Analysis of Oxygen-Conserving Delivery Methods

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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.

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

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### 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 the 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>
<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>

### 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
