Falsely elevated tidal volumes in an infant lung associated with circuit compliance changes following anesthesia machine pre-use self-test.

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Background

- Anesthesia machines deliver desired tidal volumes (TVs) more accurately by measuring breathing circuit compliance during a pre-use self-test and then incorporating this value when calculating expired TV.
- The initial compliance value is utilized in TV calculation regardless of whether the compliance of the breathing circuit changes during a case, as happens when corrugated circuit tubing is manually expanded after the pre-use self-test but before patient use.
- The aim of this study was to determine if there is a significant difference in reported TVs during pressure controlled ventilation (PCV) for a completely expanded pediatric breathing circuit when using circuit compliance values measured from a non-expanded circuit versus an expanded circuit.

Methods

- Using Drager Apollo and Datex-Ohmeda anesthesia machines, the pre-use self-test was performed while connected to a non-expanded (as delivered) pediatric breathing circuit (Westmed, Tucson, AZ).
- The breathing circuit was then fully expanded and connected to an infant or adult test lung (Maquet Model 190/191, Siemens, Germany), which was ventilated in the PCV mode at pressure settings of 18/4, rate of 24 (infant) or 15 (adult), and I:E ratio 1:2. Measured expired TV was recorded.
- The anesthesia machine was reset and the pre-use self-test was subsequently performed while connected to the now expanded circuit.
- Reported TVs were then re-recorded on the expanded circuit using the same ventilator settings.

Results

- The reported TV was significantly higher for the infant test lung when delivered with the non-expanded circuit compliance vs. expanded circuit (p<.0001).

<table>
<thead>
<tr>
<th>Machine</th>
<th>Average Compliance Non-Expanded Tubing (cL/cm H2O)</th>
<th>Average TV for Expanded Circuit with Non-Expanded Compliance (18/4)</th>
<th>Average Compliance Expanded Tubing (cL/cm H2O)</th>
<th>Average TV for Expanded Circuit with Expanded Compliance (18/4)</th>
<th>t-Test for Average TV: Two-Sample Assuming Equal Variances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drager Apollo (n =4)</td>
<td>0.4</td>
<td>15.5</td>
<td>1</td>
<td>8.75</td>
<td></td>
</tr>
<tr>
<td>Datex -Ohmeda S5 (n = 5)</td>
<td>0.43</td>
<td>16.6</td>
<td>0.95</td>
<td>8.2</td>
<td></td>
</tr>
<tr>
<td>Datex-Ohmeda - Alisys (n=2)</td>
<td>0.46</td>
<td>22</td>
<td>1.02</td>
<td>13.5</td>
<td></td>
</tr>
<tr>
<td>All Machines (n = 11)</td>
<td>0.42</td>
<td>17.18</td>
<td>0.98</td>
<td>9.36</td>
<td>P(T&lt;=t) one-tail = 0.0000006</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.04</td>
<td>2.89</td>
<td>0.06</td>
<td>2.46</td>
<td></td>
</tr>
</tbody>
</table>

- The mean increase in reported TV for the infant test lung was 88% compared to 2.8% for the adult test lung.

- The reported TV was not significantly higher for the adult test lung when delivered with the non-expanded circuit compliance vs. expanded circuit (p=.35).

Conclusions

- The anesthesia machine assumes that circuit compliance remains constant in its calculations of expired TV, but when breathing circuit tubing is manually expanded, the circuit compliance increases and alters the reported TV.
- Performing a pre-use self-test on a non-expanded pediatric circuit that is then expanded leads to falsely elevated reported TVs in infants during PCV.
- This can be avoided by expanding the breathing circuit tubing to the length which will be used during a case prior to performing the anesthesia machine check.

Implications

- Simply attaching a non-expanded circuit to the anesthesia machine and then performing the pre-use self-test is insufficient and can potentially be harmful to the patient.