Assessment of Respiratory Sufficiency using a Non-Invasive Respiratory Volume Monitor during Upper Endoscopy

Whitney Creed1, Katherine Holley DO1, Daniel Eversole PhD2, Donald Mathews MD1
1: University of Vermont, College of Medicine 2: Respiratory Motion Inc.

Introduction

Over 25 million gastrointestinal endoscopic procedures are performed each year in the United States and these procedures are frequently performed under conscious sedation and require careful monitoring of ventilation. During these procedures, adequate assessment and maintenance of a patient’s airway is often challenging, and this is compounded by: (1) loss of pharyngeal muscle tone caused by anesthetics that can lead to atelectasis and (2) respiratory volume and rate measurements. Anesthesiologists often place patients in a supine position and then use manual interventions such as jaw thrusts and chin lifts, to relieve airway obstruction and ensure adequate ventilation. When conventional monitoring equipment is used, airway maneuvers are often used to treat rather than prevent respiratory compromise – a problem that can be solved with real-time monitoring of respiratory volume. Furthermore, troubleshooting the cause of airway obstruction is especially difficult during endoscopic procedures where patient positioning can impede access and a portion of the airway is compromised by the endoscope. The ability to distinguish between anatomic and physiologic factors that can cause airway obstruction is especially difficult during endoscopic procedures where patient positioning can impede access and a portion of the airway is compromised by the endoscope. The cause of airway obstruction is especially difficult during endoscopic procedures where patient positioning can impede access and a portion of the airway is compromised by the endoscope. Furthermore, troubleshooting the cause of airway obstruction is especially difficult during endoscopic procedures where patient positioning can impede access and a portion of the airway is compromised by the endoscope. The ability to distinguish between anatomic and physiologic factors that can cause airway obstruction is especially difficult during endoscopic procedures where patient positioning can impede access and a portion of the airway is compromised by the endoscope. The cause of airway obstruction is especially difficult during endoscopic procedures where patient positioning can impede access and a portion of the airway is compromised by the endoscope. Furthermore, troubleshooting the cause of airway obstruction is especially difficult during endoscopic procedures where patient positioning can impede access and a portion of the airway is compromised by the endoscope.

During these procedures, adequate assessment and maintenance of a patient’s airway is often challenging, and this is compounded by: (1) loss of pharyngeal muscle tone caused by anesthetics that can lead to atelectasis and (2) respiratory volume and rate measurements. Anesthesiologists often use airway maneuvers, such as chin lifts and jaw thrusts, to relieve airway obstructions and ensure adequate ventilation. When conventional monitoring equipment is used, airway maneuvers are often used to treat rather than prevent respiratory compromise – a problem that can be solved with real-time monitoring of respiratory volume. Furthermore, troubleshooting the cause of airway obstruction is especially difficult during endoscopic procedures where patient positioning can impede access and a portion of the airway is compromised by the endoscope. The ability to distinguish between anatomic and physiologic factors that can cause airway obstruction is especially difficult during endoscopic procedures where patient positioning can impede access and a portion of the airway is compromised by the endoscope. Furthermore, troubleshooting the cause of airway obstruction is especially difficult during endoscopic procedures where patient positioning can impede access and a portion of the airway is compromised by the endoscope. The ability to distinguish between anatomic and physiologic factors that can cause airway obstruction is especially difficult during endoscopic procedures where patient positioning can impede access and a portion of the airway is compromised by the endoscope.

The endoscopic procedures included 15 EGD, 4 ERCP, 4 EUS and 2 gastroscopies. Airway maneuvers were frequently performed under conscious sedation for a total of 25 maneuvers in these 15 patients with the majority of these 15 maneuvers occurring during the initial insertion or removal of the endoscope, 7 immediately followed a previous maneuver, 3 were suction – these 25 were removed from the analysis. Of the remaining 20, there were 11 jaw-thrusts and 9 chin-lifts.

Jaw thrusts increased MV on average, from 4.1 ± 0.7 L/min to 6.1 ± 1.0 L/min (25 ± 6% increase) and chin lifts decreased MV, from 5.0 ± 1.0 L/min to 4.8 ± 1.1 L/min (21 ± 65% decrease) as shown in Figure 2. The increases in MV resulting from these maneuvers were significant in both cases (paired t-tests, p<0.01 and p<0.05, respectively). It is worth noting that jaw thrusts were usually performed after chin-lifts.

The sensitivity and specificity analysis, summarized in Figure 5, show that an alarm set at an RR of 6 bpm would miss more than 83.4% of MV<40% MVBASELINE. A substantial fraction of low MV measurements occurred at normal or even high RRs, and would have remained undetected by RR monitoring alone, as shown in the example shown in Figure 5.

Methods

A bio-inspired impedance RVM (ExsPiron, Respiratory Motion, Waltham, MA) was used to collect continuous digital respiratory traces from an electrode PadSet placed on the thorax (Figure 1). Following IRB approval and informed consent, continuous respiratory data were collected from 25 patients (age: 54.1 ± 20.8±3 years; BMI: 27.6 ± 4.0 kg/m²) undergoing gastroenterology procedures (i.e. colonoscopy, esophagogastroduodenoscopy (EGD) where an airway maneuver may have been helpful). Among the 25 patients, 3 were allergies, 7 immediately followed a previous maneuver, 13 were suction and 1 was a procedure. 7 immediately followed a previous maneuver, 3 were suctions – these 25 were removed from the analysis. Of the remaining 20, there were 11 jaw-thrusts and 9 chin-lifts.

Jaw thrusts increased MV on average, from 4.1 ± 0.7 L/min to 6.1 ± 1.0 L/min (25 ± 6% increase) and chin lifts decreased MV, from 5.0 ± 1.0 L/min to 4.8 ± 1.1 L/min (21 ± 65% decrease) as shown in Figure 2. The increases in MV resulting from these maneuvers were significant in both cases (paired t-tests, p<0.01 and p<0.05, respectively). It is worth noting that jaw thrusts were usually performed after chin-lifts.

Jaw thrusts increased MV on average, from 4.1 ± 0.7 L/min to 6.1 ± 1.0 L/min (25 ± 6% increase) and chin lifts decreased MV, from 5.0 ± 1.0 L/min to 4.8 ± 1.1 L/min (21 ± 65% decrease) as shown in Figure 2. The increases in MV resulting from these maneuvers were significant in both cases (paired t-tests, p<0.01 and p<0.05, respectively). It is worth noting that jaw thrusts were usually performed after chin-lifts.

First-order analysis revealed that, despite MV being a function of RR (MV = RR x TV), there was generally a poor correlation between any MV measurement and its corresponding RR measurement (r = 0.02), as shown in Figure 3.

A substantial fraction of low MV measurements occurred at normal or even high RRs, and would have remained undetected by RR monitoring alone, as shown in the example shown in Figure 5.

Conclusions

• RVM monitors continuous, non-invasive measurements of MV, TV and RR in non-intubated patients, providing respiratory data previously unavailable during endoscopic procedures.

• RVM quantifies the effectiveness of various airway maneuvers in restoring upper airway patency during endoscopic procedures.

• RVM quickly informs caregivers of inadequate ventilation, enabling them to better assess the need for airway maneuvers and avoid over-treatment of benign events and under-recognition of potentially dangerous events when RR is used alone for clinical decision-making.

• RVM has the potential to fill a significant gap in patient monitoring and ventilation to help improve patient safety during endoscopic procedures.

References


3. Du Bois, D. and Du Bois, E.F. (1916) A Formula to Estimate the Approximate Surface Area if Height and Weight Be Known. Archives of Internal Medicine


6. Reference C: Du Bois, D. and Du Bois, E.F. (1916) A Formula to Estimate the Approximate Surface Area if Height and Weight Be Known. Archives of Internal Medicine