Methods

Equipment and Population: Two cohorts were evaluated. In both cohorts, continuous RVM data (ExSpiron, Respiratory Motion, Inc., Waltham, MA) were collected using an electrode padset placed on the thorax, as shown in Figure 1.

The first cohort comprised of 54 patients (age: 65.2 ±12.1 yrs, BMI: 31.2 ± 6.3 kg/m², 31 females) undergoing elective joint replacement surgery under general anesthesia. In this group, ventilator-delivered MV and ETCO₂ data (Drager Apollo, Andover, MA) were also collected. The study was purely observational and patients were managed on the ventilator according to standard care.

The second cohort was comprised of 39 volunteer subjects (age: 48.5 ± 13.8 yrs; BMI: 27.9 ±8.6 kg/m², 14 females). Continuous RVM and capnography data (Capnostream 20, SmartCapnoLine Plus & Filterline Set, Covidien, Mansfield, MA) were collected in the outpatient setting. Subjects were coached to breathe at varying RRs for 33 min.

Results

The ETCO₂ sensitivity was significantly higher in the intubated patients than in awake, spontaneously breathing patients (-81 ± 9.6° vs. -26 ± 2.6°, p<0.005, paired t-test).

Measured ECO₂ values were systematically higher in intubated & anesthetized patients than in awake patients monitored by either an oral/nasal or in-line sensor (37.2 ± 0.6 vs. 34.7 ± 0.6 mmHg, respectively, p<0.01 for both comparisons, Figure 3B). Furthermore, ECO₂ measurements using an in-line sensor were significantly higher than those from a sampling cannula during normal breathing (36.7±0.7 mmHg vs. 33.7±0.6 mmHg), hyperventilation (40.3±0.6 mmHg vs. 36.8±0.6 mmHg) and hyperventilation (27.2±1.0 mmHg vs. 22.5±1.1 mmHg, p<0.005 for all 3 comparisons).

Conclusions

- While ECO₂ may be a sound indicator of ventilatory adequacy in patients under general anesthesia, its fidelity is greatly reduced in awake, spontaneously breathing patients.
- Confidence in ECO₂ measurements to report small changes in ventilation status for patients on the ventilator in the OR or ICU should not translate to similar confidence in capnography readings in non-intubated patients.
- The low ECO₂ sensitivity to reflect MV changes in spontaneously breathing individuals may reduce the utility of ECO₂ in non-intubated patients.
- As previously reported, we were unable to induce significant hypcapnia in spontaneously breathing subjects despite coached hyperventilation over a period of several minutes due to inherent respiratory drive.
- The use of a sampling nasal cannula with oral/nasal scoop may introduce additional challenges in ECO₂ monitoring, as it likely captures a mixture of expired and ambient air, thus systemically biasing the reported ECO₂ values.