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Clinical usefulness

Hypoxic Challenge Test for airflight in children with respiratory disease

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EDUCATIONAL AIMS:

The reader will come to appreciate how

- To assess the need for supplemental oxygen during airflight
- To know who to test.

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SUMMARY

During airflight, cabins are pressurised to 8000 ft (2438m) leading to an effective FiO_2 of 0.15. This leads to a fall in oxygen saturation in all passengers, and especially those with underlying lung disease. The hypoxic challenge test using a body plethysmograph can predict a need for supplemental oxygen during airflight, and the process is described.

INTRODUCTION

Commercial aeroplanes fly at an altitude of 30,000-40,000 feet (9144-12192 m), which would result in a fraction of inspired oxygen (FiO_2) of only 0.04 (as opposed to usual 0.21 at sea level) [1]. To counteract this, commercial air flight cabins are pressurised to 1525-2438 m (5,000-8000 feet), so that the partial pressure of oxygen falls to the equivalent of breathing 15% oxygen at sea level. Oxygen saturations drop by around 4% in healthy individuals [2], and this can cause hypoxia in pre-disposed individuals, especially those with pulmonary disease. Resting sea level oxygen saturations are a poor predictor of hypoxaemia during flight [3–7], hence the need for a predictive test [8]. The most common test used is the hypoxic challenge test (HCT), often called the 'fitness to fly' test, which helps determine who needs in-flight supplemental oxygen.

WHAT IS THE TEST AND HOW IS IT DONE?

HYPOXIC CHALLENGE TEST IN A PLETHYSMOGRAPH CHAMBER

The closest simulation to airflight would be to sit in a hypobaric chamber, as this reproduces both the reduction in atmospheric pressure and inspired oxygen. However, these chambers are not readily available hence the development of the HCT. It should be immediately pointed out that the recommended HCT has still not been compared with actual in-flight measurements, and will not take into account the dry air, noise, vibrations and disrupted sleep patterns of a real flight.

The infant/child and an adult (usually the parent/carer) sit inside a sealed body plethysmograph, with the child on the carer's lap (Figure 1). It is important to check first that the carer is not claustrophobic, and also that they are themselves healthy with no underlying cardiorespiratory condition, so that they will not be affected by the low FiO_2. A standard pulse oximeter with the correct sized probe is attached to the infant's foot or hand. Our centre also measures the transcutaneous pCO_2, although that is probably more relevant in adults with chronic obstructive pulmonary disease; nevertheless if it falls it can indicate a baby is hyperventilating in order to compensate for the hypoxic conditions. Nasal cannulae are taped into place, already attached to an oxygen source in case the child needs supplemental oxygen during the test. The test therefore is non-invasive.

The infant's SpO_2 (arterial oxygen saturation measured by pulse oximetry) and pulse rate are measured continuously. Once settled, baseline readings are made in room air for a few minutes, and then the oxygen level inside the box is reduced to an FiO_2 of 0.15 over 5 minutes, by adding nitrogen into the chamber. Timings are

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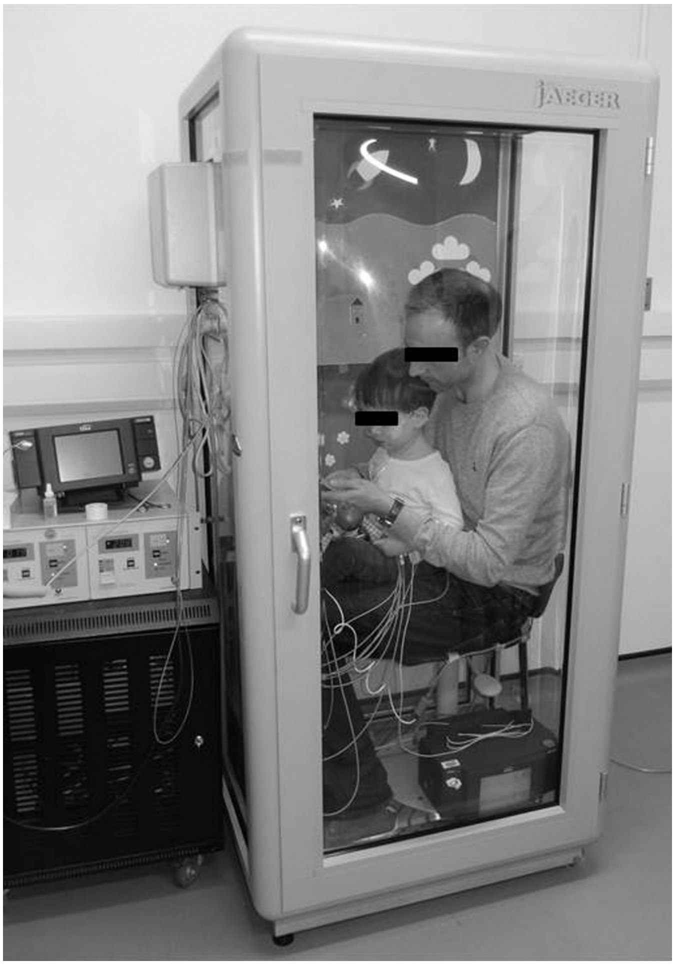

Figure 1. Child with his father having a hypoxic challenge test. Child is attached to a heart rate monitor and pulse oximeter, with nasal cannulae in place in case he required supplemental oxygen. The monitor in bottom right corner measures ambient O_2 and CO_2 concentration in the chamber. Out of the picture are the oxygen and nitrogen gas cylinders.

recorded from when the FiO_2 reaches 0.15 and the test usually takes about 20 mins. Babies can be fed during the test if necessary, but it is not a standard part of the procedure, as although it can lead to further desaturation, this is transient, resolving within 1 min (and mostly <30secs) [9].

If desaturation occurs to <85%, oxygen is administered immediately to the child and titrated to reach the baseline SpO_2. The minimum amount of oxygen required to normalise the saturation is documented. It should also be noted whether the child is awake (calm, restless or crying) or asleep.

For infants <1 year of age with a history of neonatal chronic lung disease, a failed test, according to the British Thoracic Society 2011 guideline, is defined as SpO_2 <85% for a minimum of 2 minutes, below which supplemental oxygen is recommended for flying [8]. It should be noted though that this cut off is not evidence based, but an arbitrary consensus view, that has varied in different iterations of the BTS guidelines between 85% and 90%. The current guidelines do suggest that 'paediatrician discretion' should be used for infants with SpO_2 85-90%, and if in doubt the doctor should err on the side of caution. For older children with chronic lung disease, a cut off of 90% is recommended [8].

HYPOXIC INHALATION TEST USING A FACEMASK

Since not all centres have access to a body plethysmograph, an alternative method using a tight-fitting non-rebreathing facemask incorporating a one-way valve assembly has been devised, through which 14% oxygen is administered. Much of the paediatric work has come from one centre in Perth, Australia [5–7,10].

However, the validity of this technique may be an issue. They performed their facemask test in 46 preterm babies prior to taking commercial flights at a corrected gestational age of 33-43 weeks [6]. None were requiring supplemental oxygen at the time of testing, and 76% passed the test (using an 85% cut-off level for SpO_2). However 12/35 (34%) who had passed, ended up requiring oxygen on the flight and 7/11 (64%) who had failed the test did not require oxygen. The authors concluded that their hypoxia challenge with a facemask was not accurate at identifying who would require oxygen during airflight, at least in young ex-preterm babies. They no longer recommend carrying out the pre-flight test, but instead suggest monitoring high risk preterm infants during air travel with oxygen given when necessary [6]. Of course their context is repatriating preterm infants (often still less than their full gestational age) to neonatal units nearer the parent's home, rather than children going on holiday.

It is likely that sitting in a chamber inhaling 15% oxygen is a closer approximation to airflight than breathing through a facemask, as it is probably more physiological. The mask has to be quite tight, otherwise room air entrainment occurs, which effectively increases the oxygen concentration inspired. Doubts over validity are enhanced by the fact that in one of the facemask studies, 12/24 healthy children aged <2 years desaturated to below 90% [7], and it would be surprising that such a high proportion of normal children desaturate to that degree during airflight.

One more recent study using the facemask technique has shown that healthy schoolchildren desaturate further with light activity (walking at 3 or 5 km/hr for 5 mins) under hypoxic conditions [11]. This is important as young children do not tend to sit still on flights, especially when long distance; there was no difference however between sitting, lying flat or standing positions.

WHO SHOULD HAVE THE TEST?

The BTS 2011guidelines [8] suggest the following children should be tested –

- Infants <1 year of age with a history of neonatal chronic respiratory problems. Since the guidelines were written however, one published study has shown that ex-preterm infants without chronic lung disease were at no increased risk of desaturations compared to term babies, when tested at 3 and 6 months corrected gestational age [9], so perhaps not all these infants need testing. Nevertheless, newborns and infants below 1 year of age, have an increased tendency to ventilation-perfusion mismatch making them particularly susceptible to hypoxaemic episodes, especially if they are unwell or in the presence of airway hypoxia [12].
- Children with cystic fibrosis or other chronic lung diseases with an FEV_1 <50% predicted. One study though found that the FEV_1 <50% was a better predictor of need for in-flight oxygen than a HCT SpO_2 of <90% [3].
- Infants and children who were receiving supplemental oxygen that stopped less than 6 months ago.

Children who do **not** require the test include –

- Infants born preterm (<37 weeks gestation) with or without a history of respiratory disease who have not yet reached their expected delivery date. HCT is unreliable in this age group [6] and they should have supplemental oxygen available on the flight, and receive it if they develop tachypnoea, recession or other signs of respiratory distress.

- Oxygen-dependent children. They can just have their oxygen flow doubled for flights, so do not need a test. Some people would suggest titration is still worthwhile in this group however, although oxygen supplied by the airlines tends to be available at flows of only 2 or 4 L/min.

CONCLUSIONS

There are a number of international guidelines on safety of flying for those with medical conditions [8,13,14]. The HCT is probably the best predictive test available, but still needs to be studied by comparing HCT results with actual in-flight measurements. Ultimately, if in doubt, oxygen should be arranged in advance, and of course many parents should simply consider alternative means of travel for holidays, especially with infants under one year of age.

CONFLICTS OF INTEREST

None.

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