Introduction

The use of epidural for post-operative pain relief strikes a delicate balance between effective pain control and adequate respiratory function. Too much analgesia often leads to respiratory depression and other complications. The introduction of patient-controlled analgesia (PCA) allowed for prompt pain control in the absence of direct involvement by a care provider. Unfortunately, widespread use of PCA did not eliminate opioid-induced respiratory depression (OIRD). One contributing factor is the fact that PCA protocols are generally based on standard dosing formulas, rather than being individualized based on information regarding opioid sensitivity and metabolism. Ongoing assessment of respiratory status and response to opioids could assist in creating better guidelines. In this study, we examined the respiratory effects of standard-dose (using morphine) vs. low-dose (using hydromorphone) PCA protocols. The low-dose group had 2 times more PCA button push than the standard-dose group, showing standard PadSet placement. One electrode is placed at the sternal notch, another is placed on the xiphoid and the third is placed on the right medial xiphoidal line at the level of the sternal notch.

Methods

166 patients undergoing elective joint replacement surgery (age: 65.5±10.2 yrs; BMI: 29.2±5.8 kg/m2) were enrolled. Of these, 87 (age: 64.3±11.6 yrs; BMI: 29.2±5.6 kg/m2) were managed with a PCA dose of 1 mg morphine (low-dose (standard-dose group), while the remaining 79 patients (age: 66.8±8.2 yrs; BMI: 29.8±5.9 kg/m2) were managed with a PCA dose of 0.2 mg hydromorphone (low-dose group). PCA lockout period and dosing frequency settings were the same across both groups. Patients were monitored in the PACU with an impedance-based respiratory volume monitor, as shown in Figure 1 (ExSpiron, Respiratory Motion, Inc.) that provides continuous, real-time, quantitative measurements of MV, TV and RR. Figure 1 shows standard PadSet placement. One electrode is placed at the sternal notch, another is placed on the xiphoid and the third is placed on the right medial xiphoidal line at the level of the xiphoid.

Results

Patients in the both groups left the PACU with essentially the same MV (7.1±0.4 L/min vs. 6.7±0.4 L/min, p>0.05, Figure 4A). This suggests that the two opioid regimens had similar overall effect of the group’s respiratory performance. In addition, the low-dose regimen did not significantly change PACU throughput as patients in both groups had similar lengths of stay in the PACU (188±8.4 min vs. 170±7.0 min, p>0.05, Figure 4B), although PACU discharge is clearly multifactorial.

Conclusions

RVIM monitoring provides the potential to individualize pain management strategies. This would be an improvement over current methods that standardize dosing based on the “average” patient.

- Implementation of a broad, across the board, low-dose opioid protocol or change in specific opioid administered may not reduce total opioid use or reduce the incidence of OIRD. This group of patients appeared to compensate for lower PCA dosing by increasing the number of opioid doses that they self-administered. This may be associated with a decrease in patient satisfaction.

- For patients at risk for respiratory depression, RVIM monitoring may allow clinicians to more carefully titrate opioid dosing and employ a targeted low-dose opioid protocol, or consider using multi-modal pain relief therapy.

- For patients with adequate respiratory function (MV), clinicians may safely use a more aggressive and more effective opioid dosing strategy.

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Figure 1: A non-invasive Respiratory Volume Monitor (RVM, ExSpiron, Respiratory Motion, Inc.) that provides continuous, real-time, non-invasive measurements of MV TV and RR. Figure shows standard PadSet placement. One electrode is placed at the sternal notch, another is placed on the xiphoid and the third is placed on the right medial xiphoidal line at the level of the xiphoid.

Figure 2: (A) Total opioid dose in the PACU. Patients in the low-dose group (blue, 1 mg morphine per PCA button push) used a similar amount of opioids (hydromorphone) compared to the standard-dose group (red, 0.2 mg morphine per PCA button push) during their stay in the PACU (7.4±0.8 MME vs. 6.5±0.8 MME, p>0.05). (B) Number of PCA-administered opioid doses. Clearly, to achieve the same level of overall opioid dose, patients in the low-dose group self-administered significantly more PCA doses than patients in the standard-dose group (7.4±0.8 vs. 5.3±0.5, p<0.05).

Figure 3: The distributions of number of PCA doses used by patients under the standard-dose (A) and low-dose (B) protocols. The low-dose group had 2 times more PCA doses than patients in the standard-dose group (5.3±0.5 vs. 13.6±2.3, p<0.05).

Figure 4: (A) On average, patients in the low-dose group had basically similar MV on discharge from the PACU compared to the standard-dose group (97.0±4.1 L/min vs. 7.1±0.4 L/min, p>0.05). As a percent of patients’ predicted MV, the results are even more similar: 99.6±2.4% MVp vs. 99.4±2.3% MVp for the low-dose group (p>0.05). (B) Patients in both groups had similar lengths of stay in the PACU.

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