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Evaluation of Molecular Sieve Oxygen Concentrators at Varying Flow Rates

Grace Hofmann
Kelsey Braden
Leo Ivey
Lonny Ashworth
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Grace Hofmann, Kelsey Braden, Leo Ivey, Lonny Ashworth Med, RRT, FAARC
Boise State University, Boise, ID

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 repeat hospital admission rates from exacerbations. One nasal cannula was connected to each of the aforementioned concentrators. The accuracy of the oxygen concentrator, as compared to the manufacturer’s claims, was determined.

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 new sensor 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 concentrator. Baseline respiratory values were as follows: RV 3 cm H2O/L/sec, Cst 60 mL/cm H2O, Raw 0.7 cm H2O/L/sec, Raw 80 mL/sec, FEV1 2 LPM, FEV1 3.5 LPM, and FEV1 5 LPM. The oxygen concentrators were sampled every 5 minutes, for 15 hours at each flow rate (2.5, 3.5, and 5.5 LPM).

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 less than 0.5%. Although some minor variation among the concentrators was observed, it was clinically negligible.

Conclusion: 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.

Introduction:

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 topic of great import to the aerosolized community at large and by patients in particular.

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,4,14,15 ameliorates pulmonary arterial hypertension,14,15 and reduces hospital admissions from exacerbations.3,14,15 Studies have confirmed that patients receive maximum benefit with continuous oxygen therapy.15,38,40 Baseline respiratory values were as follows: Raw 3 cm H2O/L/sec, Cst 60 mL/cm H2O, Raw 80 mL/sec, FEV1 2 LPM, FEV1 3.5 LPM, and FEV1 5 LPM. The oxygen concentrators were sampled every 5 minutes, for 15 hours at each flow rate (2.5, 3.5, and 5.5 LPM).

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 less than 0.5%. Although some minor variation among the concentrators was observed, it was clinically negligible.

Conclusion:

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.

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 new 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 cm H2O/L/sec, Cst 60 mL H2O, respiratory rate 20 breaths/minute, percent inline 20%, flow effort SHORTIE and an effort slope of 20. These values reflect a normal spontaneous breathing pattern.4 The functional dependence of oxygen concentration on oxygen flow rate was measured; each flow rate was evaluated over a period of 15 hours.2 oxygen concentration was sampled every 15 minutes at a flow rate of 2.3.5, and 5 LPM.

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 nose of 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 5.5 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 was 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 this study. The only clinically significant 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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