Defining Minute Ventilation in Obese Surgical Patients: New Perioperative Findings

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Introduction: Recently, a respiratory volume monitor (RVM, ExSpiron, Respiratory Motion, Inc., Waltham, MA) was introduced to clinical practice, allowing accurate minute ventilation (MV) assessment in spontaneously breathing patients. Reference values for MV, which have historically been calculated based on ideal body weight (IBW) or body surface area (BSA), may not be accurate in an obese population. Because the obese may be at higher risk for sedative or opioid induced postoperative MV derangements, correct MV reference data are desirable and postoperative MV monitoring may be advantageous. We hypothesized that in this population, MV based on a new reference model combining IBW and BSA will more closely reflect an intraoperative MV standard, than traditional nomograms, and we report postoperative MV changes.

Methods: Following IRB approval and written informed consent, continuous respiratory data (MV, TV and RR) were recorded using the impedance-based RVM in obese surgical patients requiring general anesthesia (GA) and positive pressure ventilation. Ventilator settings during GA were assumed to be adjusted to maintain an appropriate end-tidal CO₂ and we defined the intraoperative MV as the standard reference. We compared this intraoperative standard MV for each patient to their predicted MV (MVₚᵢₑᵢₙ) based on IBW and BSA nomograms as well as to a new composite IBW-BSA reference (Fig. 1C). In addition, we measured MV-based respiratory performance at seven time-points perioperatively and compared the

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individual data to the new IBW-BSA reference model. Two-sample F-tests for equal variance were used to compare distributions of MV at various time points.

**Results:** Data from 65 patients (age 45 ± 13 years, BMI 44 ± 8 kg/m², 47 females) were obtained. Intra-operative MV was 24.5% above the $MV_{\text{PRED}}$ by the IBW-based MV prediction, and 15.5% below the BSA-based MV prediction (Fig. 1A&B). $MV_{\text{PRED}}$ using the new IBW-BSA composite reference was most closely associated with intra-operative MV values (4.5% higher, Fig. 1C). The pre-op and spirometer MV variances were not significantly different from the intraoperative average-during-surgery MV variance ($p > 0.05$ for each comparison). In contrast, the MV variance at each of the 3 PACU time points was significantly greater than the average-during-surgery MV variance ($p<0.0001$, Fig. 1 D). Within 30 minutes of PACU arrival 9% of patients demonstrated < 80% $MV_{\text{PRED}}$ and 2% declined to < 40%. In the last 30 mins prior to PACU discharge, 17% of the patients spent more than 1/3 of the time with less than 40% $MV_{\text{PRED}}$. At 15 mins prior to PACU discharge, 13% of patients were on average below 80% $MV_{\text{PRED}}$, and 2% remained at < 40% (Fig 1D).

**Conclusions:** This study suggests that traditional MV nomograms may be suboptimal in the obese population. A new composite IBW-BSA reference model performed best compared to a defined intraoperative standard. The latter may be influenced by open vs laparoscopic procedure, by anesthesiologist and institutional preferences and other factors, and requires further investigation. We discovered a wide variability of postoperative respiratory performance that may reflect individual patient’s responses to surgery, anesthesia and analgesia. In addition, a subset of patients were identified with less than 40% predicted MV that may have been at increased risk for respiratory complications. The real-time RVM respiratory status assessment postoperatively offers refined monitoring that enables patient centered postoperative protocol development targeting improved patient safety and satisfaction.
Figure 1: (A-C) Minute ventilation (MV) settings on the ventilator during surgery for the cohort compared to predicted MV ($MV_{\text{PRED}}$) based on standard formulas and a new composite. In panel C the x-axis value represents the average $MV_{\text{PRED}}$ from the IBW and BSA formulas.

(D) MV measurements at various time-points during the case compared to the average $MV_{\text{PRED}}$. Each box-plot shows the median MV (red line), the box extends from the 25th to the 75th percentile, whiskers extend to the most extreme non-outlier data points, and red "plus" signs reflect statistical outliers. Spirometer = Minute-long spirometer trial.