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ORIGINAL ARTICLE

Concordance between hypoxic challenge testing and predictive equations for hypoxic flight assessment in chronic obstructive pulmonary disease patients prior to air travel

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KEYWORDS

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Flight;
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Predictive

Abstract *Background:* Patients with chronic pulmonary diseases are at increased risk of hypoxemia when traveling by air. Screening guidelines, predictive equations based on ground level measurements and altitude simulation laboratory procedures have been recommended for determining risk but have not been rigorously evaluated and compared. Therefore we aimed to explore the correlation and concordance between hypoxic challenge testing and predictive equations for assessment and prediction of in-flight hypoxia in chronic obstructive pulmonary disease patients prior to air travel.

Design: Comparative study.

Methods: Thirty five chronic obstructive pulmonary disease patients were studied. Spirometry data were recorded prior to hypoxic inhalation test and blood gases were analyzed before and after hypoxic inhalation and when $SpO_2 \leqslant 85\%$. Hypoxic inhalation test was performed using the ventimask method. The PaO_2 at altitude was estimated using four published predictive equations, which use values of PaO_2 (ground) and lung function measurements to predict altitude PaO_2. Results were interpreted using the BTS recommendations for prescription of in-flight oxygen and to assess agreement between hypoxic inhalation test results and each of the predictive equations.

Results: Ground PaO_2 was significantly decreased following hypoxic inhalation test.

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Conclusions: The present study supports on-HCT as a reliable, on-invasive and continuous methods determining the requirement for in-flight O_2 are relatively constant. Predictive equations considerably overestimate the need for in-flight O_2 compared to hypoxic inhalation test. Predictive equations are cheap, readily available methods of flight assessment, but this study shows poor agreement between their predictions and the measured individual hypoxic responses during HCT.

Introduction

Hypoxic challenge testing (HCT) is also known as (hypoxia altitude simulation test, high altitude simulation test or hypoxic inhalation test).

Hypobaric hypoxia develops as a result of the inverse relationship between oxygen partial pressure and altitude, resulting in a decrease in the partial pressure of alveolar oxygen (PaO_2) during ascent, and leads to reduced oxygenation of arterial blood. This occurs during travel in a pressurized aircraft cabin as ambient pressure is decreased. Commercial aircraft typically cruise at up to 40,000 feet (~12,000 m). Engineering and financial constraints do not allow pressurization to sea level, hence the aircraft cabin is pressurized to a maximum altitude of 8000 feet (2438 m), which, with respect to oxygenation, is equivalent to breathing 15% oxygen (O_2) at sea level [1] Increasing numbers of people with chronic respiratory diseases wish to travel but may be unaware that the pressurized cabin of a modern aircraft may be a physiologically challenging environment to those with lung disease [2].

There is a wide variation in the individual response to the hypobaric environment, the mechanisms of which are not clearly understood [3]. Clinical manifestations of hypobaric hypoxia include euphoria, headache, fatigue, lassitude, dizziness and in extreme cases, if untreated can lead to unconsciousness and even death [3].

Those patients who are hypoxic at sea level are thought to be at greater risk of experiencing a decrease in PaO_2 to a critical level and may develop severe hypoxia during flight [4].

The British Thoracic Society (BTS) recommend that a preflight assessment be considered in all patients with respiratory disease prior to air travel, to predict the likelihood of respiratory problems [5]. Hypobaric chambers are the 'gold standard' in flight assessment, but they are expensive and not widely available. Alternative methods used in clinical practice include hypoxic challenge test (HCT) and predictive equations [6].

There is insufficient information available to establish the extent to which either method is used, but it seems reasonable to assume that predictive equations are used more frequently by clinicians (e.g. in primary health care) who do not have access to the facilities required to perform an HCT.

The aim of this retrospective comparative study was to explore the correlation and concordance between hypoxic challenge testing and predictive equations for assessment and prediction of in-flight hypoxia in chronic obstructive pulmonary disease patients prior to air travel.

Methods

This study is conducted as a nested study and a continuation of study done by investigator was published previously on 2011 [7], where written consent was obtained for all participants, and all participants were clinically stable at the time of study.

Thirty-five volunteer participants had a clinical diagnosis of COPD according to the GOLD criteria, a FEV1/FVC ratio of less than 70% in a patient with a postbronchodilator FEV1 of less than 80% of the predicted value [8]. Severity is further stratified based on symptoms and FEV1 values, where all participants fulfilled the following inclusion criteria: Volunteer participants diagnosed COPD based on usual clinical and functional grounds; a best recorded ratio of forced expiratory volume in 1st to forced vital capacity (FEV_1/FVC) of less than 0.7, or a best recorded FEV_1 that ranged from 50% to 80% of the predicted value, in a stable state of the disease, free of acute exacerbation which excluded any one who has an evidence of ischemic heart diseases, associated lung diseases such as (asthma, interstitial lung diseases, bronchiectasis, pulmonary hypertension, lung cancer), obesity {defined by body mass index (BMI) $\geqslant$ 30 kg/m^2}, evidence of restrictive lung disease, or participants with other severe diseases that could influence survival (hepatic cirrhosis, renal failure), uncontrolled diabetes mellitus. Finally participants who required O_2 therapy were excluded and of no concept for the study.

All participants were informed of any risks and discomfort associated with the experiment, and written consent was obtained.

As part of the characterization procedures, resting pulmonary function testing, blood pressure, heart rate, respiratory rate were recorded and inhaled hypoxic gases were carried out in all participants.

According to the standardized operational procedures for pulmonary function testing, a minimum of 3 and a maximum of 5 tests were performed in each participant by (KoKo PFT Spirometer PC-Based Office Spirometry, Ferraris Respiratory, Inc USA). The best spirometric maneuvers were recorded for analyses.

Sufficient rest time was assured between test of spirometry and hypoxic challenge test (30 min) and until the first test baseline measurements were recorded, Arterial blood sample was drawn from the participant while breathing ambient air, in the morning from 9 to 12 Am, after a 15 min resting period in the supine position for arterial blood gas.

Arterial blood was withdrawn from the radial artery with a 25-gauge needle attached to a heparinized syringe and immediately analyzed with a blood gas analyzer (ABL 700; Radiometer; Copenhagen, Denmark).

All participants involved in the present study had performed (plain X-ray chest PA and RT lateral views), fasting and post prandial blood sugar, renal and liver laboratory tests and ECG.