements provides an alternative to subjective evaluation and oximetry for assessment of respiratory status. An RVM based risk assessment protocol was developed to identify patients at risk for respiratory depression following opioid administration in the PACU.

Methods

Respiratory traces were collected from an impedance based RVM (ExSpirion, Respiratory Motion, Inc., Waltham, MA) during the PACU stay of 200 non-intubated patients who had elective joint replacement surgery (mean age: 68, 19-89 years; mean BMI: 29.9, 15.4-49.4 kg/m²). Average respiratory values were calculated from four 30-second segments within the 15 minutes prior to and following opioid administration (0.2mg/kg hydromorphone or 2.0 mg PRN morphine). Predicted values for adequate MV (PREDMV) were calculated as body surface area (BSA) x 3.5 for women & BSA x 4.0 for men. “Percent Predicted” as defined below was MV Recorded/Individual MV<PRED: “At-Risk” was defined as patients with an MV <80% of PREDMV prior to opioid administration. “Un-Safe” MV was considered to be <45% of PREDMV sustained for at least two minutes.

Results

Of the 200 patients studied, 94 (47%) received opioids in the PACU (mean age: 66, range 19-99 years; mean BMI: 29.9, range 18.9-46.6 kg/m²). Baseline MV (recorded by the RVM) in this cohort pre-operatively (MV<PRED) was 7.1±0.41 L/min, 100±46.6% of MV<PRED mean ± SEM, Figure 3A) Within 15 minutes after arrival in the PACU the MV was significantly elevated and remained unchanged until after the first PACU dose of opioid. After the first dose, the average MV decreased from 7.4±1min to 8.4±1min (p<0.001, paired t-test, Figure 3A, 4th bar). Patients were stratified into two categories “At-Risk” (MV<80% of MV<PRED, MV<PRED) and “Not-at-Risk” (MV≥80% of MV<PRED) based in initial MV recorded prior to the PACU to opioids administration. Patients classified as “At-Risk” (n=41) had an average post-op MV of 6±0.22% MV<PRED (p<0.001), after opioid administration, whereas the “Not-at-Risk” group (n=53) had post-op MV of 84±7.54% MV<PRED (p>0.2). Analysis classified 41/94 patients as “At-risk” and 53/94 as “Not-Risk”. Of those classified as “At-Risk” 28/41 (68 ±3.3%) had decrease in MV to “Un-Safe” MV<45% of MV<PRED) after opioid dosing. Only 2/53 patients classified “Not-at-risk” had a decrease in MV to the “Unsafe” zone after opioid administration (p<0.001). The sensitivity of this classification was 95% with a specificity of 80%, and a negative predictive value (NPV) of 96%. Only two patients with potentially “Unsafe” respiratory compromise were misclassified. The type II error (false negative rate) was 7%.

Conclusions

✓ Non-invasive RMV monitoring provides continuous measurements of MV, TV and RR for assessment of respiratory status.
✓ This study suggests that administration of opioids to patients with MV<80% Predicted prior to dosing can lead to potentially Un-Safe Depression (≥45% Predicted) and that evaluation of the patients respiratory status prior to opioid administration is warranted.
✓ Further, data suggests that protocols for assessing MV prior to PACU discharge may increase patient safety on the hospital floor.
✓ Stratification of patient response to opioids and MV trend analysis may lead to improved pain management protocols and individualized care with the potential to enhance patient safety in the PACU and after discharge to the hospital floor.
✓ Further studies to evaluate the utility of this protocol are underway.