Continuous RVM traces were obtained in the post-anesthesia care unit (PACU) and MV, TV. 132 patients undergoing elective orthopedic surgery were studied using an impedance-based Respiratory Volume Monitor (RVM; ExSpiron, Respiratory Motion, Inc.) that provides continuous, real-time, respiratory volume traces and accurately reports Minute Ventilation (MV), Tidal Volume (TV) and Respiratory Rate (RR) in non-intubated patients. RVM has the potential to detect and quantify apneic events post-operatively.

Methods

- 132 patients undergoing elective orthopedic surgery were studied using an impedance-based RVM system (ExSpiron, Respiratory Motion, Inc., Waltham, MA).
- Continuous RVM traces were obtained in the post-anesthesia care unit (PACU) and MV, TV and RR were calculated from 30-second RVM trace segments.
- An apneic event was defined as no detected breaths for >10 seconds; a hypopneic event was defined as a >50% reduction in tidal volume for >10 sec.
- Predicted MV for each patient (during normal quiet breathing) was calculated based on body surface area.
- "At Risk" MV was defined as MV<40% predicted.
- "Un-Risk" MV was defined as MV<80% predicted.
- The distribution of discrete 30-second based MV measurements was derived during a 10-minute period of non-apneic and a 10 minute period of repetitive apneic/hypopneic breathing in those with POA.

Results

Table 1: Patient Demographics and POA analysis

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Age (yrs)</th>
<th>BMI (kg/m²)</th>
<th>Gender</th>
<th>LOS (hrs)</th>
<th># Events</th>
<th>Event Length (s)</th>
<th>#Events /hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>POA</td>
<td>26 (26%)</td>
<td>68.1 ± 10</td>
<td>27.5 ± 8.0</td>
<td>51% male</td>
<td>28.9 ± 11</td>
<td>25.9 ± 7</td>
<td>17.2 ± 11.6</td>
<td>129 ± 3.8</td>
</tr>
<tr>
<td>No POA</td>
<td>106 (84%)</td>
<td>67.1 ± 9</td>
<td>28.9 ± 7.0</td>
<td>55% male</td>
<td>32.8 ± 11</td>
<td>25.9 ± 7</td>
<td>12.3 ± 11.2</td>
<td>35 ± 3.8</td>
</tr>
</tbody>
</table>

Table 2. Percent of MV measurements in "Non-Apneic", "At-Risk" and "Un-Safe" zones

<table>
<thead>
<tr>
<th>Zone</th>
<th>#Measurements</th>
<th>% of Total MV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Apneic</td>
<td>96%</td>
<td>94%</td>
</tr>
<tr>
<td>&quot;At-Risk&quot;</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>&quot;Un-Safe&quot;</td>
<td>9%</td>
<td>1%</td>
</tr>
</tbody>
</table>

Figure 6: A non-invasive Respiratory Volume Monitor provides continuous, real-time, non-invasive measurements of MV, TV and RR. Figure shows standard electrode placement. One electrode is placed at the sternal notch, another is placed on the xiphoid and the third is placed in the right mid-axillary line at the level of the xiphoid.

Figure 7: Timeline of 10-minute periods with the most POA events (range: 7-50 events/hr). Averaged across all POA patients, the number of events in the “worst” hour was 22.3 ± 2.3. Multi-factor analysis of variance (MANOVA) found no effect of age, gender, and BMI in differentiating patients with POA events from those without (p>0.05 for all factors).

Figure 8: Averaged across all POA patients, the number of events in the "worst" hour was 22.3 ± 2.3. Multi-factor analysis of variance (MANOVA) found no effect of age, gender, and BMI in differentiating patients with POA events from those without (p>0.05 for all factors).

Conclusions

- RVM provides continuous non-invasive, real-time measurements in non-intubated patients that quantify respiration.
- RVM measurement of MV may be a clinically useful way to quantify the impact of POA.
- Continuous RVM detects apneic/hypopneic episodes and quantifies the associated reduction in MV caused by POA.
- Neither a pre-operative diagnosis nor traditional risk factors for OSA (age, sex, BMI) are predictive of POA.
- Close monitoring with RVM may help further identify at risk patients and improve outcomes.
- RVM provides measurements previously unavailable in this population that will allow health care providers to assess and quantify ventilation and POA, improve communication across the continuum of care and improve patient safety for transfer to the floor or other unit.