Pre-flight Testing of Children and Adolescent with Asthma

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Background --- Commercial aircraft cabins provide a "hostile" environment for children and adolescents with underlying respiratory disease. Although there are algorithms and guidelines for predicting in-flight hypoxemia relating to COPD, no data pertaining to bronchial asthma are available to date. The purpose of this study was to evaluate the effect of simulated cabin altitude on subjects with bronchial asthma at rest and during a limited walking task.

Methods --- Forty eight subjects (29 male, 19 female) aged 6 years to 18 years old with bronchial asthma, mild persistent disease category and forty two control subjects (20 male, 22 female) were recruited for the study. All had baseline oxygen saturation of more than 95%. Subjects underwent a standardized Hypoxia Altitude Simulation Test using 100% nitrogen while at rest and during limited walking exercise.

Results --- There is reduction on oxygen saturation and increase of heart rate in the control group. On the other hand, the asthmatic patients grouped into two: ages 6 to 12 years old and adolescents with ages 13 to 18 years old showed a statistically significant greater oxygen desaturation (p=0.00, p=0.007, respectively) and tachycardia (p=0.00, p=0.00, respectively) during the testing. There were no clinically noticeable ill effects at the level of oxygen saturation decline in all subjects.

Conclusion --- Patients with mild persistent bronchial asthma, when subjected to pre flight evaluation such as Hypoxia Altitude Simulation Test (HAST), showed a significant decline in oxygen saturation and increase in heart rate. None of the subjects involved in the study experienced any untoward reactions like shortness of breath, palpitations, and lightheadedness. A limitation of the study is its small sample size. A larger study is needed to validate its findings to other more severe forms of asthma. ***Phil Heart Center J 2007;13(2):144-148.***

Key Words: Bronchial asthma ■ Hypoxia Altitude Stimulation Test (HAST) ■ Pre-flight Testing

The number of people, including children, using commercial aircraft to travel is increasing. Most commercial aircraft generally cruise between 9150 and 13000 meters above sea level.[1] At cruising altitudes, most commercial airlines are pressurized to maintain pressure cabin equivalent to 1530-2440 meters. As the height increases the partial pressure of oxygen in the atmosphere falls, so passengers in aircraft at cruising altitude are breathing equivalent of 15% to 16% Fi02. This low oxygen environment elicits little or no clinically relevant effects in healthy adults but may result in lowered arterial hemoglobin oxygen saturation.[2] In a study done by Lee et al.[3] healthy children during air travel was noted to have desaturation as low as 94-95% during travel without notable clinical symptoms.

However, patients with pre-existing respiratory conditions such Chronic Obstructive Pulmonary Disease, cystic fibrosis, neonatal chronic lung disease, or other chronic lung diseases may develop hypoxia related respiratory distress leading to symptom exacerbation, altitude related illnesses, or even death during flights.[2]

The Hypoxia Altitude Simulation Test is a simple method of demonstrating a passenger's need for supplemental oxygen during flight and for determining in-flight oxygen requirements.[4] Data on the use of hypoxia test among infants and older children are sparse. This test predicted cases of oxygen desaturation during flight in children with cystic fibrosis. Two existing studies used hypoxia tests in infants and young children. Parkins and co workers5 performed sleep studies in 34 healthy infants aged 1-6 months during prolonged hypoxia test reported that the mean Sp02 (oxygen saturation) declined from 97.6% to 92.8%. More recently, Buchdahl, et al.,6 reported the use of hypoxia tests in 20 young children with a history of respiratory disease; 6 patients with Sp02 > 95% in room air desaturated below 90% when performing hypoxia test.

In the recent statement from the British Thoracic Society, guidelines were identified relating to professional aircrew and potential recruits with asthma, none were found relating to passengers. Surprisingly these guidelines do not mention avoidance of flying during acute asthma exacerbations.[1] The flight environment experienced by commercial passengers should

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not pose a problem for most patients with asthma. QANTAS airlines, in a review of all consecutive in-flights medical incidents reported 454 significant medical incidents, 9% of which were reported as respiratory tract infection or asthma.[7] A review of incidents on US commercial aircraft where an enhanced medical kit was used found that 10% of 362 episodes were due to asthma, lung disease or breathlessness.[8]

There are a number of environmental changes that arise from altitude, including fall in humidity, irradiation, temperature, atmospheric pressure and partial pressure of oxygen.[9] Low cabin humidity may present a theoretical risk of bronchospasm as a result of water loss from bronchial mucosa. To our knowledge, no study of this nature has been done, to this date among asthmatic children and adolescents. It is therefore useful to know physiologic effects of high altitude especially among asthmatic children and adolescents. This study was conducted to determine the effect of simulated cabin altitude on asthmatic children and adolescent at rest and during

Methods

This is a case control study involving asthmatic children and adolescents, ages 6 years to 18 years old with mild persistent disease category, which include one or more of the following: a) daytime symptoms of more than once a week, b) nighttime symptoms of more than twice a month, accompanied by c) a normal peak expiratory flow (PEF) and force expiratory volume in one second (FEV1) and a peak expiratory flow (PEF) variability of 20-30% based on the Philippine Consensus for the Management of Childhood Asthma. Subjects are in stable condition and with no modification of anti asthma treatment for at least 2 weeks. Excluded were subjects with other co morbid conditions, have respiratory symptoms (coughing, sneezing, chest tightness) of more than 2 weeks in duration and in asthma exacerbation and are unable to follow instructions for the pulmonary function test. Children and adolescents aged 6-18 years old who have no respiratory signs and symptoms two weeks prior to testing and are able to follow instructions for the pulmonary function test served as control of the study.

Hypoxia Altitude Simulation Test (HAST) was conducted at the Pulmonary Rehabilitation - Preflight Evaluation Clinic of the Philippine Heart Center. Voluntary informed consent was obtained from the parent and/or guardian.

The investigator conducted an interview and physical examination of all children and adolescent upon enrollment of the study. A standardized questionnaire was used to assess the clinical signs and symptoms of bronchial asthma based on the Philippine Consensus in the Management of Childhood Asthma.

The prediction of arterial oxygen tension in-flight was done using the hypoxia altitude simulation test (HAST) at constant barometric pressure. This method involved inhalation of hypoxic gas mixtures, allowing measurement of oxygen saturation at simulated in-flight cabin altitude. It utilized the Vohra and Klocke technique using the Venturi delivery system with a face mask covering the nose and mouth.[10] A Venturi jet was connected to a mask by a corrugated tubing to attain Fraction of Inspired Oxygen (Fi02=35%). With a nitrogen source, the Venturi device delivered an Fi02 of 16.5% to 16.9% as measured by a mini oxygen analyzer (Mini Ox 1, MSA Catalyst Research). The subjects were placed on a comfortable sitting position. Nasal cannulas connected to oxygen tank were provided. Venturi mask was tightly fitted over the face. One henudred percent (100%) Nitrogen gas was given at six liters/min for 20 minutes to allow equilibration. Heart rate was recorded every five minutes. Oxygen saturation was continuously monitored using pulse oximeter (BCI Fingerprint, BCI International, Wisconsin). While inhaling the same gas mixture, the subject was asked to stand and walk on a 5-flight of stairs in 3 minutes. Oxygen supplementation was provided when oxygen saturation fell less than 92%. Spirometric studies (pre and post bronchodilation) was done and referred to sea level.

The subjects was grouped according to age. The tables presented descriptive data as mean + SD. Paired sample correlation was done to determine the differences

Results

Fifty two (52) known asthmatic children and adolescents (30 male and 22 female), ages 6 years to 18 years old with mild persistent disease category were recruited to the study. Four subjects had respiratory symptoms of cough and coryza with pneumonia on chest xray, thus, were excluded. A control group of forty two (42) non-asthmatic children and adolescent were likewise recruited. The asthmatic group and control group were further stratified according to age: Asthmatic group 1 (6 years to 12 years old) and Asthmatic group 2 (13 years to 18 years old); Control group 1 (6 years to 12 years old) and Control group 2 (13 to 18 years old). The demographic and pulmonary function data of the study and control subjects are shown in Table 1.

All subjects studied had baseline SpO2 >95% (range = 95-100%). Of the 90 subjects studied, no one experienced feeling of shortness of breath, palpitations or lightheadedness throughout the testing. The mean oxygen saturation of the asthmatic group 1 declined from a mean sea level saturation of 97.3+1.2% to 93.5+2.3% during the test while sitting down (p value=0.002) and to 93.9+2.4 during light exercise (p value=0.017). On the other hand, significant oxygen desaturation of the asthmatic group 2 was demonstrated by a decline of the mean oxygen saturation from 97.2+1.3% to 96.3+2.7% during the test while sitting down (p value=0.05) and no

desaturation during light exercise. The mean heart rate in beats per minute (BPM) at baseline increased from 90/minute to 93/minute during the test while sitting down (p value=0.026) and to 107/minute during light exercise (p value=0.026). The results are summarized in Tables 2A, 2B, 2C and 2D.

When comparing the oxygen saturation and heart rate during the hypoxia testing, oxygen saturation and heart rate differences between the study and control groups were statistically significant for children aged 6 years to 12 years old. However, oxygen saturation and heart rate differences among adolescents aged 13 years to 18 years old did not reach statistical significance due to smaller sample size and variable results. In general, all age groups (6 to 12 years old, 13 to 18 years old) showed significant oxygen desaturation during the testing. Children age 6 to 12 years old and adolescents age 13 to 18 years old demonstrate considerable heart rate increases during the testing. The age group results are stratified in Table 3.

Table 1. Comparison of the demographic profile and pulmonary function test of four groups

Variables	6-12 years old Mild Persistent n=39	6-12 years old Control n=30	p-value	13-18 years old Mild Persistent n=9	13-18 years old Control n=12	p-value
Male	24 (61.5%)	12 (40%)		5 (55.6%)	8 (66.7%)	
Female	15 (38.5%)	18 (60%)		4 (44.4%)	4 (33.3%)	
Age (yrs)*	8.15 ±2.1	8.63 ±2.1	0.36	14.13±1.8	14.11 ±1.1	0.84
Height (cm*)	123.5±14.2	123.58±12.5	0.99	153±6.7	152.14±11.0	0.83
Weight (kg)*	26.85±12.5	23.49±7.5	0.19	45.1±9.1	39.88±8.1	0.16
BMI (kg/m2)*	16.89±4.0	15.04±2	0.016	19.25±3.4	17.11±1.9	0.074
FVC *±	95.38±15.4	94.89±1.2	0.41	99.08±7.9	87.55±11.3	0.02
FEV1*±	99.28±15.2	99.32±14.2	0.99	98.62±11.6	96.77±14.8	0.76
FEV1/FVC* ±	95.78±10.7	95.66±4.9	0.24	94.01±17.0	96.35±3.4	0.71

*Data for continuous variable expressed as mean± SD; other data expressed as n (%).

± % predicted

p value refers to comparisons of patient characteristics by age, height, weight and spirometric studies

Table 2A. Result of Hypoxia Altitude Simulation Test among asthmatic patients (Group 1) Mild Persistent (6-12 years old)

Variable Heart rate	Sea Level beats/min Mean ±SD	HAST (Sitting) beats/min Mean ±SD	HAST (Exercise) beats/min Mean ± SD
Asthmatic	90.9±13.9	93.1±13.7*	107.3±13.4*
Control	83.2±11.7	85.8±12.7*	99.4±15.1*
p value	0.017*	0.026*	0.026*

Table 2B. Result of Hypoxia Altitude Simulation Test among asthmatic patients (Group 1) Mild Persistent (6-12 years old)

Variable SpO2	Sea Level Sp02 Mean±SD	HAST (Sitting) Sp02 Mean ±SD	HAST (Exercise) Sp02 Mean ±SD
Asthmatic	97.3±1.2	93.5±2.3*	93.9±2.4*
Control	97.8±1.2	95.3±2.3*	95.2±1.9*
p value	0.066 NS	0.002*	0.015*

Table 2C. Result of Hypoxia Altitude Simulation Test among asthmatic patients (Group 2) Mild Persistent (13-

Variable Heart Rate	Sea Level beats/min Mean±SD	HAST (Sitting) beats/min Mean±SD	HAST (Exercise) beats/min Mean±SD
Asthmatic	82.5±23.2	86.6±17.4*	103.8±21.5*
Control	78.4±8.0	78.8±8.2*	98.8±12.0*
p value	0.017*	0.161 NS	0.478 NS

Table 2D. Result of Hypoxia Altitude Simulation Test among asthmatic subjects (Group 2) Mild Persistent (13-

Variable Sp02	Sea Level Sp02 Mean±SD	HAST (Sitting) Sp02 Mean±SD	HAST (Exercise) Sp02 Mean±SD
Asthmatic	97.2±1.3	96.3±2.7*	94.5±2.0
Control	97.7±1.5	96.2±1.9	96.3±1.5
p value	0.066 NS	0.962 NS	0.026*

Table 3. Correlation of heart rate and s02 at sea level and Hypoxia Altitude Simulation Test (sitting and exercise)

GROUP	Variable	Sea Level Mean±SD	HAST (Mean±SD) Sitting	HAST (Mean±SD) Exercise	p value
Asthmatic					
6-12 y.o.	HEART RATE	90.9±13.9	93.1±13.7	107.3±13.4	0.00*
	SpO2	97.3±1.2	93.5±2.3	93.9±2.4	0.00*
13-18 y.o.	HEARTRATE	82.5±23.2	86.6±6	103.9±21.5	0.00*
	SpO2	97.2±1.3	96.3±2.8	94.6±2.0	0.007*
Control					
6-12 y.o.	HEART RATE	83.2±11.7	85.8±12.7	99.4±15.1	0.00*
	SpO2	97.8±1.2	95.3±2.3	95.2±1.9	0.00*
13-18 y.o.	HEART RATE	78.4±8.0	78.8±8.2	98.8±12.0	0.00*
	SpO2	97.7±1.5	96.2±1.9	96.3±1.5	0.033*

Discussion

Predicting adverse consequences associated with hypoxia during commercial flight is important. Patients with lung diseases have potential health risks during air travel. The ascent to high altitude results in reduced inspired oxygen pressure with associated decrease in Pa02. The falling barometric pressure is responsible for the reduction in oxygen tension.

A previous study by Lee and co workers3 involving 80 healthy children aged 6 months to 14 years old were studied during their eight flights between Honolulu, Hawaii and Taipei, Taiwan. Oxygen saturation declined and heart rate increased significantly after 3 hours and 7 hours with reduced aircraft cabin pressure. There were no clinically noticeable ill effects noted at the level of oxygen desaturation.

Our study, involving children who are known asthmatic, showed that a high proportion of children aged 6-12 years old and 13-18 years old exhibit significant oxygen desaturation below 95% when breathing hypoxic gas mixture (Fi02=16.5%-16.9%).

The British Thoracic Society guidelines recommend that in-flight oxygen is not required in adults in

whom sea level Sp02 is >95% or 92-95%, depending on the absence and presence of additional risk factors.[1] In a study done by Buchdahl and co workers,[6] they reported their experience of preflight hypoxia testing in 20 young children with various chronic lung diseases. Eighteen infants and young children had normal baseline Sp02. Of these, six patients exhibited oxygen desaturation below 90% with one infant recording Sp02 of <85% during exposure to 15% Fi02. The present study support these earlier findings and suggest that a normal Sp02 in room air of children with bronchial asthma at sea level may be insufficient to determine the safety of this patient group in the low oxygen environment encountered during flight or at high altitude.

In the present study, 80% of asthmatic children and adolescent had inhaled corticosteroids and long acting beta 2 agonist as maintenance medications. In addition, all asthmatic children and adolescent had normal spirometric studies. The reasons why these children are more susceptible to hypoxia are not clear but may be due to the relative immaturity of the respiratory system leading to increased ventilation-perfusion mismatch.[11] Studies in children in high altitude regions of the world (>3000m) had shown them to have higher minute ventilation (VE), tidal volume (VT), expiratory duration, vital capacity (VC), lung compliance, oxygen extraction, hematocrit and hemoglobin levels and to maintain pulmonary vascular reactivity.[9] In a study done by Wagner and co workers13, thirty 5 to 7 year old children were exposed to 12% oxygen for 10 minutes; 7 of 10 whose oxygen saturation fell <88% had histories of reactive airways disease. Desaturation was a better predictor for reactive airways disease and had a sensitivity of 100% for reactive airways disease. This suggests that small airways disease contributes to the susceptibility to desaturate with exposure to hypoxia. This may be because airway/alveolar hypoxia induces bronchoconstriction.

When comparing oxygen saturation differences between study group and control group during hypoxia testing, there was statistical significance noted among children age 6 to 12 years old and 13 to 18 years old. Considering these asthmatics to have a normal pulmonary function test while undergoing the preflight testing, we are therefore cautious about extrapolating conclusions from our observations to asthmatic children and adolescent in general.

In the recent British Thoracic Society recommendations in managing passengers with respiratory disease planning air travel, there are three current procedures that was used to assess whether the patients are fit to fly namely: the 50 meter walk, predicting hypoxemia from equations and the hypoxia challenge test.[1] We routinely use a 20 minute hypoxia challenge test using the 35% Venturi device with nitrogen as source gas that effectively lowers the Fi02 to 16.5% equivalent to an altitude of 6,700 feet. Because of the lower density of nitrogen, less air is entrained by the Venturi device lowering the delivered Fi02. Briefly, acute hypoxia in normal individuals initiate reflex responses that reduce oxygen gradient between the atmosphere and body tissues and prevent a large fall in Pa02. Hyperventilation is the primary physiologic response to acute hypoxia and maximizes alveolar P02 and Pa02, assuming that oxygen consumption is stable. Minute ventilation increases, primarily as a result of increased tidal volume rather than tachypnea. Blood flow and oxygen delivery to the heart and brain organs with high oxygen requirements are normally maintained during acute hypoxia. Cardiac output characteristically increases initially with hypoxia in a dose dependent fashion, primarily due to tachycardia.[10] This observation was evident on all study and control subjects while doing the hypoxia altitude simulation testing (HAST). Although the degree of oxygen desaturation is statistically significant, the lack of acute symptoms from this in both asthmatic and control subjects suggest that this degree of oxygen saturation decline may not be clinically important.

A limitation of the study is its small sample size especially among adolescents aged 13 years to 18 years old. These observations suggest that larger studies, involving stable and poorly controlled asthmatics undergoing hypoxia testing.

In addition, children with preexisting acute or chronic cardiopulmonary conditions (e.g. asthma in acute exacerbation, pneumonia, bronchopulmonary dysplasia, congenital heart disease) who may already be mildly hypoxemic are the patients most likely to seek medical advice about whether to fly.[17,19,20] These patients with pre existing anemia or cardiopulmonary diseases are likely to sustain greater degrees of clinical compromise with similar degrees of oxygen desaturation and may result at greater risk of developing acute symptoms. While it may be possible to predict hypoxia among stable asthmatic during flight, there are no means of predicting symptoms or actual risk of harm during air travel.[18] Further information is required to determine the effects of hypoxia testing on poorly controlled asthmatics and the clinical significance of hypoxia testing among stable asthmatics.genital heart disease) who may already be mildly hypoxemic are the patients most likely to seek medical advice about whether to fly.[17,19,20] These patients with pre existing anemia or cardiopulmonary diseases are likely to sustain greater degrees of clinical compromise with similar degrees of oxygen desaturation and may result at greater risk of developing acute symptoms. While it may be possible to predict hypoxia among stable asthmatic during flight, there are no means of predicting symptoms or actual risk of harm during air travel.[18] Further information is required to determine the effects of hypoxia testing on poorly controlled asthmatics and the clinical

significance of hypoxia testing among stable asthmatics.

Conclusion

In conclusion, patients with mild persistent bronchial asthma when subjected to pre flight evaluation such as Hypoxia Altitude Simulation Test (HAST) showed a significant decline in oxygen saturation and increase in heart rate. None of the subjects involved in the study experienced any untoward reactions like shortness of breath, palpitations and lightheadedness. A limitation of the study is its small sample size. A larger study is needed to validate its findings to other more severe forms of

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