Adequate respiratory monitoring is a major patient safety concern in the post-operative setting, as the use of sedatives and opioids, often combined with apneic events, can lead to reduced ventilation and compromise airway patency. Monitoring is particularly important for obese patients, who are at a higher risk for perioperative complications. Direct monitoring of ventilation in obese patients is difficult, and no reliable index of respiratory compromise is available until recently, and currently used respiratory monitoring technologies are insufficient to identify early signs of respiratory compromise. Indirect indicators like oxygen saturation (SpO₂) and capnography (EtCO₂) can delay critically needed interventions, and often cause false alarms. A non-invasive respiratory volume monitor (RVM) providing direct, real-time measures of minute ventilation (MV), tidal volume (TV) and respiratory rate (RR) in non-intubated patients has been developed. Here we present the results of a study comparing respiratory status in obese and non-obese orthopedic patients and compare ventilation throughout the perioperative course.

### Methods

Following written informed consent digital respiratory traces were collected from 62 orthopedic patients undergoing elective joint replacement surgery (Age: 65.4 ± 12.0 yrs, BMI: 30.8 ± 6.0 kg/m²) under general anesthesia. A bio-impedance based RVM (ExSpiron-1Xi, Respiratory Motion, Waltham, MA) was used to collect digital respiratory traces in all patients pre-operatively, throughout the surgical procedure, and post-operatively for the length of patient stay. Indirect indicators like oxygen saturation (SpO₂) and capnography (EtCO₂) were available until recently, and currently used respiratory monitoring technologies are insufficient to identify early signs of respiratory compromise. Indirect indicators like oxygen saturation (SpO₂) and capnography (EtCO₂) can delay critically needed interventions, and often cause false alarms. A non-invasive respiratory volume monitor (RVM) providing direct, real-time measures of minute ventilation (MV), tidal volume (TV) and respiratory rate (RR) in non-intubated patients has been developed. Here we present the results of a study comparing respiratory status in obese and non-obese orthopedic patients and compare ventilation throughout the perioperative course.

Ventilation was compared against the patients predicted MV (MV_PRED) based on ideal body weight (IBW). In accordance with previous research, patients showing ventilation below 80% of MV_PRED were classified as ‘At-Risk’ of hypoventilation in the event of epidural administration. Patients showing ventilation below 40% of MV_PRED were classified as ‘Un-Safe’ and requiring ventilation monitoring. Ventilator MV (Aplo, Draeger, Telford, PA) was also collected during general anesthesia and was assumed to be adjusted to maintain appropriate EtCO₂. Patients were stratified based on obesity status (obese BMI > 30). The distributions of BMI at various times were compared (non-obese vs obese) using un-paired two-tailed t-tests and a 2-sample F-test.

### Results

62 orthopedic patients participated in this study. Patients were stratified according to obesity (BMI > 30), resulting in an obese cohort with 32 subjects and a non-obese cohort with 30 subjects. As indicated in Figure 2, the two cohorts showed similar MV_PRED based on ideal body weight: Obese: 6.2 ± 0.2, Non-Obese: 6.1 ± 0.2 L/min, p=0.3. Despite this, obese patients were managed at a significantly higher MV while intubated during surgery (6.1 ± 0.2 vs. 5.3 ± 0.2 L/min, p<0.01).

#### MV differences between the cohorts were observed to be even more significant in non-intubated conditions. Obese patients showed higher ventilation than non-obese patients preoperatively (9.7 ± 0.4 vs. 6.7 ± 0.3 L/min), at PACU arrival (11.4 ± 2.1 vs. 6.8 ± 0.7 L/min) and at PACU discharge (7.7 ± 0.5 vs. 5.0 ± 0.6 L/min). Additionally, these differences were significant at p<0.01. These observations suggest that the IBW-based MV_PRED underestimates metabolically required ventilation levels in obese patients.

#### Figure 2: Comparison of MV measurements in obese (Blue, BMI > 30) and non-obese (Red, BMI < 30) patients. Predicted MV (MV_PRED) for both groups (hatched lines, red, obese; blue, non-obese) were similar (6.0±0.2 vs. 6.1±0.2 L/min), whereas the measured MV in the obese population was significantly higher at every time point throughout the course pre-operatively (Baseline, 9.7±0.4 vs. 6.7±0.3 L/min), beginning of surgery (6.0±0.3 vs. 5.5±0.2 L/min), average during surgery (6.1±0.2 vs. 5.3±0.1 L/min), and at discharge (15.8±2.6 vs. 6.2±0.5 L/min). In the obese patients the MV measurements post- and post-operatively (spontaneously breathing) were significantly higher than while intubated on the ventilator (p<0.01).

#### Figure 3: Boxplots show MV mean and variance in (A) non-obese (BMI<30) and (B) obese (BMI>30) patients. (A) Non-obese (n=32) and obese (n=30) patients are presented respectively. Dashed lines depict MV_PRED, as well as the standard error of the mean (SEM). MV values are significantly higher in obese patients than in non-obese patients (p<0.01 for all comparisons).

#### Conclusions

- The use of RVM allows for the continuous and non-invasive assessment of respiratory function in obese patients.
- On average, obese patients have greater MV than predicted by IBW formula, likely due to greater metabolic demand.
- Conventional IBW formulas may not be accurate predictors of baseline respiratory performance in obese patients.
- Obese patients have greater variability in ventilation post-operatively when treated with standard opioid doses, and may be at greater risk for hyperventilation.
- PACU opioid dosages do not appear to correlate significantly with obesity.
- RVM technology provides data that can support individualized treatment plans.