Analysis of Oxygen-Conserving Delivery Methods

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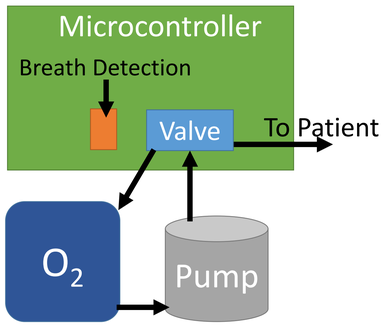
Introduction

- 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.

Age	Breath Rate (breaths/min)	Tidal Volume (mL)	Peak Inspiratory Flow (L/min)
5 Years	20	100	9.3
2 Years	30	50	7.2
6 Months	40	33	6.3

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).

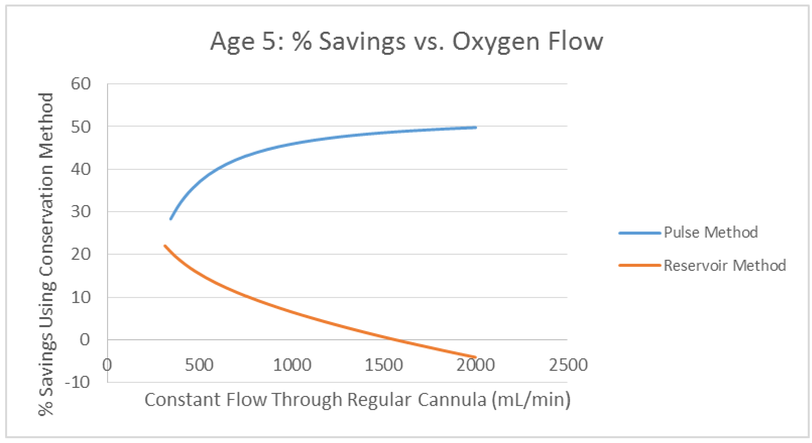


Figure 1: Percent oxygen savings for a range of oxygen flow rates for breathing pattern modeling a 5 year old patient.

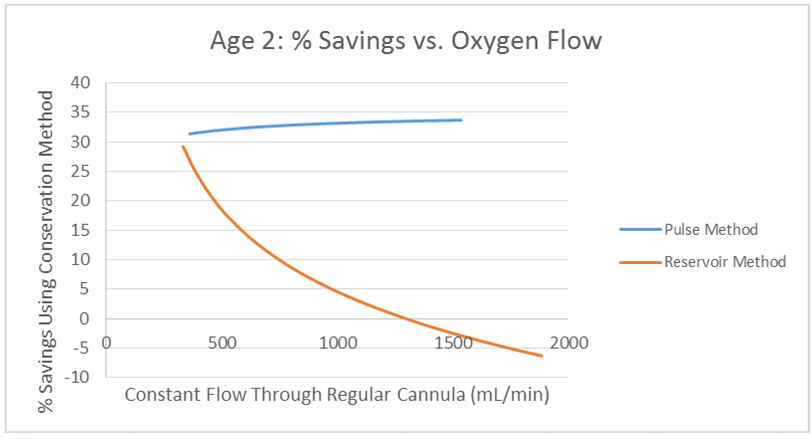


Figure 2: Percent oxygen savings for a range of oxygen flow rates for breathing pattern modeling a 2 year old patient.

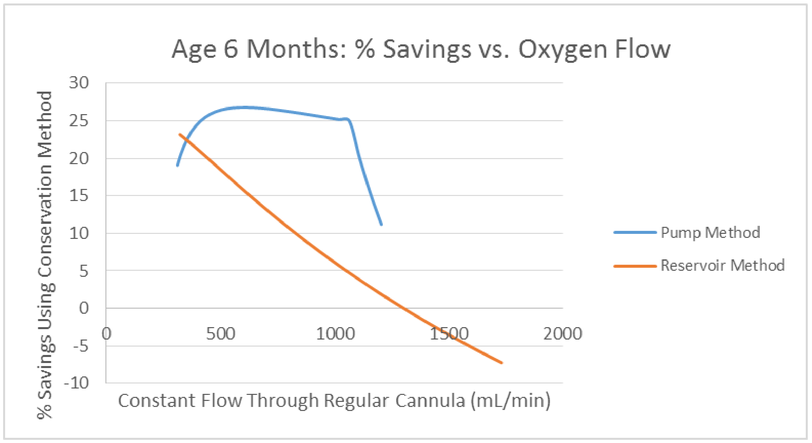


Figure 1: Percent oxygen savings for a range of oxygen flow rates for breathing pattern modeling a 6 month old patient.

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

[1] R. McCoy, "Oxygen-Conserving Techniques and Devices," Respiratory Care, vol. 45, no. 1, Jan. 2000.

[2] G. Wu, A. Wollen, R. M. Diblasi, S. Himley, E. Saxon, G. Austin, J. Delarosa, R. Izadnegahdar, A. S. Ginsburg, and D. Zehrung, "Reservoir Cannulas for Pediatric Oxygen Therapy: A Proof-of-Concept Study," International Journal of Pediatrics, vol. 2016, pp. 1–8, 2016.