Analysis of Oxygen-Conserving Delivery Methods
Jason King, Lara Brewer, Ph.D., Soeren Hoehne, Dipl. Ing., Joseph Orr, Ph.D.
Department of Anesthesiology, University of Utah, Salt Lake City, UT

Introduction
• Oxygen therapy is needed to help treat patients with a variety of medical conditions.
• Oxygen conservation methods can be used to deliver oxygen only during the beginning of inspiration.
• This can provide the same medical benefits as constant oxygen delivery while using less oxygen and reducing costs.
• These conserving methods include intermittent flow devices and reservoir cannulas [1].
• These devices have not yet been optimized for use in children [2].
• Our goal was to optimize a pulse flow and reservoir cannula device for use in children age 5 years and under.

Methods

Pulse Flow Method:
A pump is used to draw oxygen from a storage bag. The oxygen is pumped through a valve which delivers the oxygen to patient during inspiration, and back to the storage bag during expiration.

Reservoir Method:
A nasal cannula was modified by adding a thin plastic (~1mil) reservoir which holds approximately 20 mL of air. Oxygen is delivered to this cannula at a constant flow rate. The oxygen fills the reservoir during expiration and is inspired during inspiration.

Each conservation method was compared to the standard method of delivering oxygen at a constant flow rate through an unmodified nasal cannula.

This was done in a bench test delivering oxygen at rates of 250-2000 mL/min to a model child sized face attached to a test lung.

The concentration of oxygen in the test lung was measured.

The % savings was calculated as the % difference between the oxygen needed to reach a given oxygen concentration using the normal and conservation methods.

This was done for breathing patterns modeling that of children age 5 years, 2 years, and 6 months (Table 1).

Table 1: The breath rate, tidal volume, and peak inspiratory flow rate used for each model in this study.

<table>
<thead>
<tr>
<th>Age</th>
<th>Breath Rate (breaths/min)</th>
<th>Tidal Volume (mL)</th>
<th>Peak Inspiratory Flow (L/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Years</td>
<td>20</td>
<td>100</td>
<td>9.3</td>
</tr>
<tr>
<td>2 Years</td>
<td>30</td>
<td>50</td>
<td>7.2</td>
</tr>
<tr>
<td>6 Months</td>
<td>40</td>
<td>33</td>
<td>6.3</td>
</tr>
</tbody>
</table>

Results
For each breathing pattern the percentage of oxygen saved using the conservation methods as compared to the standard method was calculated (Fig. 1-3).

Discussion
• Overall the oxygen saving using the pulse flow method were much greater than for the reservoir method, especially for high oxygen flow rates.
• The pulse flow method was limited in the 6 month old model by the flow rate of oxygen that could be delivered by the pump, as it was not able to deliver more than ~1000 mL of oxygen during the inspiration time.
• Using a pump that can deliver a higher flow rate of oxygen may make the pulse flow method more effective.
• Disadvantages of the pulse flow method are that it requires electricity and is more complex which may make it more difficult to implement.
• The reservoir method was effective for low oxygen flow rates of approximately 500 mL/min, but as the flow rate increased the % savings decreased.
• One advantage of the reservoir method is that it is simple and low cost, as it does not require any equipment other than the reservoir cannula.
• These oxygen conserving methods may be used when oxygen supplies are limited to reduce costs and allow patients to be treated for a longer period of time.

References