

Titrating Oxygen Requirements During Exercise

Evaluation of a Standardized Single Walk Test Protocol

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BACKGROUND: Oxygen supplementation for exercise-induced hypoxemia is a common clinical practice that improves exercise tolerance. However, we know of no standardized exercise oxygen titration protocol using a single walk test. We report our experience with a protocol developed in our laboratory.

METHODS: Our protocol is based on the 6-min walk test (6MWT). Pulse oximetry readings (oxygen saturation [SpO_2]) are monitored, and supplemental oxygen is added in 2 L/min increments to keep $SpO_2 > 88\%$. This continues for at least 6 min of walking with the SpO_2 remaining $> 88\%$ for at least 3 min. The records of consecutive patients over 4 months undergoing this procedure were reviewed for test performance, oxygen titration results, and adverse events.

RESULTS: Two hundred twenty-two patients were tested; only two prematurely terminated the protocol because of intractable dyspnea. One hundred fifty-six patients (38%) required oxygen supplementation, with the first titration most commonly occurring between 1 and 2 min of walking. Nine of the patients had the first titration after 5 min of walking. The average test duration was 7 min (maximum, 15 min). The average number of titrations was 2.2 (maximum six). Sixteen patients could not maintain $SpO_2 > 88\%$ for 3 min despite administration of 15 L/min of supplemental oxygen (maximal dose).

CONCLUSIONS: Our protocol was easily performed as a modification of a standard 6MWT with no serious adverse events. Because it is based on a widely accepted measurement of functional capabilities, and because it determined a stable final oxygen dose for ≥ 3 min of walking in most patients, we believe this protocol can be easily adapted for clinical use.

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KEY WORDS: 6-min walk; desaturation; exertional desaturation; oxygen titration; titration protocol

ABBREVIATIONS: 6MWT = 6-min walk test; SpO_2 = oxygen saturation measured by pulse oximetry

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Exertional desaturation, defined as a decrease in measured hemoglobin oxygen saturation to 88% or less during exercise,¹⁻³ is common among patients with a wide range of respiratory diseases.⁴⁻⁶ Numerous studies have associated exertional desaturation with reduced exercise tolerance, accelerated reduction in FEV₁, and increased mortality in patients with chronic lung disease.^{2,7-10} Although providing long-term oxygen supplementation for persistent resting desaturation prolongs survival,¹¹ the long-term benefit of providing oxygen supplementation for patients with exertion-only desaturation is currently debated.^{6,9,12-14} Nevertheless, providing supplemental oxygen during exercise for such patients is associated with improvements in walking distance and reduced exercise-related dyspnea.¹⁵ As a consequence, hemoglobin oxygen saturation \leq 88% with exercise is currently considered an indication for a reimbursable prescription for supplemental oxygen use by the Centers of Medicare & Medicaid Services¹⁶ and contributed substantially to the $>$ \$1.4 billion in Medicare oxygen spending in 2015.¹⁷

Currently, there are no standardized procedures for determining supplementary exertional oxygen needs. Although one interesting approach uses a proprietary algorithm to predict exertional oxygen needs from a single walk test, this strategy appears to overestimate oxygen needs and has not been validated in other centers.¹⁸ The more common approach is to use multiple sequential exercise tests with progressive increases in supplemental oxygen until hemoglobin oxygen saturation remains $>$ 88% for the duration of the

test. This approach, however, is time-consuming and often difficult for patients with chronic lung disease to complete.

The type of exercise test to assess exercise desaturation is also not standardized. Choices include formal cardiopulmonary exercise testing and a variety of walk test protocols.^{1,4,19,20} Among these, the 6-min walk test (6MWT) has been found to correlate best with daily functional performance, has a high sensitivity for detecting exertional desaturation compared with other tests, including cycle ergometry,^{1,21} and has international guidelines describing test performance that include assessing for exercise desaturation.^{1,4} Exertional desaturation during the 6MWT has also been shown to provide valuable information regarding disease severity, impairment of daily physical activity, and prognosis across a wide range of cardiorespiratory diseases, including COPD, interstitial lung disease, pulmonary fibrosis, and pulmonary hypertension,^{1,4,8,10,22,23} as well as the timing of lung transplantation.²⁴⁻²⁶

In our pulmonary function laboratory, we have developed a standardized modification of the 6MWT to assess supplemental oxygen requirements with exercise in a single walk test. Importantly, because this walk test may last longer than 6 min and often requires clinician interventions, it should not be used as a substitute for the standard 6MWT to assess functional status. In this report, we describe this protocol and our experience using it in patients with a variety of chronic lung diseases over a 4-month period.

Methods

With approval from the Duke Institutional Review Board (Pro00085795), we retrospectively analyzed data from all oxygen titration tests completed at our institution between October 2016 and January 2017. Patient information and test data were recorded by the respiratory therapists conducting the oxygen titration test on a standardized form (e-Fig 1).

Oxygen Titration Test Protocol

Prior to the start of the test, a forehead pulse oximeter (Masimo SET M-LNCS TF-I/Rad-5v, Masimo Corp) is placed on the patient, and resting heart rate and room air SPO₂ are recorded from the device, which is either hung around the patient's neck from a lanyard or placed in a belt with a pouch to carry the oximeter. Supplemental continuous oxygen is supplied as needed to ensure a resting SPO₂ $>$ 88%. A standard nasal oxygen cannula (AirLife, CareFusion) is used for flows \leq 6 L/min, and a wide-bore nasal cannula (Salter Labs) is used for higher flows. The patient is stabilized on any supplemental oxygen for 5 min prior to the start of the oxygen titration test to establish resting supplemental oxygen demands.

All oxygen titration tests are conducted on a flat standard 30-m course with cones at each end and wall markings at 1-m intervals as

recommended by the European Respiratory Society/American Thoracic Society.⁴ Patients are instructed to walk at "a vigorous pace or one that they can maintain for at least 6 min." If necessary, oxygen is supplied by a portable standard E-cylinder on wheels, which is pulled by the patient. Time is measured on a stopwatch, with the testing time started when the patient begins to walk. The respiratory technician performing the test is stationed near the half way point on the course to continuously monitor the patient without interfering with the walking pace. The technician walks directly with the patient only if it is believed necessary as a safety precaution against falls. Heart rate, SPO₂ (read visually from the oximeter device), and any supplemental oxygen flow (L/min) are recorded every minute, or sooner with any significant clinical change. The minimum duration of testing is 6 min. If no desaturation occurs (SPO₂ remains $>$ 88%) for the duration of testing, the test concludes at 6 min.

If desaturation occurs during testing (SPO₂ \leq 88% by oximeter probe), the patient and timer are stopped and supplemental oxygen is delivered through a nasal cannula at an increase of 2 L/min greater than the current oxygen dose until SPO₂ is \geq 90%. Patients are allowed to stabilize at this level for 2 min and then the timer is restarted and walking resumes. This process is repeated as necessary until at least

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