The Use of a Non-Invasive Respiratory Volume Monitor to Measure the Adequacy of Ventilation in Patients under Conscious Sedation for Routine Endoscopic Procedures

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Upper endoscopies are generally performed under conscious sedation which requires careful monitoring of respiratory status to prevent adverse outcomes. The use of propofol is becoming increasingly popular. However, propofol-induced deep sedation may increase the incidence of respiratory depression and apnea, increasing the need for continuous airway and ventilation monitoring. Proper assessment and maintenance of airway patency can be a significant challenge. Anesthesiologists often rely on common airway maneuvers such as chin lifts and jaw thrusts, to relieve airway obstructions and ensure adequate ventilation. While both capnography and pulse oximetry are capable of detecting severe adverse events, neither is sensitive enough to detect early signs of hyperventilation. It can be both difficult to determine when an airway maneuver is necessary, as well as to properly monitor and quantify the effectiveness of a maneuver in real time. This study evaluated the use of a novel, non-invasive, Respiratory Volume Monitor (RVM) to quantify ventilation before, during, and after endoscopic procedures with continuous, real-time assessments of minute ventilation (MV), tidal volume (TV) and respiratory rate (RR). In addition, the RVM was used to quantify the effects of propofol on ventilation during the procedure. The RVM has been shown to be capable of detecting changes in ventilation in real-time, potentially preventing and predicting the effects of life-threatening hyperventilation.

Methods

A bio-impedance based RVM (Xpior, Respiratory Motion, Inc., Waltham, MA) was used to collect digital respiratory traces from an Electrode PadSet placed on the thorax (Figure 1). With the recommended electrode placement and configuration, long-term, continuous, non-invasive measurements of MV, TV and RR were obtained during the procedure. In between RVM and spirometric measurements have been previously demonstrated. Twenty-nine patients (age: 54 ± 5 years, BMI ± 23 ± 8 kg/m²) were studied. The subjects underwent the following procedures: 15 EGD (1 with colonoscopy, 1 with ERCP, 1 with manometry), 8 ERCPs, 4 EUSs, and 2 gastroscopies. Four of the patients, undergoing ERCP, were intubated prior to the procedure and were not part of this analysis. MV, TV, and RR were calculated from 30-second segments over the entire stay. All patients were sedated with propofol. Airway maneuvers (e.g. chin lifts and jaw thrusts) were performed as needed for airway patency. The anesthesiologist team was blinded to the RVM measurements. Average MV, TV, and RR of propofol were calculated from a 3-minute period of quiet breathing prior to the procedure, which were defined as the patient’s baseline metrics. Predicted MV for each patient was calculated based on the estimated body surface area (BSA).

Results

Fourteen of the 25 patients studied received an infusion of propofol while the other 11 received multiple bolus doses. At baseline, prior to any sedatives, the cohort average MVbaseline was recorded at 5.0 ± 2.1 L/min (TV = 500 ± 83 mL, RR = 15 ± 5 bpm). The average predicted MV was 7.0 ± 0.2 L/min. Figure 5 summarizes the recorded trends in MV, TV, and RR as percent of baseline (Figure 2A) and as absolute measurements (Figure 3B) before and after the last dose of propofol. Analysis of these trends revealed that MV decreased transiently, reaching a nadir five minutes after the last dose of propofol at 83% ± 10% of baseline (MV = 7.5 ± 1.0 L/min). The reduction in MV was driven by a significant reduction in TV (and not RR). At the nadir of MV, the recorded TV (TV = 480 ± 50 mL) was 64% ± 5% of baseline TV, 0.501 ± 0.151 < 0.001 vs pre-propofol TV (Figure 2B). The RR at the nadir of MV was significantly increased to 153% ± 5% of baseline (RR = 17 ± 8 bpm, P < 0.01) compared to baseline (RR = 10 ± 4 bpm, P < 0.01). Figure 3B shows that MV decreased after propofol administration compared to baseline ventilation (Figure 3B).

Conclusions

These results show that the RVM can be a useful tool to assess the adequacy of ventilation and the effects of the opioids in endoscopic environments with continuous real-time measurements of MV, TV and RR. Providing data to direct intervention and improve patient safety.

Clinical Implications

- RVM provides continuous non-invasive MV, TV and RR measurements in non-intubated patients.
- RVM provides respiratory data previously unavailable during endoscopic procedures.
- RVM provides quantification of the effect of airway maneuvers in restoring airway patency during endoscopic procedures.
- Continuous respiratory monitoring with the RVM can help clinicians quantify the degree of respiratory depression induced by sedatives and narcotics.
- RVM has the potential to improve ventilatory monitoring and optimize ventilation during endoscopic procedures to help ensure patient safety.

Figure 1: Non-invasive Respiratory Volume Monitor (RVM, Xpior, Respiratory Motion, Inc.) that provides continuous, real-time, non-invasive measurements of MV, TV and RR. Figure 2: Respiratory Trend (A) Minute ventilation (MV), tidal volume (TV) and respiratory rate (RR) relative to baseline (black dashed line) as measured with a Respiratory Volume Monitor (RVM) before and after delivery of propofol (red dashed line). Five minutes prior to the last dose of propofol, MV was 100% of baseline. MV was reduced to 91% of baseline [95%CI 89-93]% and RR was increased to 147% [95%CI 138-158]% 5 minutes after the last dose of propofol. Five minutes prior to delivery of propofol, MV was 100% of baseline. MV was reduced to 83% [95%CI 80-86]% and RR was increased to 153% [95%CI 147-159]% 5 minutes after delivery of propofol (red dashed line). R5 Absolute values of MV, TV, and RR relative to the last dose of propofol (5 minutes post bolus propofol): MV = 370 ± 58 mL, TV = 480 ± 50 mL, and RR = 15 ± 5 bpm. Five minutes prior to the last dose of propofol, TV was 480 ± 46 mL (95%CI 454-506), 15 minutes after the last dose of propofol, TV was 472 ± 47 mL (95%CI 434-510), TV was significantly reduced from baseline to 490 ± 49 mL (95%CI 441-540) and RR was significantly increased from baseline to 17 ± 8 bpm (P < 0.01).

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