Evaluation of Molecular Sieve Oxygen Concentrators at Varying Flow Rates

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Abstract
Long term oxygen therapy (LTOT) for patients with hypoxic chronic bronchitis and emphysema is critically important; it has been shown to positively impact longevity and reduces repeat hospital admission rates. Correspondingly, the technical performance of each device is of great import. In this missive, the authors purport to evaluate the FIO2 levels of home oxygen concentrators at various flow rates from two to five liters per minute. The accuracy of the oxygen concentrator, as compared to the manufacturer's claims, was determined.

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Evaluation of Molecular Sieve Oxygen Concentrators at Varying Flow Rates
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Abstract:

Background: Long-term oxygen therapy (LTOT) for patients with hypoxic chronic bronchitis and emphysema is critically important. It has been shown to positively impact longevity and reduces hospital admission rates.

Methods: The oxygen concentrators used in this study were Invacare Perfecto 2, Respironics Everflow, Respironics Millenium, and the Airsep Visionaire. In order to simulate inhalation and exhalation, a 2010 Hans Rudolph Inc. Series 1101 Breathing Simulator was attached to a Laerdal VitalSim® manikin using large bore corrugated tubing and two one-way valves for isolated input and output. A nasal cannula was placed in a Hudson RCL galvanic fuel cell oxygen analyzer, calibrated every 15 hours to room air and 100% oxygen to measure FiO2 delivered to the carina. One nasal cannula was connected to each of the aforementioned concentrators and baseline respiratory values were as follows: Raw = 3 cmH2O/L/sec, Cst = 80 mL/cmH2O, Peak flow 60 LPM. The raw sensor was calibrated by a measurement of baseline (21%) and pure (100%) concentration of oxygen. Following measurement of the Invacare platinum, the Hans Rudolph breathing simulator restored the Laerdal VitalSim® to baseline with a 21% oxygen flush, ensuring that baseline oxygen concentrations were reached before the following nasal cannula and concentrator were tested. The same measurement technique was repeated for each of the 5 concentrators with a new flow rate of 2, 3.5, and 5 LPM for 15 hours at each flow rate.

Results: The FiO2 for each concentrator evaluated remained consistent for each flow rate, with the standard deviation of the measurements slightly more than the resolution of the oxygen analyzer, which reported FiO2 percent to 1%. The reported standard deviations were equivalent to the expected detector deviation (±0.5%) and were thus negligible. Measured standard deviations were all less than 0.6%. Although some minor variation around the mean output was observed, it was clinically negligible.

Conclusions: Given the impact on at-home care-giving and the lack of literature that is both available and current, the fraction of inspired oxygen provided by home oxygen concentrators is a concern of great importance.

Introduction:

Long-term oxygen therapy (LTOT) for patients with hypoxic chronic bronchitis and emphysema is critically important. It has been shown to positively impact longevity. While it cannot prevent deterioration of lung function, when titrated appropriately, oxygen therapy stabilizes arterial blood gases. PaO2 and PaCO2 reduces polycythemia and reduces risks for pulmonary arterial hypertension. Oxygen therapy is a cornerstone of LTOT, but the standard deviation of the data were less than 0.5% in all cases. The maximum variance for any concentrator did not exceed a deviation of 2% FiO2 from the mean.

In this missive, the authors purport to evaluate the FiO2 levels of home oxygen concentrators at flow rates of 2, 3.5 and 5 LPM. In conjunction, the accuracy of the sensor was confirmed by a measurement of baseline (21%) and pure (100%) concentration of oxygen. Following measurement of the Invacare platinum, the Hans Rudolph breathing simulator restored the Laerdal VitalSim® to baseline with a 21% oxygen flush, ensuring that baseline oxygen concentrations were reached before the following nasal cannula and concentrator were tested. The same measurement technique was repeated for each of the 5 concentrators with a new flow rate of 2, 3.5, and 5 LPM for 15 hours at each flow rate.

Before testing the FiO2 and flow rate, one nasal cannula was connected to each concentrator and set at a flow rate of 2 LPM for 30 minutes. This delay allowed for appropriate damping of the transient response, and assured stabilization of FiO2 and flow rates prior to the collection of data. Over the course of 15 hours, a nasal cannula was connected to the manikin so that the Laerdal VitalSim® manikin equilibration took place for 3 minutes prior to the sampling of FiO2 and flow rate at the carina. Following measurement of the Invacare platinum, the Hans Rudolph breathing simulator restored the Laerdal VitalSim® to baseline with a 21% oxygen flush, ensuring that baseline oxygen concentrations were reached before the following nasal cannula and concentrator were tested. The same measurement technique was repeated for each of the 5 concentrators with a new flow rate of 2, 3.5, and 5 LPM for 15 hours at each flow rate.

Before the measurement of each flow rate, the galvanic fuel cell oxygen analyzer was calibrated by a measurement of baseline (21%) and pure (100%) concentration of oxygen and the appropriate response recorded. Check flow rates used.

Results:

All of the oxygen concentrators showed clinically insignificant departures from the anticipated value at all flow rates; a larger variance was measured at larger flow rates, but the standard deviation of the data were less than 0.5% in all cases. The maximum variance for any concentrator did not exceed a deviation of 2% FiO2 from the mean.

Conclusions:

Modern oxygen concentrators demonstrate excellent long-term reliability, as shown in the presented data. Given clinically insignificant deviations of FiO2 observed, long-term oxygen therapy remains an effective outpatient treatment modality with reliable device support to ensure positive patient outcomes during the in-home treatment of hypoxic chronic bronchitis and emphysema.

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References:


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Materials and Methods:

In order to simulate inhalation and exhalation, a 2010 Hans Rudolph, Inc. Series 1101 Breathing Simulator was attached to a Laerdal VitalSim® manikin using large bore corrugated tubing and two one-way valves for isolated input and output. A raw sensor was placed in a Hudson RCL galvanic fuel cell oxygen analyzer, calibrated once a day to room air and 100% oxygen to measure FiO2 delivered to the carina. One nasal cannula was connected to each of the following concentrators: Invacare Perfecto 2, Respironics Everflow, Respironics Millenium, and the Airsep Visionaire. Baseline respiratory values were as follows: Raw = 3 cmH2O/L/sec, Cst = 80 mL/cmH2O, Peak flow 60 LPM. The reported standard deviations were equivalent to the expected detector deviation (±0.5%) and were thus negligible. Measured standard deviations were all less than 0.6%. Although some minor variation around the mean output was observed, it was clinically negligible.

The four measured oxygen concentrators showed clinically negligible variance of delivered FiO2. It is reasonable to assume that the in-home use of oxygen concentrators is a valuable tool for the treatment of patients requiring increased arterial oxygen concentrations.

Conclusion:

The results are available and current, the fraction of inspired oxygen provided by home oxygen concentrators is a concern of great importance to the aesculapian community at large and for patients in particular.