Introduction

Digital respiratory tracings were collected from 119 patients undergoing elective joint replacement surgery after obtaining written informed consent. The tracings were collected via an electrode placed on the thorax (Figure 3). Twenty-one patients had general anesthesia (GA) and 93 had spinal anesthesia. Fifty of the 119 patients received opioids in the PACU. Of those, 10/50 GA and 18/93 had SA “Predicted” MV (%MVpred) and “Percent-Predicted” MV (%MVpred) were calculated for each patient using an ideal body weight (IBW) formula. Here we used three different criteria to evaluate the effects of anesthesia and opioids in the patient population:

1. Patients with sustained low MV (≤ 40% of MVpred for at least 2 minutes) within 15 minutes after the first dose of opioid dose were considered “Un-Safe” and experiencing OIRD.

2. Patients with low MV (≤0.75 of MVpred) in the 30 minutes prior to discharge from the PACU for at least 10 minutes (50% of the time) were also considered potentially “Un-Safe”.

3. Patients with ≥5 apnea events/hour over the entire PACU stay were classified as "POA"

Methods

Figure 3. Example 30-second respiratory tracings from three representative patients before (left) and after (right) a potential trigger of respiratory compromise. The likely trigger in the first two patients is likely the hydromorphone dose which leads to a 4-fold decrease in MV. The response in both patients is markedly similar, despite the difference in anesthesia used during surgery. In the third patient, the appropriate trigger is sleep state, possibly compounded by the residual anesthetics and anxiolytics from surgery. Figure 3 shows the recorded MV trends from the RVM in three same patients. In these plots, the average trend line (black) shows the level of respiratory sufficiency while the shaded envelope (blue) captures the inherent variability in the respiratory signal. While fewer spinal anesthesia patients received opioids (n=15 vs. 57 GA; p<0.02) and the SA patients received a lower morphine equivalent dose (3.6±0.8 mg, 5A vs. 6.6±1.9 mg, GA, p<0.02), the prevalence of potentially dangerous respiratory events in the SA group was lower. In fact, following opioid administration, OIRD in the SA group was 1.5 times lower than the GA group. While POA was similar in both SA and GA groups that received opioids, POA was significantly higher for those who had SA in the group that did not receive opioids. Additionally, in the group that did not receive opioids, 15% (7/50) of the SA patients were classified as “Un-Safe” prior to discharge compared to 4% (6/124) GA patients, p<0.04 (Figure 4).

Post-operative pain management after either general anesthesia (GA) or spinal anesthesia (SA) frequently includes opioids that can cause respiratory compromise, including opioid-induced respiratory depression (OIRD) and post- operative apnea (POA). Adequate assessment of respiratory status remains a significant challenge. Currently, standard monitoring does not provide continuous, noninvasive, real-time, measurements of respiratory competence in non-intubated patients. Post-operative respiratory monitoring often consists only of subjective clinical assessment and pulse oximetry readings. Oxygen saturation decreases only after significant respiratory compromise, leading to a potential delay in interventions, and can be masked by the use of supplemental oxygen. A non-Invasive Respiratory Volume Monitor (RVM) that provides continuous, real-time, measurements of minute ventilation (MV), tidal volume (TV) and respiratory rate (RR) is utilized to evaluate the effect of opioids on respiratory status in patients after general or spinal anesthesia in the post anesthesia care unit (PACU).}

Results

Figure 2. Effects of (a) opioid-induced respiratory depression in the PACU. Patients were classified by the type of anesthesia, awake or asleep GA, general GA, and GA and SA patients who received opioids (n=15 for GA patients, n=64 for SA patients). The Student’s t-test was used to evaluate the effects of postoperative opioids. While the incidence of opioid administration in GA patients was higher than in SA patients (38/121 vs. 21/93 or p<0.02), the incidence of OIRD was significantly lower in the GA group (36/121 vs. 21/93 or p<0.02). The incidence of POA was similar in both the GA and SA groups (14/121 vs. 14/93, p=0.72). In the 60-minute period post-PACU discharge, significant differences in the incidence of OIRD classified as “traces” (mild), “moderate”, and “severe” were noted in patients who received opioids. While none of the patients (n=64) classified as “traces” (mild) significantly less than the 93 SA patients (n=55, p=0.82, similar), among the patients who received opioids, 8% of GA patients (n=55) classified as “traces”, a figure significantly lower than the 15% of SA patients (n=55, p<0.02).

Conclusions

- RVM provides continuous, non-invasive, real-time respiratory traces and MV, TV, and RR measurements that allow anesthesiologists to detect potential respiratory opioids on respiratory status including OIRD, and POA in non-intubated patients.
- Patients receiving both GA and SA were shown to be at risk for respiratory depression.
- Patients undergoing SA had significantly higher incidence of respiratory depression.
- Data showed that, in patients who received no opioids, more SA patients had “Un-Safe” MV prior to discharge than GA patients (15% vs. 3%).
- RVM provides data of potential benefit for monitoring patients undergoing either anesthesia or non-invasive respiratory opioid dosing, PACU discharge timing and follow-on care requirements.
- Further research into these findings is ongoing.