



Letter

Assessing hypoxia risk during air travel after a severe asthma exacerbation in children

Decreased atmospheric cabin pressure in commercial aircrafts (cruising altitude 9,000–13,000 m), requiring cabin pressurization from 1,530 to 2,440 m, is equivalent to breathing a fraction of inspired oxygen (FiO_2) of 15.1% at sea level.

These conditions can cause severe hypoxia in patients with chronic respiratory disease. The normobaric hypoxic challenge test (HCT) is the recommended method to estimate the risk of in-flight hypoxia in patients with respiratory disease, allowing symptom observation and titration of oxygen (O_2) requirements.¹ Asthma is reported to be the most common potentially life-threatening condition encountered during flight.² Different guidelines assessing fitness to fly have been published, but there are no specific recommendations for hypoxia risk or for how long the flight should be postponed after hospitalization for asthma exacerbation with O_2 requirements.^{1,3,4}

Our main objective was to determine hypoxia risk during air travel after hospitalization for severe asthmatic exacerbation by performing the HCT in children. A secondary objective was to determine the risk of hypoxia during the HCT in relation to lung function and other conditions.

This prospective study was performed at a pediatric pulmonary function testing laboratory in a tertiary care hospital. Ethics approval was granted (IBNo1867/12 PI). All parents signed informed consent.

We included patients (2–15 years old) hospitalized for severe asthma exacerbation with O_2 dependence (baseline O_2 saturation [SpO_2] < 92%) who were planning a flight after discharge. Exclusion criteria were respiratory (except asthma), cardiovascular, neurologic, or hematologic diseases. Epidemiologic data, clinical variables, duration of hospitalization, and use of O_2 therapy were collected. After completing 24 hours without a need for O_2 , including feeding and sleeping periods (baseline $\text{SpO}_2 \geq 92\%$), spirometry was carried out according to American Thoracic Society and European Respiratory Society guidelines. Then, the HCT was performed according to the recommended method¹ by introducing nitrogen (50 L/min) in a sealed body plethysmograph (Jaeger MasterScreen Body, Becton-Dickinson, Franklin Lakes, New Jersey) that lowered FiO_2 from 21% to 15%, simulating hypoxia during air travel. SpO_2 and heart rate were monitored by continuous pulse oximetry. If SpO_2 decreased to lower than 90%, we titrated O_2 until hypoxia was resolved ($\text{SpO}_2 > 92\%$). Patients who remained with an SpO_2 higher than 90% at an FiO_2 of 15% for 20 minutes were considered a “no in-flight hypoxia risk.” Those who did not were requested to repeat the HCT after 24 hours.

For statistical analysis we used SPSS 12.0 (SPSS, Inc, Chicago, Illinois). To test the hypothesis and analyze the correlation between lung function parameters and HCT outcomes, we performed the Mann-Whitney test.

Fifty-one children (27 boys, mean age 6.5 years, range 2.5–12.2) were recruited from January 2014 through December 2016. Demographic and clinical data such as spirometry and HCT results are listed in Table 1. Forty-six of 51 children (90%) passed the HCT after 24 hours without O_2 therapy and were considered a no in-flight hypoxia risk. Of those 5 of 51 (10%) who did not pass, the HCT was repeated after 48 hours without O_2 and all (100%) passed the test. Mean decrease in SpO_2 while performing the HCT was 4.5%. Patients who did not pass the HCT within the first 24 hours showed lower mean forced expiratory volume in 1 second (FEV_1) compared with the group who passed the HCT (FEV_1 69% vs 89%, $P = .038$). No differences were found in SpO_2 before the HCT, days of hospitalization, required O_2 , and maximum FiO_2 . No significant side effects while performing the HCT were observed.

Because of socioeconomic changes, the number of air travel passengers has been increasing steadily in recent years. During air travel PaO_2 can decrease to 60 mm Hg in travelers without pulmonary disease, causing mild hypoxia, but the shape of the oxygen-hemoglobin dissociation curve usually prevents SpO_2 decreases lower than 92%. In patients with respiratory diseases, SpO_2 decreases are more severe. Sometimes air travel after hospitalization for asthmatic exacerbation is unavoidable. Unfortunately, there is a lack of recommendations for how long air travel should be delayed after hospital discharge.

Most guidelines consider pulse oximetry or arterial gasometry values when selecting patients with hypoxia risk during flights. In fact, patients with PaO_2 higher than 70 mm Hg or SpO_2 higher than 95% are considered fit to fly in most cases. Nevertheless, in recent years, different studies have shown that the “fit-to-fly criteria” based on basal PaO_2 are insufficient.^{3,5} Equations might be used to predict in-flight PaO_2 ; however, these equations are derived from patients with chronic obstructive pulmonary disease, interstitial lung disease, and cystic fibrosis. Their precision remains unclear in patients with asthma but improves in those with other lung diseases after introducing FEV_1 or ratio of FEV_1 to forced vital capacity values.^{6,7} Particularly in adult patients with severe asthma, baseline O_2 saturation appears to be a poor predictor for the need for in-flight O_2 .⁸

Performance of the HCT offers several advantages over equations. It is an individual and more accurate evaluation and allows for an observation of clinical signs of hypoxia. Nevertheless, the HCT has a number of limitations because cabin pressure and density are not reproduced.

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Table 1
HTC Results in Asthmatic Patients

	Total	Patients passed HTC in first 24 h	Patients failed HTC in first 24 h	P
n	51	46	5	
Age, y (mean $\pm$ SD)	6.5 (3–12.2)	6.4 $\pm$ 2.8	8 $\pm$ 1.3	NS
FEV ₁ pre-HCT (mean $\pm$ SD)	85% (42–120%)	88.1 $\pm$ 0.16	68.8 $\pm$ 0.18	.038
FiO ₂ max (mean $\pm$ SD)	0.35 (0.28–1)	0.43 $\pm$ 0.18	0.4 $\pm$ 0.16	NS
SpO ₂ pre-HCT (mean $\pm$ SD)	96% (92–99%)	96 $\pm$ 1.8	94 $\pm$ 1.5	NS
Minimum O ₂ saturation during test (%)		92	88	NS
Mean O ₂ saturation drop (%)		4.2	6	NS
Days of admission (mean $\pm$ SD)	4.9 (3–14)	4.8 $\pm$ 2.2	5 $\pm$ 1	NS

Abbreviations: FEV₁, forced expiratory volume in 1 second; FiO₂ max, maximum fraction of inspired oxygen during hospitalization; HCT, hypoxic challenge test; NS, not significant.

This is the first study assessing in-flight hypoxia risk in children with asthma who were hospitalized for asthmatic exacerbation and required O₂. Although the reliability of the HCT is under discussion, it still is considered the most appropriate test for preflight evaluation.^{1,9} Despite including patients with high O₂ requirements during hospitalization (FiO₂ up to 100% and 14 days of admission), no increased risk of hypoxia while performing the HCT was observed, a fact that makes our results more consistent.

According to our data, in children hospitalized for asthma exacerbation without O₂ therapy for 48 hours, no increased in-flight hypoxia risk was detected and performance of the HCT was not necessary.

In our study, the group who did not pass the HCT in the first 24 hours after O₂ therapy showed lower pretest FEV₁ values, and although this it does not seem to be a sufficiently reliable indicator, an FEV₁ lower than 70% has to be taken into account.

The main limitation of our study is that the HCT was not performed in a hypobaric chamber, and although the results for hypoxia were similar to those of previous studies, symptoms from lower cabin pressure can appear. Another limitation is that PaO₂

values are not registered. This painful test is not used habitually in children because of ethical concerns.

In conclusion, pediatric patients with acute respiratory failure from asthmatic exacerbation requiring hospitalization are passing the HCT in the first 48 hours after removing O₂ therapy. These results suggest a low risk of hypoxia during air travel after this period. Although other concerns such as humidity, pressure and temperature variability have to be considered, this study could provide information as to how soon after severe asthmatic exacerbation it is safe to fly.

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