The Evaluation of a Non-Invasive Respiratory Monitor in General Surgery Patients Before and After Anesthesia

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Introduction

The administration of anesthetics before general surgery may cause reduction in respiratory effort, however objective and non-invasive continuous monitoring of this respiratory depression is not available with existing technology, posing patients at risk. Benzodiazepines are commonly used for induction in anesthesia for either general anesthesia or monitored anesthesia care (MAC). They are fast acting agents, which can act as central nervous system depressants if and without adequate monitoring, may cause respiratory decompensation. Previously, no technology provided continuous, non-invasive, real-time, accurate measurements of the effect of these medications on ventilation. Capnography, while useful in intubated patients, has little utility in non-intubated patients. Oxygen saturation does not provide a real-time measurement of respiratory status, especially in patients receiving supplemental oxygen. In previous studies, a novel non-invasive Respiratory Volume Monitor (RVM) has demonstrated accurate, continuous, non-invasive measurement of minute ventilation (MV), tidal volume (TV), and respiratory rate (RR). The capability of the RVM to provide objective respiratory data to track the response to specific anesthetics in spontaneously breathing patients is evaluated in this study.

Methods

Under an IRB approved protocol, 50 spontaneously breathing adult patients (mean 46 ± 1.4 range 26-88; BMI: 29 ± 4.8; range 19-46) undergoing elective surgery with monitored anesthesia care (MAC) and general anesthesia (GA) were studied using an implantable RVM system (Eclipse, Respiratory Motion, Inc., Waltham, MA). Continuous digital respiratory traces were collected from 6 electrodes placed on the thorax (Figure 1). RVM data collection began in the pre-operative setting and continued for the duration of the procedure. Medications and administration times were recorded. Thirty of the fifty patients (48 ± 3.1 years, range 21-71; BMI: 30 ± 3.0; range 19-46) received an IV bolus of midazolam of 0.2 mg per minute of anesthesia induction. MV, RR and percentage RM values were calculated from 3-second segments in the 10 minutes prior to and after the RVM was established from respiratory data within 10 minutes prior to the first administration of 3.0 mg midazolam and the effect of the medication was assessed in the 10-15 minutes following administration.

Results

Figure 1: A representative Pulmonary Volume Monitor (PVM) system (Eclipse, Respiratory Motion, Inc., Waltham, MA), that provides accurate, non-invasive measurement of MV, TV, and RM. Figure shows standard electrode placement. The PadSet electrodes are placed on the sternum and neck, the two back pads along the right and left xiphoid area just below the xiphoid.

Figure 2: A histogram trace demonstrating a decrease in MV and TV following midazolam during an intubated patient (of GA). MV and TV decreased from pre-dose values (26.4±5 and 3.0±4) immediately following the bolus dose. MV and TV values were plotted over time measurements of MV, TV and RR were calculated from 3-second segments in the 10 minutes prior to and after the first administrations of 3.0 mg midazolam. The pre-medication baseline was established from respiratory data within 10 minutes prior to the first administration of 3.0 mg midazolam and the effect of the medication was assessed in the 10-15 minutes following administration.

Figure 3: A histogram trace illustrating the change in MV and TV after midazolam during an intubated patient (of GA). MV and TV decreased from pre-dose values (26.4±5 and 3.0±4) immediately following the bolus dose. MV and TV values were plotted over time measurements of MV, TV and RR were calculated from 3-second segments in the 10 minutes prior to and after the first administrations of 3.0 mg midazolam. The pre-medication baseline was established from respiratory data within 10 minutes prior to the first administration of 3.0 mg midazolam and the effect of the medication was assessed in the 10-15 minutes following administration.

Figure 4: A histogram trace demonstrating a decrease in MV and TV following midazolam during an intubated patient (of GA). MV and TV decreased from pre-dose values (26.4±5 and 3.0±4) immediately following the bolus dose. MV and TV values were plotted over time measurements of MV, TV and RR were calculated from 3-second segments in the 10 minutes prior to and after the first administrations of 3.0 mg midazolam. The pre-medication baseline was established from respiratory data within 10 minutes prior to the first administration of 3.0 mg midazolam and the effect of the medication was assessed in the 10-15 minutes following administration.

Figure 5: A histogram trace demonstrating a decrease in MV and TV following midazolam during an intubated patient (of GA). MV and TV decreased from pre-dose values (26.4±5 and 3.0±4) immediately following the bolus dose. MV and TV values were plotted over time measurements of MV, TV and RR were calculated from 3-second segments in the 10 minutes prior to and after the first administrations of 3.0 mg midazolam. The pre-medication baseline was established from respiratory data within 10 minutes prior to the first administration of 3.0 mg midazolam and the effect of the medication was assessed in the 10-15 minutes following administration.

Discussion

Results demonstrate that the RVM can provide objective measurements of MV, TV and RR that have clinical utility in patients during the administration of anesthetic medications. Objective, non-invasive, continuous monitoring of MV, TV and RR using RVM provides accurate, real-time information not demonstrated by other methodologies including pulse oximetry and RR measurements alone. The data also illustrates the RVM’s ability to detect potentially life-threatening suppression of respiratory drive in elderly patients secondary to benzodiazepine administration. Continuous RVM monitoring could improve ventilatory assessment and allow providers to better adjust dosages of delivered anesthetics and improve patient safety. Additional studies are ongoing to further quantify hypventilation following administration of benzodiazepines and other anesthetic medications.

Conclusions

- RVM can provide accurate, continuous, non-invasive, real-time measurements of MV, TV and RR, not available with other methodologies
- RVM can demonstrate, in real time, the effects of anesthetics on respiratory performance and provide critical utility in peri-anesthesia setting
- RVM can differentiate individual responses to standard dosing
- RVM data can provide trends in MV to assist with dosing adjustments and other interventions
- RVM can identify and quantify the effects of benzodiazepines during induction of anesthesia and improve patient safety.