Respiratory Volume Variability Prior to Opioid Administration as an Indicator for Opioid-Induced Respiratory Depression

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Introduction: Pain management during post-operative recovery, in critical care, and hospital floor settings utilizes opioids, often with other medications. Respiratory depression, including opioid-induced-respiratory-depression (OIRD), remains a major complication in most hospital settings, as standard monitoring technologies are inadequate to identify early signs of respiratory compromise. A non-invasive respiratory volume monitor (RVM) was used to evaluate the effects of opioids on respiratory status in patients in the PACU. We evaluated whether the patient’s minute volume (MV) and tidal volume (TV) variability could predict either a weak or a strong response to opioids.

Methods: RVM data were collected from 93 patients (65.7±9.5yrs, BMI:29.1±5.0) who received one or more doses hydromorphone (0.2mg) in the PACU. Cohort was homogenous for demographic and clinical features. Average pre-opioid MV, TV&RR values were calculated for each patient within 15 minutes before first opioid dose. Continuous data from 15 minutes before and after first opioid dose were normalized based on the patients’ calculated average pre-opioid values. Patients were stratified based on recorded decrease in MV into “Strong Responders” (highest 25%) and “Weak Responders” (lowest 25%). Un-paired 2-tailed t-tests were used to evaluate differences in MV, TV, and RR across the two groups. MFANOVAs evaluated the effects of height, weight, age, BMI, and sex across the two groups.

Results: Effect of opioids on respiratory status was clearly captured by the RVM (Fig. 1A). Both MV and TV trends showed systematic decrease following dose of hydromorphone (0.2mg) reaching a nadir of approximately 80% of pre-opioid values within 10-12 minutes. RR did not show a significant systematic decrease, remaining around 95% of pre-opioid levels. Stratifying patients based on decrease in MV revealed that pre-opioid respiratory variability might be a useful predictor for OIRD (Fig. 1B). “Strong Responders” had nearly twice the MV variability of “Weak Responders” before first opioid dose; similar effect was also present in TV but not RR variability. There was no significant effect of demographics across the two groups.

Conclusions: Assuming homogeneity of the population, a differential sensitivity towards opioid therapy occurred. Preliminary results show continuous monitoring of minute ventilation and variability could be a useful predictor of individual opioid sensitivity, marking patients at risk for respiratory depression. Development of patient-specific treatments and understanding effects of treatment would allow clinicians to transition away from using generalized” treatment plans. Patient-centered care could lead to reduction in complications, improved patient safety and satisfaction, along with cost savings and improvements in throughput.
Figure 1: Respiratory measurement trends and variability before and after a single dose of 0.2 mg hydromorphone. (A) Average trends across the whole patient cohort (n=93). The systematic decrease in minute ventilation (MV, top) and tidal volume (TV, middle) clearly captures the effect of a single opioid dose (within the first 15 minutes of administration) on respiratory function across the patient cohort. In contrast, over the same time period respiratory rate (bottom) remains practically unchanged. (B) Differences in variability between patients with a large MV decrease following opioids ("Strong Responders") and patients with small MV decrease ("Weak Responders"). Using the standard deviation of each measurement, calculated over the 15-minute window, as a proxy for measurement variability and stratifying patients based on the magnitude of their MV decrease, the top quartile ("Strong Responders", red) are compared against the bottom quartile ("Weak Responders", green). Prior to the first opioid dose, the “Strong Responders” had significantly greater MV (top, left) and TV (middle, left) variability than the “Weak Responders”. The difference in RR variability between the two groups was not significant. Following the opioid dose, the “Strong Responders” maintained significantly higher MV variability while TV variability differences diminished and became non-significant. RR variability differences did not change significantly either.

NS p>0.1, * p<0.05, ** p<0.01