Introduction

Opioids are routinely used for the management of post-operative pain, and adequate respiratory monitoring remains a major challenge. Opioid-induced respiratory depression (OIDR) and post-operative apnea (POA) are commonly assessed with RR, oxygen saturation (SpO₂) and subjective clinical evaluation. This does not give a true picture of respiratory competence. Obstructive sleep apnea (OSA) has been considered a risk factor for post-operative respiratory complications. OSA remains undiagnosed predominantly in 80% of patients. Many patients without a previous diagnosis of OSA manifest apneic breathing patterns after surgery; referred to here as “post-operative apnea” (POA). Here we use the RVM to assess a respiratory depression risk algorithm for the use of opioids in the post-operative setting and to evaluate POA.

Methods

Respiratory data from 150 patients undergoing elective orthopedic surgery (age 66 ± 9.6 years; BMI: 30.2 ± 5.5 kg/m²), were collected in the PACU following general (34 patients) or spinal (116 patients) anesthesia via endotracheal tube placed on the thorax. Written informed consent was obtained prior to enrollment. “Predicted MV” (MV PRED) was calculated for each patient using standard formulas. “Percent Predicted” was defined as MV PRED/MV PRED x 100. Opioids was defined as >5 apneic events per hour (respiratory pause > 10 sec) in the PACU. PCA opioids (0.2 mg/ml hydromorphone) were administered to 74 patients (age 65 ± 10.6 years; BMI: 29.7 ± 5.4 kg/m²). Prior to opioids, patients were stratified as “Not-at-Risk”, MV < 80% MV PRED and “At-Risk”, MV > 80% MV PRED. “Low MV” was defined as MV < 40% MV PRED.

Results

Figure 2 shows an example case demonstrating a potentially dangerous opioid administration pattern in the PACU. Upon entering the PACU, the patient had adequate MV ranging between 9 and 11 L/min (2A, left panel); shortly after arrival, patient developed hyperventilation and POA (2A, middle panel) and after the first dose of PCA hydromorphone, severe respiratory depression (2A, right panel).

Figure 28 displays the continuous MV trend of the patient. For the first 30 minutes, the patient’s MV often drops below 80% MV PRED (yellow zone). After the first opioid dose, MV drops to below 40% MV PRED (red zone) and remains mostly into the “Low MV” range for nearly 2 hours. The patient is eventually discharged from the PACU with a “Low MV”.

Figure 2C and 2D display TV and RR trends, respectively. It is noted that they are not as event-specific as the MV trend with the RR trend being the least event-specific of the three.

Out of the 150 patients, 74 (49%) received opioids in the PACU. Figure 1 shows that classifying patients “At-Risk” (32 patients) successfully identified 22 out of 24 patients who developed “Low MV”. This protocol yielded a sensitivity of 91.6%, a specificity of 95.5%, positive predictive value (PPV) of 88.8%, negative predictive value (NPV) of 95.2%, and likelihood ratios of 9.28 and 0.02. The resulting “Low MV” threshold was 69%, demonstrated “Not-Low MV” 95% of the time whereas patients who receive opioids with MV < 80% MV PRED, become “Low MV” 69% of the time. 32 patients were identified as “At-Risk” and 42 were identified as “Not-at-Risk”. 22 of the 32 patients classified “At-Risk” displayed “Low MV” level after opioid administration, whereas the remaining 10 did not. Of 42 “Not-at-Risk” patients demonstrated “Not-Low MV” whereas only two of the 42 “Not-at-Risk” patients were considered “Low MV”. This protocol yielded a sensitivity of 91.6%, a specificity of 80.0%, with a positive predictive value (PPV) of 68.8% and a negative predictive value (NPV) of 95.2%. Importantly, this protocol focuses more on sensitivity than specificity, with only 2% of patients with potential respiratory compromise misclassified (note the NPV = 95%). This suggests that patients with an MV < 80% MV PRED have a high likelihood of being at risk for a low dose protocol for opioids for pain management.

Conclusions

- Non-invasive RVM monitoring provides continuous, real-time and objective measurements of MV, TV and RR which quantifies respiratory depression and the effects of opioid-induced apnea.
- MV < 80% MV PRED is a strong predictor of OIDR and suggests that administration of opioids to patients with MV < 80% MV PRED prior to dosing can lead to potentially “Un-Safe” respiratory depression (<40% MV PRED).
- Evaluation of respiratory pattern and MV opioid levels can measure to improve pain management protocols and patient-specific care plans with the potential to improve PACU flow, decrease healthcare costs and enhance patient safety.