

BRONCHIAL PROVOCATION TESTING FOR INTENDING DIVERS WITH A HISTORY OF ASTHMA OR WHEEZING

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Abstract

A retrospective analysis of 100 hypertonic saline challenge tests, performed as part of an assessment of medical fitness to dive, was undertaken. The candidates were intending scuba diving students who had passed all other aspects of a diving medical, but gave a history of asthma or wheeze. An analysis of 50 histamine provocation test results was also undertaken, the selection criteria being identical. Twenty one candidates (21%) were deemed unfit to dive as a result of their response to hypertonic saline. These either had a fall in FEV₁ of 20% or greater after hypertonic saline inhalation or developed wheezing or shortness of breath. Of the 50 candidates who had a histamine challenge, 17 (34%) had been deemed unfit as a result of a 20% or greater fall in FEV₁ after inhalation. These results suggest a higher incidence of significant bronchial hyperresponsiveness to a pharmacological challenge with histamine when compared with a non-isotonic challenge with hypertonic saline. The results also suggested an increased incidence of bronchial hyperresponsiveness to hypertonic saline in the group of Japanese candidates compared with other nationalities. Smokers demonstrated a greater response to inhalation than non smokers. A family history of asthma or a personal history of atopy were poor predictors of response.

Introduction

All prospective self contained underwater breathing apparatus (scuba) divers in Australia require a medical examination to assess their fitness to dive before learning to dive. A would be diver who gives a history of asthma or recurrent wheeze may be at risk of developing bronchial airway narrowing while exercising when diving. These diving candidates are therefore referred for bronchial provocation testing to assess the reactivity of their airways. There are several triggers when diving, including breathing dry air, exercise and non-isotonic water (salt water or fresh water) inhalation. The Australian Standard AS 4005.1 for prospective recreational divers states that "any evidence of obstructive airways disease, e.g. current asthma, chronic bronchitis, allergic bronchospasm, shall automatically disqualify. In case of doubt, specialist medical opinion should be sought. Such opinion should include provocative testing if any doubt concerning the possibility of bronchial hyperreactivity exists".¹

The Thoracic Society of Australia and New Zealand² states that "intending divers with a history of

current asthma should be advised not to dive.....Intending divers with a past history of asthma and asthma symptoms within the previous five years should be advised not to dive.....Those who have had asthma in the past, but who have normal spirometric tests and no symptoms, and have not taken asthma medication at all in the last five years, should proceed to bronchial provocation testing". Although most physicians consider that if bronchial hyperresponsiveness is present, subjects should not be passed fit to dive, the present recommendations against subjects with bronchial hyperresponsiveness and past asthma are made on theoretical grounds. There are good reasons to suggest that, along with current asthmatics, such divers have an increased risk of pulmonary barotrauma or arterial gas embolism, but there is insufficient data to confirm or refute this.² Provocation tests are of practical use in identifying those persons who would seem to be at risk of acute airway narrowing during diving. Those who have demonstrable bronchial hyperresponsiveness should be told that they may be at increased risk of pulmonary barotrauma and details of the possible consequences should be explained. Traditionally tests for measuring bronchial hyperresponsiveness have been challenges with pharmacological agents such histamine and methacholine. These are less acceptable to the intending diver as the stimulus is not seen to be relevant to the diver. The use of non-isotonic stimuli as a physical challenge to the airways is becoming more popular. It has been shown that during exercise, the increased rate of respiratory water loss acts as a hypertonic stimulus to induce asthma.³ Strenuous exercise is occasionally required from a diver, all air breathed by diver is dry and a fine aerosol of hypertonic saline is often produced through a faulty expiratory valve. Experience has shown that if challenge with salt water causes breathing difficulty, or excessive coughing, the intending diver is immediately aware of the potential for the same thing happening while diving and accepts exclusion more readily.

Method

A retrospective analysis of 100 hypertonic saline challenge tests performed as part of an assessment of medical fitness to dive, was undertaken. These candidates had been referred to my diving medical practice in Cairns, North Queensland, for a diving fitness assessment between May 1994 and April 1995. A further 50 histamine challenge tests were also analysed. These had been performed during 1991 and 1992 for identical reasons. All these subjects had passed a recreational diving medical on all other aspects of their health, but had given a history of asthma or wheeze.

The selection criteria used has been outlined and follows the guidelines of the Australian and New Zealand Thoracic Society.² All the candidates had normal lung function as shown on respiratory function testing (RFT)

using Knudson predicted values,⁴ and gave no history of significant asthma or wheeze within 5 years. A small group of candidates went onto provocation testing although they had symptoms more recently, but only when the aetiology or severity of the symptoms was questionable.

Hypertonic saline challenge⁵ was performed using 4.5% NaCl through an Omron ultrasonic nebuliser (NE-UO6). The nebulising rate was approximately 1.5 ml/min. The protocol used was as outlined by the Lung Function Laboratory in the Department of Thoracic Medicine at the Royal Adelaide Hospital.⁶ Baseline measurements of forced expiratory volume in one second (FEV₁), and forced vital capacity (FVC) were taken before inhalation. The FEV₁ was measured before challenge and at 30 and 90 seconds after the inhalation. The time of inhalation was doubled after each exposure, starting with 30 seconds, then 60 seconds, 1 minute, 2 minutes, 4 minutes and 8 minutes or until a reduction in FEV₁ of 20% or greater occurred. A minimum amount of 15 ml of saline was nebulised or the test was extended. Inhalation with a bronchodilator (salbutamol) was given at the end of the test and the percentage rise in FEV₁, from baseline, calculated. A fall in FEV₁, at the completion of the test, of 20% or greater after hypertonic saline or a rise of 15% or greater after salbutamol, was considered to indicate significant bronchial hyperresponsiveness and these candidates were recommended not to dive. The lability index, the sum of the percentage fall in FEV₁ during inhalation and the percentage rise after bronchodilator (from baseline), was also calculated. This calculation was used to identify the candidates who may have had some degree of airway's restriction at commencement of the test. If this result was 20% or greater, then diving was not recommended.

The histamine challenges were performed using the rapid hand operated technique described by Yan et al.⁷ using a DeVilbis hand held nebuliser. Responses to these challenges were compared with the history of symptoms, smoking status and nationality, in order to identify any trends. The hypertonic saline challenge test responses were also compared to responses from a group of experienced divers who volunteered to undergo challenge testing as part of another study.⁸ Volunteers had various past histories (including some with asthma) and diving experiences. The protocol and equipment used was identical. The volunteers were tested between September and December 1994.

Hypertonic saline challenge results

Of the 100 students presenting for hypertonic saline challenge, 62 (62%) were male and 38 (38%) were female. The mean age of the group was 25 years. Twenty seven (27%) were smokers. Thirty six of the group (36%) were Japanese, 18 (18%) Australian, 12 (12%) were British, 17 (17%) European, 14 (14%) from North America, and there

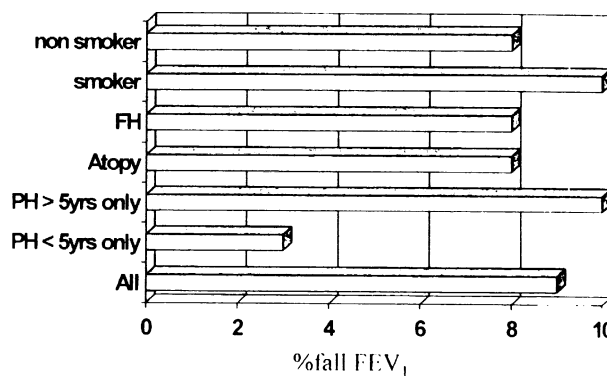


Figure 1. Average falls in FEV₁ after 4.5% saline provocation testing in candidates with various past histories. FH = family history of asthma or wheezing. PH = past history of asthma or wheezing.

TABLE 1

FALLS IN FEV₁ AND FAILURE RATE

Fall in FEV ₁ after 4,5% saline	Number of students	%
10% or greater	33	33%
20% or greater	23	23%
30% or greater	18	18%
Total failed		21%

were 3 (3%) others. A greater percentage of the 36 Japanese were currently smokers at 9 (25%) compared with 17% for both Australian (3) and European groups (3). Six of the USA and Canadian group were smokers (40%). The numbers here are too small to be statistically significant. In the group as a whole 9 (24%) of the females smoked compared with 18 (29%) of the males.

The average fall in FEV₁ at completion of the challenge test was 9%. As a group the Japanese fared worst with an average fall of 12%. This was also mirrored in the overall outcome. As a result of the provocation test diving was not recommended in 21% of the group as a whole. Again, the Japanese were over represented in this group with 11 (31% of all Japanese students) completing the test being recommended not to dive. Percentage fall in FEV₁ was also compared in groups with various risk factors and is represented in Figure 1. The results are suggestive but not statistically significant.

Figure 1 shows that smokers had a higher than average fall in FEV₁. Also that candidates who gave a history of symptoms of asthma or wheeze within the last 5 years had the least reaction to saline. Although this may seem contradictory, the students who were selected to do

the provocation test in this group where ones whose symptoms either seemed insignificant or there was question as to the diagnosis. The resultant average fall in this group of 3% shows that the selection criteria imposed on this group was justified. Summary of the percentage falls after inhalation of hypertonic saline is shown in Table 1. Twenty one prospective divers were recommended not to dive because of a 20% or greater fall in FEV₁ after inhalation or the development of clinical signs of airway narrowing.

Histamine challenge results

Examination of the 50 histamine challenge tests on diving candidates, using identical selection criteria, showed that 17 (34%) of the candidates were found to have significant bronchial hyperresponsiveness and were advised not to dive. Compared with the 21 (21%) of candidates who showed significant airway reactivity to hypertonic saline, it is clear that a greater proportion of students were unable to dive as a result of the histamine challenge. This reinforces what has been found in a population study showing that a significant proportion (30%) of people can have a positive response to inhaled histamine but have no symptoms or clinical history of asthma.²

Table 2 shows the responses in prospective divers to different stimulants and compares them with the group of volunteer divers studied at the same medical practice using identical techniques.⁸ These 50 volunteers were challenged with hypertonic saline as part of a study carried out between September and December 1994. The results are published on page 249- 253

Discussion

The results show that the Japanese students demonstrated a higher than average incidence of significant bronchial hyperresponsiveness, with an average percentage fall in FEV₁ after inhalation of 4.5% NaCl of 12% compared with the average of 9%. 31% of the Japanese students discontinued their scuba diving course as a direct result of the challenge compared with 21% of the total. The Great Barrier Reef is a great draw card for travellers to Far North Queensland and to Cairns in particular. Many of these travellers come especially to explore this world wonder and while doing so experience the excitement of scuba diving. A significant proportion of these travellers come from Japan. Analysis of statistics of open water certifications processed from one of the dive schools in Cairns, was kindly provided to me by PADI Australia.⁹ The majority of students seen at my surgery were from this particular dive school. Analysis of the statistics showed that during the 12 month period commencing 1 April 1994, 33% of all the students successfully completing their open water certification were

TABLE 2

FALLS IN FEV₁ WITH PROVOCATION TESTING IN 50 EXPERIENCED DIVERS AND 150 DIVING STUDENTS

Group	Divers	Students	Students
Challenge	4.5% Saline	4.5% Saline	Histamine
% fall in FEV ₁			
10%	30%	33%	
15%	12%	23%	
20%	4%	18%	34%

The groups above are 50 experienced divers tested with 4.5% saline,⁸ 100 diving students tested with 4.5% saline and 50 diving students tested with histamine.

Japanese. This would suggest that more than one third of the open water diving students presenting to this particular dive school were Japanese (remembering that a proportion of those presenting failed to complete the course due to the outcome of the pre-dive medical assessment). Although some dive schools in Cairns may not attract as many Japanese student divers to them, there are other schools that cater solely to the Japanese traveller. I think that we can safely say that in our area a significant proportion of the diving industry dollar comes from Japan. The reason I have emphasised this is that some tour operators feel quite strongly about their loss of commission when a diving candidate does not continue with their diving course. One such operator suggested to me that as Cairns was such a high risk area, for failure to dive on medical grounds, that it was becoming too great a business risk to send their Japanese travellers to Queensland and that perhaps Micronesia would be a better destination as a medical examination was not required there at all. Although obviously to doctors the safety of the individual diver is of paramount importance, the financial side takes precedent in other quarters.

There was also a higher than average response to inhalation of 4.5% NaCl in current smokers. Those that gave a history of symptoms or use of bronchodilator within 5 years showed insignificant responses and this was an indication of the selection methods. Past history of atopy or family history of atopy or asthma was a poor predictor of response.

There was also a greater positive response rate to histamine challenge compared with challenge with 4.5% NaCl. Again this highlights the findings in a population study which showed that a significant proportion of people (30%) had significant response to histamine without any history of asthma.²

When comparing the group of experienced volunteer divers with little or no past history of airway

reactivity with the group of prospective divers all having a history of airway's reactivity, we see that both groups had a similar (30% and 33% respectively) response at the 10% level to hypertonic saline. This suggests that the criteria outlined, by Edmonds et al.¹⁰ in *Diving and Subaquatic Medicine*, stating that "asthma provocation producing 10% or greater reduction in FEV₁ after both histamine and hypertonic saline challenge" leads to a FAIL, may be too stringent. In these two studies, fall in FEV₁ of 10% after provocation failed to differentiate between the group of experienced divers and the student divers. Further studies will be required to decide whether a 15% fall in FEV₁ after provocation indicates significant increased risk to diving (as suggested by Anderson et al.¹¹) or whether a greater than 20% fall is stringent enough (at present part of our protocol). In order to answer these questions, more data is required. It would be useful to follow up candidates with borderline challenge test results and, if they have chosen to continue to dive, document their progress. This is the only way that guidelines can be set out based on clinical data rather than on purely theoretical grounds.

Acknowledgments

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DIVERS WITH ASTHMA: AN INVESTIGATION IS REQUIRED

Douglas Walker

"For any complex question there is a solution which is simple, appealing...and wrong."

There is undoubted logic in the medical opinion which states that asthmatics will be exposed to excessive risk if they attempt to scuba dive and should therefore never be granted permission to do so if a medical fitness certificate is requested.¹ Certainly it is the medical dogma in Australia that such people are subject to an unacceptable increased risk of morbidity and death should they be in an environment of changing ambient pressure. Questioning of self-evident truths requires an open-minded attitude which is not always easily reconciled with the advantages of accepting what is the local shibboleth. Unless we continually check the fit of what we believe against new data we are claiming that everything which there is to know is already known and understood.^{2,3} In reference to the subject of asthma and diving it is timely to remember that in England a more relaxed opinion is held and there had not been any evidence of increased morbidity among scuba divers as a result.⁴

Nobody researches problems they believe fully understood. It is therefore necessary first to question the obvious, a worthwhile undertaking even if it only confirms the validity of beliefs. The fact that some asthmatics do indeed scuba dive cannot be denied,^{5,6} a few coming to