ARE ASTHMATICS FIT TO DIVE?

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PREFACE

For many years, physicians, divers, and diving organizations have struggled with the issue of safety for the asthmatic individual who wishes to participate in diving activities requiring the use of devices supplying compressed gas. Clearly, compressed air diving is not a blatantly lethal or morbid experience for the individual with asthma. Unfortunately, theoretical considerations and available, albeit limited, quantitative observations fail to reassure critical observers that the risks associated with compressed gas diving are similar for both asthmatic and non-asthmatic individuals. In this ambiguous setting, organizational guidelines, recommendations of physicians and compliance with patients have followed diverse, inconsistent pathways that seem determined, in part, to self-interest rather than safety.

Predictably, governmental-military organizations, wishing to minimize operational and liability risks, issue conservative regulations, generally excluding asthmatic individuals from compressed air diving. Diverse non-governmental organizations generally offer more liberal but discrepant guidelines that reflect the divergent beliefs held by members of various diving communities. Physicians, faced with a paucity of scientific data and concerns about their liability for not opposing an activity that is inherently risky for even the healthy person, may recommend against diving when the additional risk is minimal. The professional diver, anxious to preserve his occupational status, more likely than not will conceal from his physician diverse symptoms including manifestations of asthma. Also. the individual seeking to dive for recreational purposes has a vested interest in avoiding externally imposed constraints, and is likely to deny respiratory illness. The extreme example, observed during a recreational trip, is of physician parents allowing their asthmatic child to scuba dive.

Inevitably, this chaotic tableau of decision making and behavior has triggered a much-needed convening of experts in diving medicine and physiology. They have critically reviewed both the pathophysiological bases for concern and available data regarding the asthmatic individual participating in compressed gas diving. Distinguished experts have presented thoughtful cases, supported by available data, in defense of and in opposition to more permissive guidelines. Areas of agreement and disagreement have been delineated. The presenters and audience have shared a dialogue that has helped define important questions that require additional research for resolution. Finally, the panel has considered these proceedings into 12 consensus statements, providing more coherent and generally more permissive guidelines for assessing the fitness of asthmatic individuals to dive.

This observer was greatly encouraged by the free and thoughtful exchange of ideas that characterized this symposium. In addition to the contents of this document, serving as a useful reference for the diving community, future research, stimulated by this undertaking, should yield new information and more definitive guidelines in the years ahead.

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ARE ASTHMATICS FIT TO DIVE?

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NOTE: A few of the speakers cannot be identified from the tapes and some names may be wrongly transcribed. To them we offer our apologies.

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INTRODUCTION

D. H. Elliott

Welcome to the "Sunshine State," but I regret Florida is trying to give a new meaning to the words "Underwater Symposium."

Today should be a turning point in this series of "Fit-to-Dive" meetings. These have been running for some years as courses, originally for the benefit of those who certify professional divers for fitness to dive, but it was obvious at the first meeting in Hawaii that the majority of people attending were more interested in the recreational diver. Since then we've been looking at both aspects in parallel.

But what emerged last year, and is summed up in the objectives of this meeting today, is the realization that doctors are going to have trouble with the Americans With Disabilities Act (and similar laws in other countries) unless we could justify what we're doing when we make a person unfit.

OBJECTIVE

The theme of the 1994 FIT TO DIVE meeting in Denver was a review of the Americans with Disabilities Act and its medical implications on fitness to dive. Several prominent attorneys told us that, in making a person unfit to dive, medical judgement is no longer sufficient. The law now expects evidence that any specific deficit in an individual's health which disqualifies them medically from diving would, in fact, compromise his or her safety. It was conceded that this would be difficult and it seems improbable that the courts would demand controlled trials between, for example, those who have and those who have not a spontaneous pneumothorax. But, as yet, no precedent has been set.

The outcome, after much discussion, is that there is a need to develop appropriate consensus guidelines for medical assessment and, where possible, some pass/fail standards.

It is the objective of this meeting to make progress toward a consensus on guidelines for divers and their doctors on asthma and fitness to dive.

In essence, the purpose of this meeting is not only to educate, but also to try and achieve agreement. The very least we will do is to identify the areas of difference where consensus may not be achievable, but that too will be very important.

The structure is to begin with invited speakers, and then this afternoon to pursue one or two consensus statements which everybody will be able to debate.

THE COINCIDENCE OF ASTHMA AND MORBIDITY OR MORTALITY IN RECREATIONAL SCUBA DIVERS INVOLVING UNITED STATES CITIZENSAND REPORTED TO DIVERS ALERT NETWORK (DAN)

G. Yancey Mebane

I will present some information that we have at the Divers Alert Network in regard to decompression illnesses and fatalities related to asthma in some way or other. The mission of DAN is to assist divers and, in addition, to collect dive injury and fatality data.

First, when we ask individuals whether they have asthma, we have in mind the disease coded by the International Coding System as unspecified asthma 493.9. Whether that individual has the same thing in mind when answering the question is open to doubt. Individuals frequently are not able to say what asthma is. The lay person may not understand and may think of a variety of illnesses as asthma. So we have a problem to begin with.

Our information comes from the completion of a form which generally is done by the individual, except in the case of a fatality when, obviously, it's done by someone else. So this is more or less a volunteer effort on the part of the diver, that they will or will not complete this form. Most chambers throughout the country are provided with this form. Eventually it arrives at DAN headquarters and is entered into the database.

When these forms are received, the individuals are contacted, if possible by telephone, to flush out some of the questions that are missed. Nevertheless the precision is certainly not 100%. Over the years we've received about 4,500 forms of which 3,000 entered the database. Some 1,500 forms have been discarded (about a third) for one reason or another, usually incompleteness or they weren't decompression sickness.

During this period, 1988–1994, there were 369 cases of arterial gas embolism; 2,720 of decompression sickness. Of this group, 23 individuals who had arterial gas embolism responded that they also had asthma. There were 123 individuals who had decompression sickness and also responded that they had asthma. So that the total respondents with decompression illness was 126 as 20 persons had both gas embolism and decompression sickness. I think the last line is also of some interest. Fifty-nine of that 126 had indicated on their form a second medical problem.

So now, how do we distinguish what the influence of asthma was as compared to whatever the other medical illness was, which may have been quite significant. So these are the individuals who had a decompression illness which they survived, and this group also indicated that they had some form of asthma according to their interpretation.

One cannot look at any of these numbers and come up with an incidence rate. Incidence rates are not available in diving injuries, since the basic information is not there. A study was done by DAN in which 1,000 individuals who were members of DAN were sent a form about

asthma. Of that 1,000, approximately 700 responded, and 50 of them had or did have asthma at the time. These individuals had done almost 6,000 dives and they did not have any problem, which indicates that there are some 600 "asthmatic"divers out there who have been diving and who have not had a problem, but it doesn't tell you anything about the incidence of diving with asthma.

The problem of course is that it was just a simple mailing and not a random survey. Asthmatics may not have answered, and there are untold problems with that kind of a study. So I don't think that helps us very much.

Let's look at fatalities. DAN collects information on diving deaths of U.S. citizens and fatalities occurring within United States waters. In the last 8 or 9 years, the average fatality incidents has been about 100 per year. The total has oscillated around the 90–100 mark. During this period of study there have been approximately 700 or 800 fatalities. During that length of time, we have three fatalities where there was some indication that asthma was present. And I thought I would just read these three cases to you and you can make up your own minds as to whether asthma had anything to do with the outcome.

First was a physician who had had ulcerative colitis, had had a colostomy, and had developed asthma after his surgery. He was diving out of the country and was found dead on the surface after about 10 minutes of dive time. He was using oral medications and using an inhaler for his asthma at the time. Unfortunately the autopsy was done out of the United States and so we do not have a report. This is an instance of an individual who was signed out as drowning by the local medical authorities also had these other problems. You could postulate that asthma did have something to do with this, but it's not possible to state conclusively that it did. But you do have an individual who died who was known to have asthma.

A similar situation was a female who was a beginning diver and was diving offshore in the open ocean on the West Coast, not a significantly deep dive, but probably under some environmental stress. After a dive at 17 feet for 20 minutes, she returned to the surface and indicated to her companion she wasn't feeling well. They started swimming toward shore. She felt further difficulties and dropped her weight belt. By the time she was assisted to a nearby breakwater she was cyanotic and was not breathing. The medical examiner decided this was death due to unknown natural causes. I'm not sure that he knew she had asthma. So you could postulate that she did have an asthmatic attack and either drowned at the surface, or for whatever reason developed a sudden death. The obesity didn't help; she also had nonalcoholic liver disease. So again, an individual with a history of asthma who died while diving. And whether we can say more than that, I'm not sure.

The third case is a male who was making an open water training dive—and this was the free ascent dive or buddy breathing ascent. At the surface he was found unresponsive by the instructor, who rescued the diver and performed CPR. He did have bubbles on autopsy within the coronary circulation and in the cerebral veins. An epinephrine inhaler was found in his dive bag.

The autopsy showed left ventricular hypertrophy, which is considered an absolute contraindication to diving, and coronary artery disease. Defining the proximate cause is not possible, and perhaps it was related to all three.

This next study was interesting. This is from a university where the team physicians had 304 varsity athletes. Of that 304, they knew that 8 had asthma, so they did challenge tests on the remaining 295, just as a study. They were trying to predict exercise-induced asthma in this

group of athletes: who might have trouble and who didn't. It was very interesting, out of that almost 300 group of athletes, 50 responded positively to the methacholine challenge test and of that 50, 35 had a greater than 20% decrease in FEV_1. What does that mean to us as far as examining divers and predicting whether they will develop either asthma or exercise-induced asthma?

Dr. Elliott: In introducing the next speaker, let me say that the whole point of inviting Dr. Mark Harries to talk to us is because many of us have very definite opinions on the relationship between asthma and fitness to dive. So it is important for us to have somebody to review the subject who has no preconceived ideas about diving, and yet is familiar with water sports. Mark is eminent in the World Surf Lifesavers Association; editor of the *Oxford Textbook of Sports Medicine*, in which he wrote the chapter on asthma; clinical director of medicine in a large postgraduate hospital, and medical director of the British Olympic Medical Center.

WHY ASTHMATICS SHOULD BE ALLOWED TO DIVE

Mark Harries

Introduction

It has been agreed that gas can readily escape from the bronchial tree despite the increased intra-luminal secretions or airways narrowing encountered in the asthmatic diver, and so gas trapping should not prove a problem (1). But bronchial constriction induced by inhaling cold, dry gas or by exercise can be severe enough to pose a significant risk due to a reduction in exercise tolerance. Effective treatment means a return to normal lung function and a return to diving. It is the responsibility of the diving physician to recognize asthma, assess its severity, and to provide effective treatment.

Physiologic considerations

The normal lung may be regarded as a membrane one cell thick (the alveolar capillary membrane) with blood on one side and alveolar air on the other. The membrane covers a surface area roughly the size of a tennis court and offers no barrier to gas diffusion. CO_2 and oxygen pass across freely down a concentration gradient. At rest, alveolar ventilation (Va) is perfectly matched with perfusion (Q), ensuring that air and blood are always on opposite sides of the membrane at the same time. Oxygen is only sparingly soluble in plasma, but oxygen transport is transformed by the presence of hemoglobin, each gram of which takes up to 1.36 ml of oxygen. The reaction takes a fraction of a second and erythrocytes become fully saturated first pass through the lungs, and this remains true (though not quite) almost to the limits of physical capability. Any fall in hemoglobin percentage saturation therefore indicates a mismatch of perfusion with ventilation (Va/Q defect, or a shunt).

Importance of high minute ventilation for working divers

Energy for physical activity derives from a cycle of chemical reactions in which glucose and free fatty acids are burned, liberating carbon dioxide. There are oxygen-dependent reactions. Higher demands can be met, but only over very short periods, by metabolizing glucose anaerobically with sodium lactate the product. Unlike CO_2, lactate is non-diffusible and begins to accumulate in plasma at levels beyond 4 mmol · liter^{-1} inhibiting further physical activity.

The rate at which oxygen is consumed therefore provides an indication of work rate. The level at which work can be sustained is bounded by the point at which lactate begins to accumulate. To increase work rate (oxygen consumption), both cardiac output and lung output (minute ventilation) must also increase until this threshold is reached. Minute ventilation and oxygen consumption have a linear relationship, the higher the oxygen consumption, the higher also must be the minute ventilation (Fig. 1).

Do the lungs limit aerobic power?

Minute volume is the product of breath volume and the respiratory rate and is limited absolutely to the resistance to air flow imparted by the convulsions of the respiratory tract. These flow limits are demarcated by the maximal effort flow volume curve. Air flow rate at the mouth falls form peak expiratory flow (PEF) at total lung capacity (TLC) at the beginning of

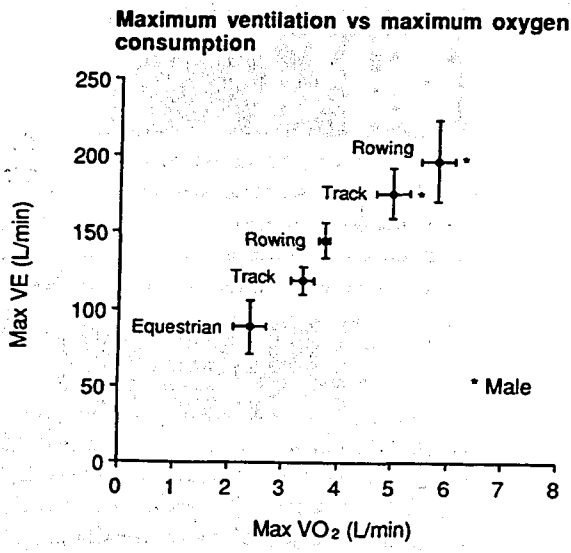

Fig. 1—High minute ventilation is needed to achieve high oxygen consumption. Minute ventilation is measured during sustained maximal exercise testing in a sample of Olympic competitors ranging from equestrians to rowers

expiration, to reach zero at residual volume (RV), at the end of expiration. The mean is best defined as the flow rate reached at mid-expiration, in other words, at 50% of vital capacity (MEF50% liter · min^{-1}) during a forced expiratory maneuver (2).

Average breath frequency measured in elite male athletes exercising close to their maximum sustainable ventilatory capacity (MSCV) is in the range of 60 and 80 breaths a minute with the mean around 70, or roughly one breach per second (Fig. 2). This falls well short of the maximum that is achievable (maximum minute ventilation, MVV) which lies in the range 100–120 breaths per minute. Average breath volume at MSVC is only around half of the volume that can be forcibly expired in 1 second (FEV_1) and about 40% of vital capacity (Fig. 3).

So during exercise there is the capability to increase both respiratory rate and breath volume to reach the boundaries of the flow loop at MVV. Indeed, minute ventilation can be raised still further by breathing a mix in which helium replaces nitrogen, indicating that the limiting factor is the resistance to passage of gases in the airways rather than a mechanical failure of the muscles of the chest wall (3). These considerations have led to the assumption that factors other than pulmonary mechanics limit tissue oxygen delivery, and these include hemoglobin concentration and cardiac output. If normal, the lungs should offer no limitation at all to aerobic capacity. But there are a number of conditions in which structure and function of the lung are far from normal and which undoubtedly do limit aerobic capacity, and asthma is one such.

How airways obstruction (asthma) limits ventilation (aerobic power)

During inspiration, the bronchioles lengthen and widen, returning to their original dimensions by elastic recoil in expiration. During light-to-moderate exercise, inspiration and expiration are equal in length, but as the level of exercise increases, expiration occupies a greater proportion

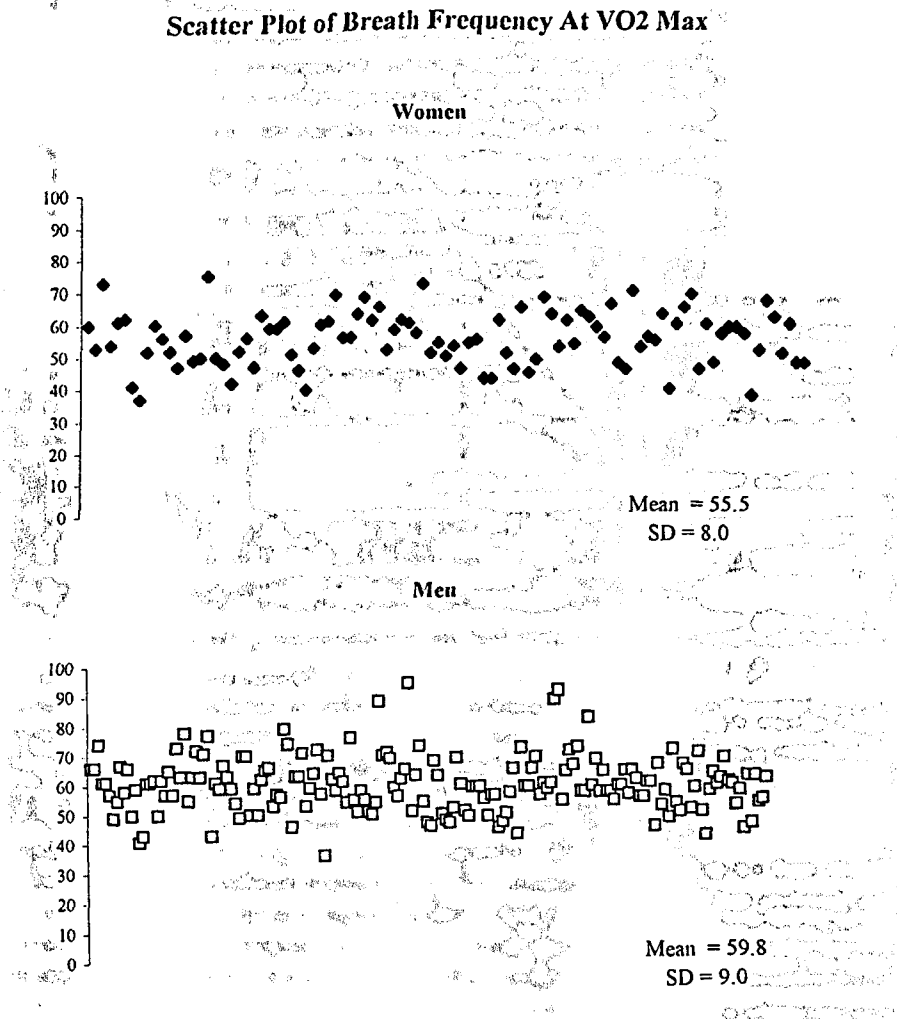

Fig. 2—Breath frequency is shown on a scatter plot recorded during sustained maximal exercise tests performed on a large number of elite sportsmen and women. Mean breath rate for male Olympic competitors exercising at their sustainable maximum is around one breath per second.

of the respiratory cycle and becomes a more active process. Any obstruction of the airways not only prolongs the expiratory phase but also demands a greater expiratory effort, with the result that intrathoracic pressure rises. Respiratory bronchioles that are unsupported by cartilage then tend to collapse, causing a fall in mid-expiratory flow (MEF_{50}) and producing a highly characteristic scalloping of the expiratory flow loop (4).

Asthma is an important condition to recognize in any person wishing to dive, because the airways narrowing can be triggered by exercise or by breathing cold or dry air, any of which the diver is especially likely to encounter. Indeed, a single exercise test may be enough to precipitate incapacitating airways obstruction (Fig. 4). By definition, asthma is a condition in

which obstruction to the airways is variable, and so simple spirometric measurements alone may reveal no abnormality. For this reason a bronchial provocation test is desirable if the subject at risk is to be identified. Both histamine and methacholine inhalation have been used, but an exercise test is the more pragmatic and, what is more, can be conducted with complete safety without the necessary laboratory support required for inhalation tests.

Relationship between FEV1 and Breath Volume at Maximal Aerobic Exercise

	FEV1(l)	*Breath Volume (l)*	*Ratio of Breath Volume to FEV1*
Elite Male Rowers (n=8)			
Mean	5.82	2.99	51.93
Confidence Level (95%)	0.45	0.17	4.55
Elite Male Middle Distance Runners (n=10)			
Mean	4.91	2.93	60.92
Confidence Level (95%)	0.43	0.14	6.84

FIG. 3—Average breath volume measured in world-class male athletes exercising at their sustainable maximum shows that only around 50% of FEV_1 is accessed each breath. If mean breath rate is 60 (Fig. 2) minute veltilation (MV) can be estimated: $MV = 1/2FEV_1 \times 60$.

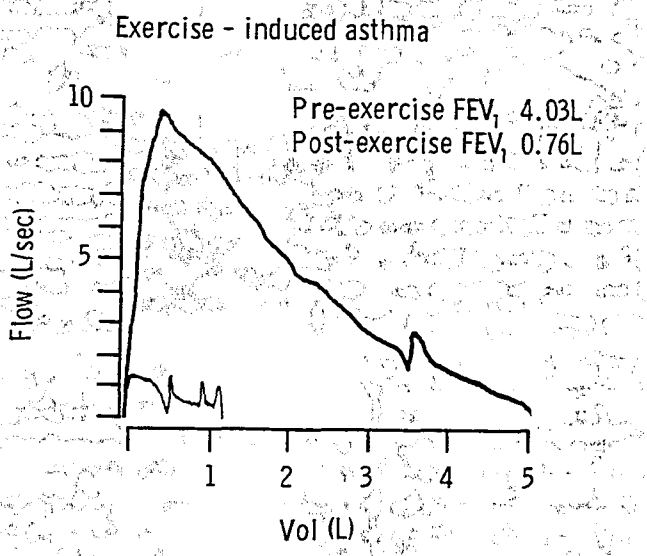

FIG. 4—An example of very severe exercise-induced asthma. Pre-exercise FEV_1 measured over 4 liter falling to less than 1 liter 5 minutes after exercise. Note also the dramatic fall in vital capacity from 5 to less than 1 liter. Bronchial constriction was so marked that the subject was unable to speak and would have been severely compromised had this occurred at depth.

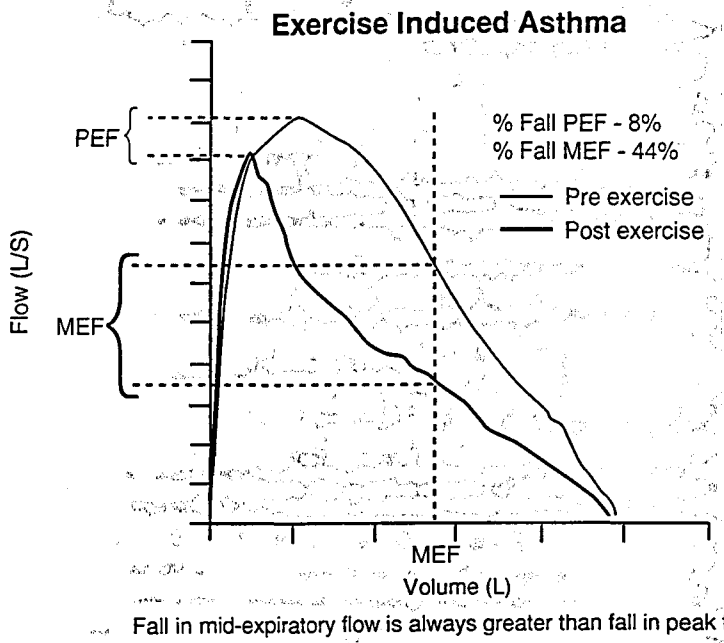

Fig. 5—Fall in mid-expiratory flow is a more sensitive indicator of exercise asthma (and therefore of underlying asthma) than fall in peak flow of FEV_1. In the example shown, post-exercise fall in peak flow is not greater enough for a diagnosis of exercise asthma to be reached (fall in peak flow must be more than 20%), but mid-expiratory flow (MEF) falls by 44%, clearly an abnormal test indicating exercise-induced asthma.

Identifying the asthmatic diver with an exercise test

All asthmatics wheeze on exercise and an exercise test does no more than reveal an underlying bronchial hyper-responsiveness (5). While there is no standard test protocol, certain ingredients are important. Running in the open air is a more potent stimulus to bronchial constriction than exercising on a treadmill or bicycle ergometer. The reasons for this are complex and are related in part to climatic conditions. Cold, dry air causes more bronchial constriction than warm, moist air. The exercise must be vigorous, sufficient to raise the heart rate to around 80% of the maximum that can be achieved (220 minus age in years). The duration of the test is also important. It should last at least 3 minutes, but need not take more than 5 minutes to complete.

Most test protocols compare either peak flow (PEF) or FEV_1 before and about 5 minutes after exercise. A fall in either value of more than 20% is said to be diagnostic. But a much more sensitive measure is a comparison of the fall in mid-expiratory flow (MEF50%). In the example shown (Fig. 5), fall in peak flow reached 8%, a negative test, and fall in mid-expiratory flow was 44%, so clearly this was an asthmatic subject.

Treatment of exercise-induced asthma

Bad exercise-induced symptoms imply poor asthma control. Treatment is the same as that given to any asthmatic, using inhaled corticosteroid as the mainstay. The modern dry powder breath-actuated delivery systems (Fluticasone Accuhaler, Beclomethasone Diskhaler, and

Budesonide Turbohaler) are superior to metered dose inhalers, with the added advantage that protection is provided with twice-daily medication, once in the morning and once in the evening. If doses in excess of 2,000 μg daily fail to suppress symptoms, systemic medication should be considered. β-agonists, Cromolyn and theophylins provide only short-term symptom relief and are best used as adjuncts to inhaled steroid therapy (6).

Conclusions

- Asthmatics who dive are at risk from exercise limitation, not peripheral gas trapping.
- Well-controlled asthmatics face no problems, but an exercise test is required to gauge asthma severity.
- Fall in mid-expiratory flow (MEF50%) post-exercise is a more sensitive indicator of asthma than fall in either PEF or FEV_1.
- Subjects with a post-exercise fall in MEF of more than 50% are at risk.
- Exercise asthma is best controlled with inhaled corticosteroid taken twice daily.

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DISCUSSION

Dr. Faesecke: Having shown the role of temperature, could you say something about the role of humidity, because the diver, for obvious reasons, breathes a totally dry air?

Dr. Harries: Many publications by Regis McFadden and others show the influence of drying the air on bronchial hyperactivity, interpreted as change in histamine sensitivity, but we don't have the data here.

Unidentified Speaker: It is not reasonable for all athletes to have pulmonary function tests, so are there clues in the examination that would help you to decide whether an individual has any problems with airway reactivity?

Dr. Harries: The answer to that is no. There's no way of guessing it. You must do an exercise test in my view, and flow loop spirometry is so simple that at a cost of a few hundred dollars it should be in every physician's office.

Unidentified Speaker: Is there any value in, for example, listening during a forced expiration?

Dr. Harries: Yes, if you listen over the trachea during forced expiration, whether air flow obstruction is due to asthma or to chronic bronchitis and emphysema, they will have a prolonged expiratory phase and will make a noise in expiration. It is a beautiful clinical rule: don't listen

over the lung for asthma, listen over the trachea.

Dr. Saltzman: I'd like to expand on this elegant presentation with a few points that I think are germane. First, patients with impaired pulmonary function often can perform surprisingly well and I'm not convinced that one can use parameters such as mid-flow reliably to predict the outcome of a particular impairment. The other point is that, for asthmatics in general, the risk of hypoxemia is a consequence of failure to exhale CO_2 with ensuing hypercapnia and, ultimately, anesthetic depression of respiration. I think perhaps one needs to focus on that point in considering limitations for diving.

Dr. Harries: Well, taking your second point, air flow obstruction has to be very severe indeed to witness any change in the P_{CO_2}. As you know, during the early stages of an asthma attack, P_{CO_2} falls, then rises to normal. It's only when there is airway plugging and alveolar hypoventilation that the P_{CO_2} begins to rise. So it's a sign of a patient who is *in extremis* and, in many cases, an indication for mechanical ventilation.

Concerning your point about the collapse of airways in expiratory flow, it is very important for the primary physician to witness the performance of forced air expiration test, because it may tell you straight away that the patient is cooking the result. It's very easy to see someone who is not doing it properly. It is vital that you do not rely on your technician to do this. If you want to make an accurate diagnosis, you do it yourself.

In my experience, those who are trying to say that they've got a condition which they haven't are not able to produce airways collapse in expiration. It is something that cannot be faked, and it's highly reproducible and in my experience, highly reliable.

Dr. Kelleher: We screen a number of divers and submariners with pulmonary function tests (PFT) and a number have low ratios. Please comment on the pattern of a large lung volume and what you might then see in a flow volume loop.

Do you see a peaking in scaphoid expiratory---

Dr. Harries: No, we see the very best athletes in the world with the very biggest lungs and if they're normal, they have a normal expiratory loop. So you don't see that in normal lungs, however big they are.

Dr. Torre: I have a comment not a question. First a quick introduction. I'm on the National Faculty of the National Asthma Education Program coordinated by the National Institutes of Health. The National Faculty consists of asthma experts who give asthma management lectures around the United States to primary physicians.

You can't always tell if someone is having an asthma episode clinically by listening, because the peak flow rate or FEV_1 usually has to be below 70–80% of expected value to hear wheezing and, as you said, many severe asthmatics present with coughing not wheezing. The history actually offers the best clues for picking up asthma. Symptoms like coughing, wheezing, or shortness of breath with exposure to allergens, irritants, cold air, exercise, or for more than 10 days following an upper respiratory infection all increase the likelihood of asthma. Past diagnosis like asthmatic bronchitis, reactive airway disease, and recurrent bronchitis (except perhaps in a smoker) are all likely to reflect asthma. If one were to pursue these types of clues in the history, many more people may be diagnosed as having asthma with the appropriate pulmonary function testing. An important point is that people with asthma may present without a history of wheezing, but still need to be diagnosed to receive proper treatment, and of course this may be even more important for the diver, to lower the risk of possible consequences.

Dr. Harries: Can I first of all concur with everything you said and say that it accords exactly

with what an earlier questioner said, and that is that the severe asthmatic may not necessarily have a wheeze. The young man who had the most severe exercise asthma that I've seen in years, presented with no story that might have suggested he was bad, save the fact that he was waking in the middle of the night unable to sleep.

Dr. Torre: But one of the signs of severe asthma according to the NIH Guidelines is frequent nocturnal symptoms. Just a quick example of another person with significant symptoms but no wheezing: I've done a number of asthma seminars with an Olympic Gold Medal "asthma" swimmer in whom the diagnosis of asthma was missed until an on-deck physician suspected the diagnosis while hearing her cough just after her attempt to win her fourth gold medal. Despite the fact that she had been seen by numerous physicians as part of the Olympics; that her father was a physician and gave allergy shots to her brother with asthma (and many other patients as well); that she occasionally became so short of breath after exercise, she literally passed out; that she routinely had severe coughing with exercise—the diagnosis of asthma had never been made because wheezing was not part of her symptom complex. Again, coughing was the primary symptom, and while physicians may not have been aware of it in the 1980s, it is very important to recognize cough variant asthma now in the 1990s. I see a significant number of divers coughing after dives with a typical asthma cough, who insist they don't have asthma. The problem is that untreated they still have all the theoretical risks of those diagnosed as having asthma, without the advantage of appropriate medication to normalize their pulmonary functions.

THE question—the one BIG question: From your data, I gather that you're saying that if you can normalize an asthmatic's pulmonary function tests, including post-exercise, your feeling is that he should really be relatively safe?

Dr. Harries: Completely.

Dr. Torre: Okay, I concur with that.

Unidentified Speaker: Are you suggesting to me, as a person who screens a lot of divers initially and continues to screen them throughout their career, that I can have a person who is going to suddenly develop asthma? Or are you saying that if I screen them at one point and they're okay, I can forget asthma in the future?

Dr. Harries: I'm sure there are many who have had the experience of a perfectly normal subject who, out of the blue, gets an upper respiratory viral respiratory infection, followed by the most severe asthma which never clears. You can test them when they're perfectly normal and you see nothing, and 6 months later they get a viral infection which renders them asthmatic and converts them into persistent bronchial hyperactivity. All you can do is to certify that at the time that you tested your patient, they did not have air flow obstruction which was severe enough to preclude them from diving. It doesn't tell you that they're never going to get asthma.

Unidentified Speaker: So, if I have a person who understands that he is probably going to lose his livelihood if he admits to these symptoms, essentially I would have to do the provocative testing every year in order to say that at this point in time this person does not---

Dr. Harries: No, I don't think so. You need to do it once and you certify that at the time you did that test it was normal.

Dr. Elliott: Thank you. In fact, you've anticipated the comment that I was going to make, and that is the difference between the average hospital patient, who wants the best possible diagnosis, and on occasion a professional diver who wants to avoid losing his job.

Dr. Harries: I couldn't agree more. It 's very difficult to answer that question without

appearing to be discourteous to our subjects. It's essential that the physician monitors and observes the test. It takes a lot of experience, and you shouldn't leave it to the practice nurse or to the technician.

Dr. Torre: A "plug" for having a consensus: One of the problems we face in New Jersey (where there are many asthmatics, many divers, and many asthmatics who dive) is that many divers or potential divers lie about having asthma in order to be "allowed" to dive. When this occurs, it is unlikely that the person will receive appropriate treatment; the dive shop or instructor will not make a physician referral and the usual treating physician is not likely to have given instructions related to asthma and diving. If in fact we develop a consensus, the diver will be able to admit to having asthma and therefore get the appropriate physician referral. With published guidelines (both the fitness to dive consensus we are trying to develop today, as well as the NIH asthma diagnosis and management guidelines already available), the physician will be better able to evaluate the patient's ability to dive and develop a management plan to optimize both asthma control and diving safety. If one lies about asthma, the chances of getting appropriate management are nil and the risks are, in fact, much greater.

Dr. Harries: You have kindly summarized exactly what I've tried to say in the last 45 minutes. That is: there is no reason why asthmatics should not dive.

Dr. Sanchez: What percentage of FEV_1 would you accept for asthmatics to be able to dive? If you bring them back to normal, what percentage?

Dr. Harries: That will be discussed this afternoon. The literature says that exercise-induced asthma is diagnosed when FEV_1 falls by 20%. Some people say 15%, others say other percentages. I suggest that you draw the line at a fall in mid-expiratory flow at greater than 20% below the predicted.

A REVIEW OF SPIROMETRY AND UK SUBMARINE ESCAPE TRAINING TANK INCIDENTS (1987–1993) USING OBJECTIVE DIAGNOSTIC CRITERIA

P. J. Benton, J. D. Woodfine, and T. J. R. Francis

The training facility

The Submarine Escape Training Tank (SETT) at HMS *Dolphin* was opened in 1954 as the center for Royal Navy submarine escape training. During its 39 years of operation (it was closed for an extensive refit in 1974) all Royal Navy submariners have undergone escape training at this facility.

The SETT is a cylindrical tank, 30 meters deep and 5.4 meters in diameter, filled with warm, fresh water. Entry into the water may be made from the surface, at various depths through a system of locks, or from a diving bell. The air locks at 9, 18, and 30 meters are designed to simulate submarine compartments while the air lock at 28 meters is a one-man escape tower similar to that found in most classes of Royal Navy submarines.

The training schedules

The Submarine Escape Training Review Committee (SETRC) was established following the death of three trainees undergoing submarine escape training over the period 1970–1974. It was tasked with reviewing submarine escape training in the Royal Navy. In its report (1), a number of recommendations were made, among which was that there be a requirement for accurate statistical data to be recorded on all ascents and incidents. Before 1974, detailed data were not recorded; indeed between 1954 and 1965 no distinction was made between buoyant ascents and those made as part of other "in-water" training. The 1974 SETRC report also concluded that the 100-foot (30 m) buoyant ascent was no longer essential and that, since it accounted for no less than 40% of all the incidents in the tank, it should be removed from the training schedule. From 1975 to 1994, the training schedule has been as follows:

Initial trainees:

(a) Two buoyant ascents from the 9-meter lock.
(b) One buoyant ascent from the 18-meter lock.
(c) One unpressurized "dry" run in the 30-meter lock.
(d) One 28-meter hooded ascent from the SET.

Requalifiers:

(a) One buoyant ascent from the 9-meter lock.
(b) One unpressurized "dry" run in the 30-meter lock.
(c) One 28-meter hooded ascent from the SET.

All submariners are required to undergo initial submarine escape training, requalify 3 years later, and thereafter every 4½ years. After the age of 35, submariners may choose to requalify "dry" (unpressurized), as may trained submariners who are assessed as medically unfit for "wet" pressurized SET training.

Lung function testing

Another recommendation of the SETRC Report was that all trainees should have routine spirometry performed before undertaking SETT. The objective of this was to identify and exclude trainees with any evidence of obstructive airways disease, as this was thought to be potentially a predisposing factor for PBT.

Classification of SETT incidents

A SETT incident report is raised in all cases where the Officer in Charge of the SETT considers that a significant event has occurred. Unfortunately, the definition of a significant event is unclear. Extreme illustrations of this are the lack of incident reports following the therapeutic recompression of two trainees in the 1950s and the occasional recompression of trainees for no apparent reason. In general, incident reports are raised on all cases where recompression therapy was initiated as well as cases where there was evidence of diving-related diseases which did not require recompression.

In previous reviews of SETT accidents (1–5), incidents that resulted in diagnoses of AGE or PBT, according to the Pearson Criteria (2), have been labeled as "accidents." However, the validity of the Pearson Criteria, in light of current thinking, is open to question. While the presence of radiographic or clinical evidence of extra-alveolar gas are specific to PBT, the presence of frothy, blood-stained sputum, although a sign of PBT, can also occur in cases of near-drowning, acute congestive cardiac failure, and a number of other less common medical conditions. Furthermore, it is readily confused with the blood-stained saliva or sputum which commonly occurs following sinus barotrauma or simply from accidental biting of the tongue or cheek. The potential for misdiagnosis can be illustrated by an incident in which the decision to recompress the subject appears to have been based primarily on the presence of blood in the man's mouth, which was subsequently found to have arisen from an epistaxis.

The criteria for the diagnosis of AGE may also be criticized for lacking specificity, as it is now recognized that it may be undistinguishable, clinically, from decompression sickness. The rapid onset of neurological symptoms and/or signs is not exclusive to AGE and may occur in cases where dissolved inert gas is an equally likely pathogenetic mechanism (6). Thus, use of an arbitrary latent interval does not necessarily promote accurate diagnosis.

In previous reviews of SETT accidents, dissolved inert gas as a significant factor in the development of disease has not been considered as it has been assumed that the pressure/time exposures in the SETT are such that the inert gas burden, and hence risk of decompression sickness, is so small as to be insignificant. As part of this study, this assumption has been reviewed. An estimate of the gas burden of a tissue (Q) can be made by use of the equation (7):

$$Q = P\sqrt{t}$$

where P is the absolute pressure and t is the time spent at pressure. The time spent under pressure in the 9- and 18-meter locks, and the 30-meter submarine section, before a trainee makes his ascent, will depend on the number of trainees ahead of him, but is unlikely to be

greater than 10 minutes. The 28-meter SETT ascent takes approximately 1 minute from the start of compression to reaching the surface. There may be occasions when, due to difficulty in equalizing middle ear pressure during descent, trainees will spend longer periods but, even in these cases, Table 1 reveals that their gas burden will be considerably less than that of the diver who carries out a maximum no-stop dive permitted for that depth by current Royal Navy decompression tables (8).

Given the negligible gas burden imposd by the SETT ascent, the past practice of ascribing overt, short-latency, neurological manifestations to PBT and arterial gas embolism is considered reasonable. However, the inert gas burden following the 18- and 30-meter ascents, although small, is not negligible and the same assumption cannot be made with confidence.

The difficulty in attempting to ascribe an origin for the disease-provoking gas can be illustrated by an incident which involved an instructor who had been assisting a group of trainees make 30-meter buoyant ascents. On completion, he made a slow, free ascent to the surface. Within 1 minute of reaching the surface, he reported a progressive weakness of his left arm which rapidly resolved on recompression. In all previous reviews of SETT incidents (1–5) this incident has been categorized as having been caused by AGE on the basis of the rapid onset of symptoms, despite there having been no clinical signs or investigations compatible with a diagnosis of PBT. Evaluation of the dive profile reveals that this individual had accumulated a substantial inert gas burden (maximum depth of 30.6 meters for a total bottom time of about 20 minutes, Q = 18.2) and the possibility that his signs and symptoms were the result of dissolved gas cannot be ignored. Consequently, in this study a descriptive approach to the diagnosis of past SETT accidents was adopted.

However, this approach was complicated by the treatment policy which was in force over the period; namely, "if in doubt, treat." Although the rapid recompression of an individual with confirmed DCI is the treatment of choice, recompression is not without risk to the patient and attendant. In many of the incidents the decision to "pot" the trainee was made on the evidence of minimal symptoms and without any neurological examination being performed. In the very brief time available for assessment, neurological DCI could be confused with, for example, the headache of sinus barotrauma, middle or inner ear barotrauma, alternobaric vertigo, or syncope of any origin. The limited information which is therefore available made accurate, retrospective diagnosis difficult.

Table 1: Values of Q for SETT Ascents and for Maximum No-stop Dives (RN Table 11) to Equivalent Depths

Depth, m	Time in Lock, min	Value of Q for Sett	No-stop Time, min	Value of Q for No-stop Dive
9	10	6.00	–	–
18	10	8.85	60	21.69
30	10	12.65	20	17.89
28 SETT	1	3.80	20	16.99
28 SETT	4	7.60	20	16.99

In an earlier study (9), Brooks and Pethybridge analyzed the spirometry results of all SETT trainees since 1975. Somewhat surprisingly, they reported an association between PBT and low FVC rather than spirometric indices of obstructive airways disease. However, the diagnosis of PBT in the study was made by application of the Pearson Criteria (2). The aim of this study was to determine whether the association holds true when the diagnosis of PBT was made using more objective criteria.

Methods

All of the SETT incidents which occurred since the implementation of the SETRC Report were analyzed and divided into five groups on the basis of the probability of PBT being the causative mechanism, the five categories being defined as follows:

Group 1: Cases were there was clinical and/or x-ray confirmation of pulmonary barotrauma.
Group 2: Cases were there was an insignificant inert gas burden and positive diagnosis of neurological DCI of short latency (less than 10 minutes) had been made.
Group 3: Cases where, although AGE following pulmonary barotrauma cannot be excluded, there was a significant inert gas burden and/or uncertainty as to the diagnosis of neurological DCI.
Group 4: Cases where there was a significant gas burden and long latency (range 90 to 210 minutes) before the onset of symptoms.
Group 5: Cases where pulmonary barotrauma can be excluded. This includes cases of ENT and dental barotrauma, and cases where there was no obvious reason for recompression.

For each case, the Standard Residual (SR) for the FEV_1, FVC, and FEV_1:FVC ratio was calculated as follows:

$$SR = \frac{Observed - Predicted}{1\ Standard\ Deviation\ of\ Predicted}$$

The predicted values used being derived from the Brooks and Pethybridge study of spirometric values in normal submariners (3).

Results

The number of each type of ascent made during the period 1975–1993 is shown in Table 2.

Between 1975 and 1993 there were 44 incidents involving initial trainees and 8 involving requalifiers. The incident rates being 0.61/1,000 ascents for initial trainees and 0.18/1,000 ascents for requalifiers. The incident rate for initial trainees and requalifiers combined being 0.48/1,000 ascents. Trainee incidents which followed pressure exposures other than standard ascents are not included in these figures.

In Table 3 the 50 cases are listed by group with the Standard Residual (SR) of FEV_1, FVC, and FEV_1:FVC ratio.

Cumulative distribution of SR of FVC for the groups defined above is plotted in Fig. 1.

This reveals that the SR of FVC for each of the five cases allocated to group 1 and the three

cases allocated to group 2 has a negative value. Since the FVC of submariners is normally distributed (9), then the probability that a random sample of five (group 1) should all have negative values is less than 3% ($P < 0.03$). If groups 1 and 2 are combined (as it is difficult to conceive a mechanism of causation other than arterial gas embolism following subclinical PBT in the cases allocated to group 2), the probability that a random sample of eight trainees should all have negative values of standardized residual of FVC is less than 0.4% ($P < 0.004$) and as such must be considered to be statistically significant. Examination of the standardized residuals of FEV_1 and FEV_1:FVC revealed no correlation between their values and the incidence of PBT.

Table 2: Number of Ascents made by Trainees from 1975–1993

Depth	Initial Trainees	Requalifiers	Total
9 m	36,388	16,364	52,752
18 m	17,877	–	17,877
SETT	17,642	16,226	33,868
Total	71,907	32,590	104,497

Table 3: Standardized Residual of FEV_1, FVC, and FEV_1:FVC Ratio by Diagnostic Group for SETT Trainee Incidents 1975–1993

Group 1

Incident Number	Depth	SR FEV_1	SR FVC	SR FEV_1:FVC
134	SETT	–0.41	–0.61	0.29
142	18	–1.92	–2.01	–0.09
145	18	0.54	–0.40	1.38
167	9	–1.29	–0.88	–0.74
187	18	–0.65	–1.46	1.12

Group 2

Incident Number	Depth	SR FEV_1	SR FVC	SR FEV_1:FVC
136	SETT	0.24	–0.43	1.02
185	SETT	–0.77	–0.51	–0.47
188	SETT	0.33	–0.50	1.11

Group 3

Incident Number	Depth	SR FEV_1	SR FVC	SR FEV_1:FVC
128	SETT	−1.80	−2.18	0.57
131	SETT	−0.51	−0.63	0.11
132	18	−0.53	0.11	−0.93
133	18	0.41	−0.37	1.14
135	SETT	−1.40	−1.04	−0.71
137	SETT	0.30	0.47	−0.23
138	SETT	0.44	0.48	−0.01
139	SETT	−0.47	−1.15	0.91
140	18	−0.20	−0.67	0.60
141	18	−1.03	0.01	−1.38
143	SETT	−1.27	−0.41	−1.31
144	SETT	1.57	1.85	−0.22
147	SETT	1.24	0.36	1.15
148	SETT	−1.30	−2.36	1.57
149	SETT	−1.33	−2.19	1.07
150	SETT	0.03	−0.38	0.49
151	SETT	−1.22	−2.36	1.72
156	9	−1.03	−2.28	1.74
157	9	1.37	1.40	0.13
158	SETT	0.34	2.02	−1.73
160[a]	SETT	1.16	0.82	0.49
161	SETT	0.58	−0.94	2.31
162	9	−0.04	0.62	−0.71
164	18	−0.58	−2.17	2.20
165	18	−0.41	−0.33	−0.18
166	18	0.78	−0.11	1.18

Group 3, *continued*

Incident Number	Depth	SR FEV_1	SR FVC	SR FEV_1:FVC
168	SETT	1.04	0.58	0.65
169	SETT	–0.27	0.15	–0.67
170	18	–0.33	–0.37	0.01
171	SETT	–0.66	–0.47	–0.33
181	18	–0.78	–0.59	–0.37
183	9	–0.30	–2.09	2.62
191	18	–1.45	–2.85	1.91

[a]No values available from date of incident (1985), values given from 1980.

Group 4

Incident Number	Depth	SR FEV_1	SR FVC	SR FEV_1:FVC
130	18	–3.82	–3.68	–0.74
163	18	0.32	0.30	0.04
190	18	–1.73	–1.28	–0.88

Group 5

Incident Number	Depth	SR FEV_1	SR FVC	SR FEV_1:FVC
129[b]	9	–	–	–
146	18	–1.06	–1.63	0.78
155	SETT	0.47	–0.28	1.06
175	9	0.57	0.11	0.68
178	SETT	2.25	1.55	0.89
186[c]	SETT	1.32	–0.21	1.76

[b] No record of height available, therefore not possible to calculate values of SR.

[c]No values available from date of incident (1991), values given from 1987.

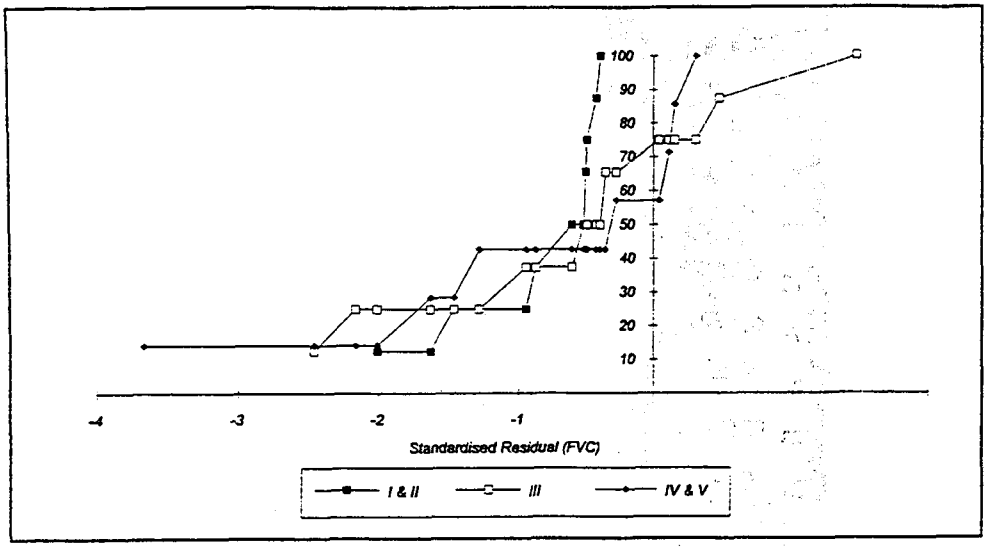

FIG. 1—Cumulative distribution of standardized residual of FVC by group.

Discussion

Routine spirometry has been carried out on all trainees since 1975 in an attempt to identify those who may be at an increased risk of PBT. When this policy was introduced, it was considered that those with evidence of obstructive airways disease were the at-risk group and trainees with an FEV_1:FVC ratio of less than 75% at initial training and 70% subsequently were excluded from training. Since 1982 this was discontinued in favor of permitting such candidates for SETT to undergo training regardless of their spirometric values provided that full lung function testing, including provocation testing (by exercise), lung volumes (by helium dilution), and transfer factor were normal and there was no contraindication to SETT in their medical history or physical examination. The value of the FVC per se was not an excluding criterion over the whole time period of this study. However, those with a very large FVC (and consequently liable to have a low FEV_1:FVC ratio) may have been excluded from 1975 to 1982. Consequently, it is possible that the value of FVC for the 50 trainees involved in incidents in this study was not normally distributed

This study confirms an association between low values of FVC and PBT, with all individuals with PBT having FVCs below that which would be predicted on the basis of their height and age. However, only one individual had a standardized residual of FVC greater than –2. Thus determining an exclusion criterion based on the measurement of FVC may be difficult because a "low" FVC appears to be insufficiently specific for the purpose of identifying those individuals at risk of developing PBT. It is however of note that 20% of all reported SETT incidents since 1975 have involved individuals with standardized residuals of FVC greater than –2. This is 8 times the predicted figure. Thus, using an exclusion criterion of FVC of more than 2 standard deviations below the predicted value may not prevent all cases of PBT; it might be predicted to prevent 20% of SETT incidents. It is of interest that there appears to be no association between low values of spirometric indices of obstructive airways disease (FEV_1 or FEV_1:FVC ratio) and SETT incidents.

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DISCUSSION

Dr. Elliott: Questions as to fact, please. Let's not get into the general debate.

Dr. Harries: No debate. Genuine statistical question. You assume the distribution of the standardized residual was normal and my assumption is you mean a Gaussian normal?

Dr. Francis: Yes.

Dr. Harries: I am not sure, however, that that assumption is necessarily valid because it assumes then that there's an equal distribution of big standardized residuals versus small standardized residuals. However, anything that might affect somebody's vital capacity, forced or otherwise, would more tend to make it small rather than large. What would happen if you reexamined your data statistically, not making the assumption that there's a Gaussian normal distribution, but in fact half of a normal Gaussian distribution, i.e., instead of it being two-tailed, having one tail?

Dr. Francis: We could certainly do that, but the way we did it: 0.4% as a probability is highly significant. If it goes to half of that because it's really a one-tailed affair rather than a two-tailed affair, that doesn't necessarily change statistical significance.

Dr. Sanchez: Just a question, maybe I missed it, but I thought you were screening out the submariners having very low FEV_1:FVC ratio?

Dr. Francis: No. We have decided not to do that anymore and there were two reasons for this. First, the Navy didn't like it because they were losing 12% of potential submariners and they asked us to look at what we were doing and why, and could we justify this loss of manpower? We thought about it for a while, and then said can we really justify these values, which had been plucked out of the sky, effectively. So we couldn't justify the values. What we

did was to say, right, we will ignore the absolute value of FEV_1:FVC ratio with respect to making people fit or unfit to dive, and check out the rest of their lung functions and see if that is normal. We carried on doing these measurements at unit level as a screening test and those who quote "failed" the criteria came to be examined at the lab at INM. So we don't screen them out, we examine them closely.

Unidentified Speaker: The volume is an interesting observation and I think it's gotten everybody sort of scratching their heads about what it means. You mentioned that you thought that this was small lung volume for the body size.

Dr. Francis: Yes.

Unidentified Speaker: Is that indeed the case, or is it just small people with small lung volume with essentially normal volume to body size?

Dr. Francis: The people come in all shapes and sizes and it's just that their FVC is below predicted, given a normal subject.

Dr. Örnhagen: When you measure the forced expiration in the laboratory, the flow restriction is mostly caused by dynamic closure of the small airways. During the ascent you have expansion of the gas in the alveoli and there should therefore be no such effect. Do you have any explanation except for the fact that you also have immersion during the ascent?

Dr. Francis: Sir, I don't quite understand your question.

Dr. Örnhagen: The difference between the laboratory and being in water is the immersion pooling a large amount of blood in the pulmonary circulation. Could that be an explanation, because I don't think that the dynamic restriction of flow really exists in the ascent situation.

Dr. Francis: I don't know how to explain this. What I'm putting forward to you is an observation based on a very large number of ascents made by a great number of people, and it came as a surprise to us because we had all thought that obstruction might be associated with pulmonary barotrauma, and that was clearly not the case. The only thing that did have a statistical association was an index of restriction.

Dr. Örnhagen: So there is no hypothesis?

Dr. Francis: I have no hypothesis.

Dr. Örnhagen: Thank you.

Dr. Elliott: Following a discussion with Dr. Torre during the break, I would now like to ask him to summarize for us a classification of asthmatics which has just come out from NIH.

Dr. Torre: When I introduced myself before, I mentioned the lectures we give for the National Asthma Education Program of the National Institutes of Health on the diagnosis and treatment of asthma. These lectures typically last an hour or more and address six areas that are crucial to proper care including: (1) education of patients to develop a partnership in care; (2) objective measurements as peak flow and spirometry; (3) environmental control measures and avoidance of triggers; (4) establishing plans for both exacerbations, as well as (5) long-term management, and finally (6) the need for providing regular follow-up care. In my allotted time, I will discuss those aspects that I feel are most important for our fitness-to-dive seminar today.

Before the 1990s, asthma was considered to be a reversible airway disease primarily characterized by bronchospasm and therefore treated with bronchodilators. In 1991, with a better understanding of the pathophysiology of asthma, a new definition included not only reversible airway obstruction but stressed chronic airway inflammation and the resultant hyper-reactivity. This increased reactivity or responsiveness causes constriction of the airway to stimuli that would normally have little or no effect and is related to the degree of airway

inflammation. For divers this means that the more inflamed your airways are (from allergen exposure, respiratory infection, etc.), the more likely exercise or cold, dry air associated with scuba will precipitate an asthma episode and the more severe the episode will be. Questions about past history of childhood asthma which is "outgrown" may really be moot. Chronic inflammation can persist a lifetime with "temporary remissions" seemingly suggesting that the patient no longer has asthma. Often, if a careful history is taken, recent symptoms may be uncovered like nocturnal coughing, exercise-induced coughing or shortness of breath, colds that "go to the chest" or take more than 10 days to clear up, all of which point to the patient's having a current diagnosis of asthma according to the Global guidelines, and without proper treatment place the diver at an increased risk.

For the remainder of my time I want to discuss the present classification of asthma and its relationship to proper therapy. Three sets of guidelines have now been published. The NHLBI (National Heart, Lung and Blood Institute, division of the NIH) where the first set of guidelines, published in 1991, and these were mailed to every physician in the United States. The International Consensus Report followed in June of 1992. In January 1995 the NHLBI and the World Health Organization combined to form the Global Initiative for Asthma (GINA) workshop report which I will discuss today. It's important to remember that these are guidelines not biblical rules; however, they do represent the "state of the art" management and should be followed as closely as possible to obtain the best outcome for our patients.

Asthma is currently classified into four categories based on the severity and frequency of symptoms (the original guidelines had three).

The first category is *Mild intermittent asthma*. Clinical features (before treatment) include intermittent symptoms, less than once a week, associated with a less than 20% fall in peak flow or FEV_1; brief exacerbations lasting a few hours to a few days; nocturnal symptoms occurring less than twice a month; between exacerbations patients should be asymptomatic with normal or near (within 80%)-normal pulmonary functions. This distinction is really very important because this is the only classification that does not require maintenance anti-inflammatory medicine. Many people think they have mild asthma, with symptoms much more often than allowed for in this classification. This is important for our "land-based" patients, but may be even more crucial in our diving population. If untreated, the underlying inflammation that occurs in all the other steps would increase airway responsiveness as mentioned earlier, and make diving more likely to cause some airway obstruction with resultant consequences.

A few words about the terms we use in assessing airway obstruction. The peak expiratory flow rate (PEFR) or peak flow for short measures flow rate in the largest of the airways and occurs during the first 150 milliseconds of forced expiration; this measurement correlates best with bronchospasm. Peak flow meters can be used by the patient and physician alike, with most costing $20.00–$30.00. The FEF_{25-75} (forced expiratory flow measuring the flow rate exclusive of the first and last quarters of the vital capacity) corresponds to the smaller airways and correlates best with the amount of inflammation. This value can only be measured with a spirometer and is therefore done only in the physician's office or a hospital. The FEV_1 (forced expiratory volume expired in the first second) is considered by many to be the most useful measurement because it includes all of the peak flow as well as the earlier portion of the FEF_{25-75}. This is also generally done with a spirometer, but recently a small, portable device called SPIRO-1 was developed costing about $120.00 which measures both peak flow and FEV_1. In fact, one can even suspect a lowered FEF_{25-75} value if the patient has a normal peak

flow but a reduced FEV_1. According to the guidelines, everyone with the diagnosis of asthma should have a spirometry performed as well as those patients needing pulmonary function testing to help confirm the diagnosis. From my personal point of view, anyone doing diving medical evaluations should at least have a SPIRO-1 to evaluate basic airway function.

Back to the treatment of mild episodic (intermittent) asthma. The treatment of choice here is the intermittent use of short-acting β-agonists (the bronchodilators) on an as-needed basis. However, if the patient has periods when symptoms occur more than a couple of times a week or if the FEV_1 or peak flow fails by more than 20%, his classification and therefore treatment plan changes according to the appropriate step. So another point: the classification is variable, patients may move from class to class depending on their circumstances, and therapy is dependent on their particular classification at the time.

The next step is *Mild persistent asthma.* Like mild intermittent, peak flows should be normal or near normal with less than 20% variation, though now symptoms occur more than once a week (but still less than once a day) and exacerbations affect sleep, with nighttime symptoms greater than twice a month. The symptoms and changes in pulmonary function are still mild but occur on a more regular basis. Treatment now requires daily anti-inflammatory (e.g., Cromolyn or Nedcromil) as a "controller." Other anti-inflammatory measures should also take place, including environmental controls and avoidance of allergic triggers. The short-acting bronchodilators are still used for rescue medication, but you don't expect to use it more than a couple of times a day and ideally less than three times a week after the anti-inflammatory measures take effect. Long-acting bronchodilators may be used at night to prevent nocturnal symptoms (particularly while waiting for the anti-inflammatory measures to "kick in").

Step three is *Moderate persistent asthma.* It is important to remember that the presence of *even one* objective or clinical feature is enough to place the patient in that category of severity. Symptoms (even cough) may occur daily OR symptoms interfere with activity or sleep (with nighttime symptoms greater than once a week) OR there is daily use of (short acting) bronchodilators. Objectively, PEFR or FEV_1 are generally between 60 and 80% of predicted with variations of 30% or greater. Again, many patients have the above symptoms and really believe they have mild asthma; worse yet, some patients with the above symptoms and/or their physicians still insist they don't have asthma at all. An article in *Diver's Alert Network* about a year ago pointed this out very well. One reader wrote in and asked "Every time I exercise, I cough; my doctor told me I don't have asthma. Can I dive?" The answer—if your doctor says you don't have asthma, you can dive. Well, any asthma expert and by now all those in this room know that if you cough with exercise, you probably have asthma. I assume the physician did no pulmonary function studies and certainly not an exercise challenge. Saying you don't have asthma certainly fulfills our present criteria for fitness to dive, but unfortunately it's not in the patient's best interest. Denial of the disease doesn't make it go away, and the inability to recognize asthma is probably the worst thing we can do for our patients, especially those that dive. Chronic inflammation, if untreated for 5 years, leads to remodeling and permanent airway damage.

Interestingly, most patients I see who do not realize they have asthma, actually fall into the moderate category. They have significant coughing episodes a few times a week, especially with exertion and at night (so both daytime activity and sleep are affected), but often suspect post-nasal drip as the cause of their coughs. As one would anticipate from a patient with symptoms compatible with moderate asthma, the pulmonary functions even at baseline are significantly

affected. If this patient is a scuba diver, it is even more important to pursue the correct diagnosis and severity classification. Not only can the base-line airway function place the diver at more risk, but with the increased airway responsiveness, the diver is more likely to have an acute exacerbation during the dive or the surface swim.

Treatment of moderate persistent asthma requires daily "controller" medications, generally inhaled steroids. Environmental control and avoidance of triggers is even more important in this category. Bronchodilators are used as needed, but our goal is to reduce the *need* for "rescue" medication to several times a day, and ideally to only several times a week. Remember, the more inflammation, the more variable the pulmonary functions will be, and the more frequent and severe the symptoms will be. The basic strategy then is to use "enough" anti-inflammatory therapy so the moderate persistent patient *on* medication will essentially be similar to the mild episodic patient *off* medication. If one cannot meet this goal, the maintenance management must be reevaluated. Allergy immunotherapy may also be useful in both the mild persistent and moderate persistent patient as another anti-inflammatory modality.

The fourth category is *Severe persistent asthma*. These are the patients with continuous symptoms and peak flows or FEV_1 of 60% of normal or less. Because of the severe inflammatory process, the smaller airways are more significantly involved. The FEF_{25-75} is the best measure for this and is generally low. As a simple screen, the base-line FEV_1, as mentioned before, will more accurately reflect the degree of obstruction than the peak flow rate which *only* correlates with the larger airways. Exacerbations with a 30% or more fall in peak flow or FEV_1 occur frequently. Physical activity is limited by asthma symptoms, and nocturnal symptoms, as seen in the first case presented today, occur frequently as well. Remember that any one feature is sufficient to place a patient into the more severe category because in that first patient only the nocturnal symptoms revealed him to be in the severe category; his changes in flow rates seemed to suggest a milder process. Treatment of severe, persistent asthma consists of multiple daily controller (anti-inflammatory) medications including "high dose" inhaled steroids. Long-acting bronchodilators like theophylline and/or long-acting β-agonists are also appropriate. Oral corticosteroids may be used for a 7–14 day acute course to decrease inflammation and increase responsiveness to the β-agonists as well. Many times daily or alternate-day oral steroids may also be necessary for maintenance.

An important point to remember: No matter what the severity, the goal is to use enough anti-inflammatory modalities, including medication as well as environmental controls and possibly allergy shots, to achieve "control of asthma." Control consists of minimal (ideally no) chronic symptoms including nocturnal, normal exercise tolerance, infrequent episodes; no emergency visits, and minimal (less than two or three times a week) need for PRN β-agonist bronchodilator therapy.

In my talk today I have shown only the medication summary slides. One interested in the entire presentation for the future to get a more complete understanding of asthma can contact me directly or arrange for a local speaker by contacting the NHLBI National Asthma Education Program.

Dr. Elliott: That was really a statement straight off the press—further discussion will occur later.

The South Pacific Undersea Medical Society has just had its annual workshop on this same topic, and so it is with particular pleasure I ask Des Gorman, who is president of that society, to share with us what they concluded.

THE BASIS FOR THE PASS/FAIL CRITERIA USE IN AUSTRALIA AND NEW ZEALAND

D. F. Gorman

What I'd like to do is review the local general practice, with respect to the assessment of fitness for diving in Australia and New Zealand in the context of asthmatics, and then to quickly outline the SPUMS policy which arose from the workshop we held recently in Fiji.

The fundamental questions are those that are common to any form of health surveillance, and are reasonably simply answered in the context of asthma and diving.

- Is the condition or the treatment of the condition important?
- Is the condition prevalent?
- Are there sensitive and specific screens?
- Is the condition consequently worthy of screening?

I will now address the importance of asthma and the worth of screening for this condition. First, I will consider the prevalence of the condition in our subject population. The prevalence of asthma in our communities is extremely high. Most conservative surveys in Australia and New Zealand suggest that just under 30% of the total population will wheeze at some stage in their life. It follows that the dogmatic stance that people who wheeze at any time are not fit for diving will effectively prevent a third of our population from ever diving.

It is possible to determine the importance of asthma in diving by considering three questions. First, will diving make the divers' asthma or its treatment worse? Certainly, diving may precipitate an asthma attack, by a combination of exercise and breathing a dry, cold gas or alternatively by breathing a salt-water aerosol, and by consequent anxiety, stress, and panic.

Second, will asthma or the treatment of asthma compromise the divers' or their buddies' safety in the water? It is obvious that even a moderate asthma attack will make it very difficult for the diver to survive—for example, it would be impossible for them to swim 400 meters against a knot and a half of current.

Third, will asthma or the treatment of asthma predispose the diver to a diving-related illness? There is at least a theoretical increased risk of pulmonary barotrauma in asthmatics, and some bronchodilators will impair the ability of the lungs to filter venous bubbles.

Consequently, most Australian doctors will discourage people from diving if they have a history of current, active asthma. It follows that the requirement here is for a definition of asthma currency. The Australian and New Zealand Thoracic Society produced a position paper in this regard (*Med J Aust* 1993; 158:275–279), and chose a 5-year period of disease and medication absence. The choice of 5 years was a compromise; the people who led this debate were actually arguing for 3, that is, if someone hadn't taken medication or hadn't had any symptoms of asthma in the last 3–5 years, then the Thoracic Society argued that there is no requirement for any further survey and that such individuals should not be discouraged from diving.

Most attention in Australasia in this context then is focused on how best to determine the risk in diving for people with a past history of asthma. Many practitioners rely on spirometry alone; but you've heard from James Francis today about the lack of predictive power for FEV_1 data and FEV_1:FVC ratios and the weak prediction of risk that can be deduced from FVC data.

A point needs to be made here in the context of the use of spirometry and FVC data in diver fitness. We have a crazy situation in the two navies that I'm involved with—the Australian and the New Zealand navies—of doing annual spirometry on divers to help determine their fitness for diving. Given that our own data show that the only predictive measure, FVC, does not decrease significantly with either age or diving, there is no requirement, in the absence of lung disease or injury, to measure a diver's FVC more than once.

Some Australian practitioners use exercise in their consulting rooms to test for active asthma. Far more often however, a practitioner will request either a hypertonic saline or methacholine/histamine challenge. Hypertonic saline was chosen as a method of detecting exercise-induced asthma, on the basis of exercise inducing asthma by changes in bronchial tonicity. The result of this test in Australia varies enormously.

In Sandra Anderson's laboratory at the University of Sydney, hypertonic saline testing has a high sensitivity. Elsewhere, a very high false negative rate is often reported. The latter is particularly true in asthmatics who are treated with regular inhaled steroids. Histamine and methacholine tests are going out of favor in Australia and New Zealand because of false positive rates of about 20%.

Finally, it is worth noting that diving medical assessments in our part of the world are shifting from a prescribed format to one of discretion; based on a determination and explanation of risk and an ongoing monitoring of health. The latter process is compatible with some (former or inactive) asthmatics diving.

What I'd like to do now, on behalf of the South Pacific Underwater Medical Society, is to review the Society's policy on asthma and diving. This policy was developed during the workshop held at our meeting in Fiji last month.

This is the policy as it will appear in our Journal. First, the Society makes a statement about the prevalence of asthma in Australasia.

"A *history of asthma is common in diving candidates.*" This is a relative understatement. *"The assessment of risk for a diving candidate with a history of asthma should be conducted by a medical practitioner who has had training in diving medicine."* This is an argument that the members of SPUMS believe in very strongly.

Second, the Society has a policy on the importance of asthma in diving. *"Asthma is a potential cause of mortality and morbidity in divers. The level of risk in this context needs to be measured. Diving may precipitate an asthma attack, and asthmatics are at risk of shortness of breath, panic, and drowning on the water surface."* It is possible that we've worried for too long about pulmonary barotrauma in asthmatics and overlooked the far more likely scenario of an asthmatic drowning on the surface. Certainly, local analyses of diving deaths show that asthmatics who die while diving, usually do so by drowning on the water surface.

The Society also has a policy statement on the nature of existing groups of diving asthmatics. *"Asthmatics who dive may be a self-selected population, and the experience of this group may not be representative of the risks of diving for the general asthmatic population."* Of relevance here is the infamous BSAC epidemiological survey; which I believe is a role model of

"how not to do such studies."

Third, SPUMS has a policy on relative risks for asthmatics who dive. *"Current information suggests that the relative risk for asthmatics who dive compared with non-asthmatics for decompression illness is about two."* These data are soft and need to be considered in context. It would appear that even for novices doing emergency ascent training, the risk of some injury with an emergency ascent is about one in 20,000 to one in 60,000. Consequently, even if the relative risk is about two, the actual risk is still low.

Fourth, SPUMS has a policy on the assessment of risk for a diving candidate with a history of asthma. *"The society believes that the determination of risk for diving for someone with a history of asthma requires a gradation of the severity and currency of their asthma.*

"Risk stratification for someone with a history of asthma who wishes to dive would require a thorough history and examination, and often lung function testing, including provocation tests." It is again noteworthy that in many laboratories, medicated asthmatics are not showing any abnormalities on their provocation tests—the basis of a reasonable argument for their fitness to dive.

Finally, SPUMS recognizes the lack of objective data in this context. *"As the risk for diving in someone with a history of asthma is uncertain, permanent records should be retained as part of a SPUMS-sponsored study."*

Thank you very much.

Dr. Elliott: Thank you Des. We will take questions and discuss this, if we may, after the next speaker, who is here to represent the British SubAqua Club.

ASSESSMENT OF ASTHMATIC DIVERS IN THE UK

Patrick Farrell

The BSAC Medical Committee no longer exists and we now have a U.K. Sports Diving Medical Committee pooled from an amalgamation of the BSAC, the Scottish SubAqua Club, and the SubAqua Association to set unified standards for the U.K. It's really on their behalf that I'm here, although much of the data come from BSAC.

Today I'd like to discuss the experience of allowing asthmatics to dive for the past 15–20 years. By 1980, the BSAC Medical Committee was aware that there were many asthmatics diving despite advice to the contrary. We couldn't stop them and the BSAC Committee at that time prepared a set of empirical standards to try and protect those considered to be most at risk.

These were basically: you could dive if you had asthma in childhood: you had not wheezed in the previous 48 hours or used a β_2 agonist; you were allowed inhaled steroids. But diving was banned if you had cold-induced, exercise-induced, or emotion-induced asthma. Interestingly, nobody defined how to assess cold, exercise, or emotion. It was left to the individual doctor.

At the end of the 1980s we looked at the statistics and we could find no asthma deaths in the BSAC accident record. There were no accurate figures at the time for air embolism or decompression illness in the U.K. Most of the centers at that time didn't exchange such information.

This has changed dramatically since the formation of the British Hyperbaric Association and the Royal Navy Data Base. What is now regarded as an infamous study was designed in 1990 by Pete Glanville and myself. We organized a postal questionnaire in *Diver* magazine and found 104 surviving asthmatic divers with 12,000 dives and no episodes of air embolism or pneumothorax. We had a group of severe asthmatics who wheezed daily who had managed over 1,000 dives uneventfully (50% claimed to have no idea of current recommendations); but the study, as I said, was well criticized.

Peter and I at this point set out on a prospective study which we started virtually as soon as the previous correspondence was finished. The prospective study uses a similar postal questionnaire to the original study. We have most of the original cohort; we have new divers taking up the sport; we have old diving asthmatics who surfaced "through the grapevine."

The data are unpublished as the study has several years to run yet. However, we have over 250 asthmatic divers in the study and they had done over 20,000 uneventful dives. We've had more than 20 free ascents without problems. They still don't know the current recommendations for asthmatic divers. The asthma care of most, regrettably, does not follow British Thoracic Society guidelines and, in fact, it's lamentably poor.

At the end of 1994, I looked at whether the asthmatics were getting more gas embolism or decompression illness than the rest of the diving population. Like other people who run chambers, we didn't see asthmatics. So we took 25 of the BSAC medical referees at random and sent them a letter to get details from a number of branches, e.g., how many people are in your

club, how many take asthma medication, and how many regard themselves as asthmatic? We have about 70,000 divers in the U.K. and we found that about 4% of the diving population is probably asthmatic. I then asked all the chambers, the Hyperbaric Association, and the Institute of Naval Medicine how many people they have treated in the period 1991–1993. We found 393 non-asthmatics and 9 asthmatics. There was no statistical difference between the normal population and the asthmatics.

This year the new Medical Committee has redrawn the original asthma standard, and this is how it will look:

U.K. Sports Diving Medical Committee Asthma Standard

"The theoretical risks should be fully explained to the asthmatic diver. There is little, if any, evidence that the moderate, controlled asthmatic who follows the guidelines below is more at risk than the normal population. Asthmatics may dive if they have allergic asthma, but not if they have cold-induced, exercise-induced, or emotion-induced asthma. All asthmatics should be managed in accordance with the British Thoracic Society guidelines. Only well-controlled asthmatics may dive. Asthmatics should not dive if they have needed a bronchodilator in the last 48 hours or have any other chest symptoms."

The diving asthmatic should not need more than occasional bronchodilators, i.e., daily use would disqualify, but inhaled steroids are allowable. During the diving season he or she should measure peak flow twice daily. A deviation of 10% from best should exclude diving until within 10% of best values, for at least 48 hours.

The diver should perform an exercise test, such as the 18-inch step test, running but not on a bicycle ergometer for 3 minutes, and a decrease in peak flow of 15% for 3 minutes should be taken as evidence of exercise-induced bronchial constriction, and hence disallow. The reason we chose a step test on a peak flow is it can be done in any doctor's surgery. Most doctors in the U.K. do not have access to spirometry or lung flow volume loops. If you consider 4% of 70,000 divers, that is a lot of folk to get through.

We also said on advice that a β_2 agonist may be taken pre-diving as a preventative, but not to relieve bronchial spasm at the time. Despite the possibility of shunting, we feel it would contribute a lot to psychological well-being to take it "just in case."

That's the new standard. It will be available to each asthmatic diver with, when it's written, an explanatory booklet on symptoms and how diving may affect the condition.

We believe that prohibition fails in those countries where asthmatics are banned. We believe in selection and education, which has to be the way forward with this group. Of course we are not interested in letting people dive who go to the ITU twice a week. They shouldn't be anywhere near the boat, let alone in the water.

So can asthmatics dive? In the amateur world, yes, I believe they can. They always have a choice as to whether they get into the water. In the commercial or military world, a diver cannot say to a supervisor, "I don't feel like going into the water. I'm a bit wheezy today." That is not realistic.

DISCUSSION

Dr. Elliott: We can now discuss the last two papers.

Dr. Saltzman: A question for the last speaker. One of the concerns in compiling statistics

for divers is that the worst outcome occurs; the diver does not return to shore and does not fill out a questionnaire. Is your survey reliable in terms of including people who may not have been fortunate enough to return to shore?

Dr. Farrell: We know what the dropout rate is in the prospective study, and fortunately in the U.K. all the accident deaths are reported, so we can check asthmatic deaths off against our database, and so if they don't return, we would know about it.

Dr. Torre: Are these people allowed to be on maintenance medication like Thumalin or Tilade or inhaled steroids before they do the exercise-induced test, or is that without any medication?

Dr. Farrell: The exercise test is done on their normal medication. We believe everybody should be managed in accordance with the British Thoracic Society guidelines, so if they're on inhaled steroids, they have the exercise test, if it's normal that is fine, and if it isn't, it isn't.

Unidentified Speaker: I have a question for Dr. Gorman on the predictive value of methacholine challenge. The statement was made that methacholine challenge has too high a false positive rate to be useful, and I wonder if that could be broken down into positive and negative predictive values and what is the cutoff used to make that statement?

Dr. Gorman: There was a survey done by the Australian-New Zealand Thoracic Society, and in an unselected population of people with no history ever of asthma and no clinical findings of asthma they found an abnormal response to histamine.

Dr. Kelleher: I'd like to comment on the statistics from the INM database. First, we don't keep track of deaths at all unless they died in a chamber. We receive reports from the chambers throughout the United Kingdom, but if they died on the surface and were never recompressed, we wouldn't receive a report.

Second, I think it's important to look at the statistics as you have done. I would just like to mention that in the 9 out of the 393 that were reported as asthmatics there was at least one that was clearly an asthma attack that was provoked at depth. The individual surfaced unconscious and then had a recurrence of the asthma attack in the hyperbaric chamber. So although there's no difference, I think it's worth mentioning the individual case just to reflect that there may be a true risk, although it appears to be small.

Dr. Bove: I have a question for Des and I think I asked this question a couple of weeks ago in Fiji. When you do predictive testing, you need to define an end point. I thought I heard you say exercise testing was an end point, but my question is that when the predictive testing is done, is there a clear-cut end point? Because I got a sense that the end point in some cases was the result of the test, rather than some other outcome.

Dr. Gorman: What answer did I give you a couple of weeks ago, Fred?

Dr. Bove: I don't think you gave me a clear answer.

Dr. Gorman: Well, I hope your expectations are no higher now. You're quite right. The end point is often the test itself. For some of the tests there are reasonable nomograms: for hypertonic saline it's 15%, for example. At the SPUMS workshop, the argument is for a 20% shift, but you're quite right, the end points are the tests themselves.

Dr. Francis: Patrick, as you are well aware, the investigation of diving deaths in the U.K. is far from systematic. So although we may not be aware of asthmatics who died diving, that doesn't mean they don't exist. It's just that they haven't been looked for properly.

Dr. Farrell: I'm not entirely sure that's true because certainly the BSAC incident reports have been looking into the deaths for the last 3 years for anybody who has been asthmatic. They come

straight to my desk as a matter of course.

Dr. Francis: Yes, indeed, but you have no control over who does the postmortem investigation and that, we know, is often too elementary.

Dr. Elliott: The debate will begin after the two next presentations, the first one of which is to be Tom Neuman, who will propose the case for allowing asthmatics to dive.

THE CASE FOR ALLOWING ASTHMATICS TO DIVE

Tom S. Neuman

Let me begin by taking a slide from the cover of an early SPUMS journal that was shown last year and try to answer the question of whether "anyone can do it."

There are some striking theoretical reasons why asthmatics should not dive, and those theoretical considerations are:

1. obstruction can lead to arterial gas embolism;
2. overpressurization can lead to arterial gas embolism; and
3. decreased compliance has also been associated with arterial gas embolism.

Since all those things are associated with asthma, and since there was an extraordinarily well-done study by Wagner that showed that marked abnormalities in ventilation perfusion ratios exist even in asymptomatic asthmatics, and that as many as half the perfused lung units can be ventilated only by collaterals; this led to a theoretical consideration—and it seemed reasonable at the time—that asthmatics simply should not dive. It was open and shut.

On the other hand, asthma is not one disease, and as has been explained earlier, there are variations and gradations of asthma, and it ranges in severity from those with the most severe disease to essentially those without disease at all (without symptoms and without complaints) from whom maybe the only thing that you ever hear is that they cough a little bit longer after a cold than folks without asthma. It makes little difference whether you look at FEV_1 or FEF_{25-75}, you see the same kind of variation in asthma.

So do we really have to treat every asthmatic in exactly the same way? I think the answer to that intuitively ought to be no.

Now, how did I get involved with this whole asthma business, and how did I really change my mind? I was trained, like many of the people in this room, by the Navy—and that was: If you had an asthma attack after the age of 12 you didn't dive. Period.

Several years ago there was a fitness to dive symposium that was sponsored by the Undersea and Hyperbaric Medical Society, and Paul Linaweaver was the moderator. Paul asked me to construct a straw man. He asked me to go and look at the data and come up with the statement that "everybody can dive" and that straw man would then be attacked.

And so I did. And I discovered something rather interesting. At the time, it was a few years ago, the risk of being shot to death *while diving* was greater than the combined risk of asthma, epilepsy, or diabetes while diving. I presented that at the symposium and of course there were people there who said, "Well, Tom, the answer to that is obvious. The reason that none of these folks show up in the fatality statistics is because they don't dive. It's selection bias."

And I said wait a minute. I give this "asthmatics shouldn't dive" talk twice a month, and there are always six guys at the back of the room who raise their hand and say, "You mean I shouldn't have been diving for the last 10 years?"

As a result of that, we did a study—and this was the first one that I'm aware of. Just like Dr. Farrell's study, it had its limitations to say the least; We looked at the prevalence of asthma,

diabetes, and epilepsy in a population of newly certified divers whom we got from PADI. Approximately 1,700 questionnaires were mailed out and, as usual, 1,300 didn't respond.

We had 405 negative responses, six were returned in the mail for incorrect addresses, but we did have 45 affirmative replies, which represented about 2.6% of the entire population. Even if you assume that the only people who were likely to respond to such a study were the ones who had the disease or condition, still 2½% of folks gave positive responses. If you assumed that the distribution of responses was the same across the whole population, then we're talking slightly more than 10%.

Well, that was the first one but it was by no means the only study that had been done. There is the study that Dr. Farrell did several years ago. I am going to present some data here that you've seen before, but in a magazine with a circulation of 38,000, there were 104 positive respondents; 22 wheezed daily, 9 dived within 1 hour of wheezing. Those who wheezed within 1 hour of diving logged 1,241 accident-free dives, and in the remaining asthmatics, 12, 864 safe dives were logged.

Again, in another study, which was published in SPUMS Journal recently, there were 813 divers and 31 asthmatics (thus there were about 4% asthmatics). Also just published in this month's SPUMS Journal, 12% of present Auckland open water trainees are asthmatic or have a history of asthma. Thus, in the United States, Britain, and the South Pacific the numbers are similar.

In the *Annals of Emergency Medicine* in 1983, another study of 1,000 divers, 36 of 674 respondents stated they had asthma. That came from the DAN data. Then Dr. Bove and I did another *Skindiver Magazine* reader questionnaire, and here were the questions:

- Are you a certified diver?
- Have you ever had asthma?
- Do you currently have asthma?
- Do you currently dive with asthma?

There were 10,400 responses. We designed this questionnaire in a slightly different way so we didn't get a selection bias as far as asthmatics are concerned, by using a survey card included for readers who ask for information about advertised products. Thus the questionnaire was incidental, and here were the results from the certified divers.

- Have you ever had asthma? 8.3%.
- Do you currently have asthma? 3.3%.
- Do you dive with asthma? 2.6%.

Dr. Farrell showed in his study that asthmatics have no statistically significant increase in dysbaric illness over the normal population. In his ongoing study of 200 asthmatic divers, he also mentioned 30,000 accident-free dives with greater than 20 unscheduled free ascents without an incident in his ongoing study of 200 asthmatic divers.

In looking over the 13 years of collecting mortality statistics at the University of Rhode Island, only one death in 1,300 could be attributed to asthma.

In talking to researchers at the Catalina Marine Science Center (where they never got around to publishing their data, so this is word of mouth), but in looking at the etiology of systemic gas embolism, they found that the cause was among their emergency ascents—buoyancy control problems, panic, non-panic breath hold, and pulmonary blebs. They didn't have asthmatics in

their group. In a study at the Los Angeles county coroner's office, of 18 consecutive scuba fatalities, none was linked to asthma.

Now, looking at the DAN database, Fred Bove and I and our collaborators published an article on asthma and diving just recently, and so almost everything that I'm saying is in that article. In looking at the DAN database in 1987, there were 95 cases of arterial gas embolism, or a risk of what's probably around one in 200,000. Of 38 cases with adequate data, there were four asthmatic victims. This would suggest that there's an increased risk of arterial gas embolism in asthmatics by a factor of two to three, but on the other hand, three of the four asthmatics had rapid and/or uncontrolled ascents.

In 1991, the DAN database was presented at the UHMS meeting in San Diego, and again they had 1,200 cases of decompression-related illness; 196 cases of arterial gas embolism; 16 with a history of asthma; 755 cases of type 2 decompression sickness; 54 with a history of asthma; and 25 currently asthmatic.

Looking at the odds ratio, this and the confidence interval around it, you find an odds ratio in this case for arterial gas embolism of 1.58 in all asthmatics, and if you only look at the active asthmatics, it's 1.98. Notice the confidence interval around this—it's 0.8–2.99 and 0.65–5.33, respectively. None of these numbers reach statistical significance. You can as easily make an argument that it is safer for asthmatics to dive than it is more risky for them to dive.

That argument would run as follows: We've been telling asthmatics for years that it's unsafe for them to dive, and as a result of it they monitor their air more carefully and they don't do foolish things. Since the vast majority of diving accidents are due to divers doing foolish things, the asthmatic, because he knows he's at additional risk, actually is more careful in the water and has a lower risk. The argument is not unreasonable, therefore, that it's safer for him to dive.

Now, looking at all of the DAN data that were available from 1988 through 1991, using the DAN codes which was code 1, which was usually type 1 decompression sickness; code 2 through 5, which was usually type 2 decompression sickness; and code 6, which was usually arterial gas embolism—taking a look at all of the cases and whether these divers have a history of asthma, either current or past, you can see the percentages compared to the rest of the population. And given the population statistics and the number of asthmatics that we found in the population of divers, which ranges from 3 to 7%—you can see that these numbers are not appreciably different and these numbers do not achieve any statistical significance as far as increased risk is concerned (Table 1).

These are from Project Stickybeak, 100 scuba diving fatalities in Australia and New Zealand from 1980 to 1990, with 125 causes of death, and there were 9 deaths in subjects with a history of asthma. This has been quoted over and over again as an indication that asthmatics are over-represented in the diving deaths in Australia and New Zealand. I'm not sure why, if 12 or 20% of the population of Australia and New Zealand are asthmatic, but nonetheless, Dr. Walker who was one of the authors of Stickybeak stated categorically that "this appears to be untrue in relation to Australia and New Zealand."

So this led to the conclusion that there is a group of asthmatics who can dive. I won't say safely because there are inherent risks in diving, and diving is not 100% safe. Incidents are going to happen, and I'm sure there are people in the room who can raise their hand and give us a specific incident of an asthmatic getting into trouble. That's not the point. The issue is whether asthmatics are over-represented, whether they get into trouble so way out of proportion to everybody else getting into trouble that the risk is unacceptable. But there is always a risk.

Table 1: Non-fatal Diving Accidents 1988–1991

	All Cases	History of Asthma Current # (%)	Past # (%)
Code 1, usually DCS I[a]	192	4(2.1)	7(3.6)
Code 2–5, usually DCS II	1,214	18(1.5)	45(3.7)
Code 6, usually AGE	148	2(1.4)	7(4.7)
	1,554	24(1.5)	59(3.8)

[a]DCI I—type 1 decompression sickness; DCS II—type II decompression sickness; AGE—arterial gas embolism.

Table 2: Approximate Lower Limits of Normal at Fifth Percentile Level

Parameter	Percent of Predicted
VC	Below 75
FRC	Below 70 or above 130
RV	Below 65 or above 135
TLC	Below 80 or above 120
FEV_1	Below 80
FEV_1:FVC %	Below 85
FEF_{25-75}	Below 65

From Clausen J. Pulmonary function testing. In: Bordow RA, Moser KM, eds. Manual of clinical problems in pulmonary medicine, 2d ed. Boston: Little, Brown & Company, 1985.

Several years ago we felt that asthmatics who could dive were those who were wheeze-free for more than 2 years with normal PFTs and those with sporadic attacks triggered by defined factors with normal PFTs between attacks. The individuals that we believed could not dive were those who were on maintenance medication; those with exercise-induced, cold-induced, or emotion-induced asthma; and those without normal PFTs when not symptomatic.

Now we've changed our mind, and we've become somewhat more liberal about this because the key seems to be how they function. They either can do the exercise or they cannot do the exercise. The risk for barotrauma doesn't seem to be there. So now, basically we use pulmonary function testing and we want it to be normal, indicative of both exercise tolerance and a certain lack of variability. The asthmatics who we like to clear are those who have well-defined triggers and who are unlikely to get significantly worse underwater. And that well-defined trigger can be defined in any way that you want, as long as you know what the trigger is.

The person who has tremendous variability and may get bad very quickly for no apparent reason is the kind of person we want to screen out. The asthmatics we generally don't let dive are those without normal pulmonary function testing and those with poorly defined triggers, likely to get worse under water. Simply because we don't know what they're capable of doing or when they're capable of doing it.

We define normal as two standard deviations away from the mean. That's what abnormal is. It strikes me that if you have a test where 20% of the population is abnormal, the test is wrong. It's not the 20% of the population is abnormal. So these are two standard deviations away from the mean for typical pulmonary function tests (Table 2),

The methacholine challenge test is not indicated in assessing whether asthmatics can dive.

DISCUSSION

Dr. Davidson: One of the slides on pulmonary function tests earlier said "not on maintenance medications"—is the pulmonary function test to be normal with or without medication?

Dr. Neuman: The slide earlier that said "not on medications" was our old thinking and I brought it to show you the progress of our thinking. The issue is function, not whether your medication achieves that function.

So to answer the question, the tests are done on medication, particularly inhaled steroids. Dr. Torre mentioned this, but we've changed our thinking about the management of asthma dramatically over the last several years, and people who have regular attacks often should be maintained on inhaled steroids. Many of those individuals who are maintained on inhaled steroids will have normal methacholine challenge tests. If you put them on inhaled steroids, they don't have asthma in a sort of philosophical sense.

THE CASE THAT ASTHMATICS SHOULD NOT DIVE

Richard E. Moon

Medical exclusion for recreational activities

Why should there be medical exclusions for divers while there are none for many other more dangerous activities? I believe the reason is that while it is self-evident, when one is considering hang gliding or mountain climbing for example, to foresee the potential risks that would be incurred by muscle weakness, poor balance, or impaired visual acuity, most divers do not have the same intuitive feel for the pathophysiology of diving-related illness. In treating serious decompression illness (DCI) one hears, not infrequently, statement such as, "if only I had known it could be like this I would never have done it." One of our duties as diving physicians is, when appropriate, to "save people from themselves" by pointing out potential physiological risks of which they may not be aware.

Second, diving doctors and their diver patients have a duty to the divers' buddies, rescuers and also those who must bear the costs of transportation and treatment of divers who may become injured because of a susceptibility to diving illness for which the diver should receive counseling or medical exclusion.

Risks for asthmatics

There are two possible risks for asthmatics. The first is the possibility of impaired exercise capacity due to a reduction in maximum ventilation incurred by increased airways resistance. This is a relatively easy issue to deal with, because the effects of immersion and diving on ventilation are well described in the literature (1-8) to increase airways resistance, the breathing resistance of the gas supply apparatus and immersion itself. Exercise ventilation during a dive may approach maximum voluntary ventilation, even in normals. Increased airways resistance due to asthma will reduce a diver's maximum ventilation further, possibly causing respiratory limitation at only moderate levels of exertion.

The other issue is the risk of pulmonary barotrauma and decompression illness. The hypothesis is that airway obstruction, airway closure and gas trapping caused by asthma and other pulmonary diseases can precipitate pulmonary barotrauma (PBT) during ascent. Overexpansion of gas spaces in the lung could cause rupture, and release of gas into the pulmonary interstitium, pleural space, or pulmonary venous blood. Large amounts of intra-arterial air result in the classic clinical picture of arterial gas embolism (AGE). The release of arterial bubbles from PBT could also predispose to DCS in divers with a significant inert gas load via the mechanism suggested by Neuman and Bove ("type 3 DCS") (9). Upon immersion in water, there is an influx of blood into the central circulation. Using high resolution computed tomography in experimental animals, Mitzner et al (10) have demonstrated that administration of intravenous fluid or blood results in an increase in airway wall thickness and a reduction in luminal diameter (10). This raises the possibility that immersion may compound the increased airways resistance in asthmatics.

There are reports in the literature containing illustrative cases. For example, in a paper by Mellem (11), a young woman on her first dive complained of chest pain during ascent and then developed neurological abnormalities. On radiographic imaging of her chest a large bulla was clearly evident, which was presumed to have been the source of gas embolism. While it is not difficult to believe that severe bullous disease might predispose to gas embolism, asthma is not the same disease. Nevertheless, indirect evidence of gas trapping exists even in asthmatics with minimal or no symptoms (12,13). It is at least theoretically possible for constricted airways to retard the decompression of gas spaces in the lung during ascent, and this could be augmented by the tendency for immersion to cause airway closure (6,8,14–16). Weiss and Van Meter reported two cases of AGE occurring in asthmatics during scuba training in a swimming pool (17). A few years ago we treated a diver who appeared to be similarly predisposed at Duke Medical Center. He was a 30-year-old male asthmatic who stated that he only used albuterol inhaler once or twice a month. During ascent from his fourth dive he was observed to experience a generalized convulsion. He received recompression treatment, had another convulsion, and ultimately was transferred to our hospital, where he was noted to be lethargic, paraparetic, had a T_8 sensory level, and expiratory wheezes. After additional hyperbaric treatment his neurological status gradually improved. Despite bronchodilator therapy his vital capacity was 79% of predicted, and his FEV_1 was significantly reduced below normal, at 61% of his predicted value. His brain MRI scan showed areas of infarction. Five years later, he decided to try diving again, dived to 30 feet and reported no problems. After 5 more years, he made another dive (only his sixth dive overall), to 60 feet for 10 minutes, a fairly low risk profile for traditional decompression sickness. Nevertheless, during ascent, at a depth of 20 feet, he described a "strange feeling" in his arms and legs. When he exited the water, he felt arm pain and had difficulty walking, after which he was treated for DCI. This is a man who, during the course of six dives, had two episodes of neurological DCI, with documented cerebral infarction. Clinical evidence therefore supports the concept that there are asthmatics who are at high risk of DCI and should be precluded from diving.

Medical decisions can be based initially upon theoretical principles, but a firmer grounding is obtained by a progression to anecdotal clinical information (such as currently exists), and then epidemiological information based on studies of populations.

Ideal data would be obtained by obtaining otherwise comparable populations of randomly chosen asthmatics and non-asthmatics, who are then followed prospectively while they follow the same dive profiles, and record the number of DCI incidents in each group. It is unlikely that such an experiment will ever be done. Dr. Farrell should be commended for doing a prospective study (*see* elsewhere in this report), but any such practicable study has the inherent problem that the asthmatics who dive are likely to be self-selected, lower risk individuals. Divers such the ones described above are unlikely to remain in the diving population. Some may have been screened out before they started diving, causing random asthmatics in the general population and ones who choose to dive to have different characteristics.

A more realistic study, though less perfect, is to compare the prevalence of asthma in a population of divers who have suffered DCI and with a control diving population without such a history, or, second best, non-divers. Edmonds et al. stated in 1992 (18) that although only 1% of divers are asthmatic, 9% or more of the deaths in his series were in asthmatics, and in another 8% asthma was a contributing factor. It was noted that at least 7% of patients in his series of fatalities had respiratory disease other than asthma. The percentage of asthmatics in the diving

population, at least among American divers, is probably higher than 1% (*see* below), so it is possible that these data somewhat overstate the contribution of asthma to diving deaths.

Another approach is to look for divers among an asthmatic population. This was done by Dr. James Wells in conjunction with DAN, in a large group practice, containing 16,000 patients with allergy, all of whom were receiving immunotherapy and approximately 4,000 had asthma. Questionnaires were sent to each one to solicit divers, and they were specifically asked whether they had experienced pulmonary barotrauma or decompression illness. The results were as follows (19). In this population, 32 divers answered the questionnaire, of whom 17 were asthmatics and 15 non-asthmatics. The median number of dives for each person was 100 in the non-asthmatics, 28 in the asthmatics. The total number of man-dives was roughly comparable; however there were no episodes of pulmonary barotrauma in either group. Because of the low numbers, this approach turned out not to be fruitful.

Another way of attacking the issue is to look for asthmatics among divers. Dr. Tom Neuman has already quoted his own results of such a search in this Workshop. The Divers Alert Network (DAN) in 1989 sent out 1,000 questionnaires to randomly selected DAN members, of which 696 were returned. In those divers 5.3% reported that they were asthmatic, of which 13 reported that they were currently asthmatic, which was defined as an attack within one year or taking bronchodilators on a regular basis. There were about 6,000 man-dives logged, with no reported episodes of decompression illness. This provides an estimate of the upper bound for the risk (i.e., risk < 1/6,000 dives).

The study of Farrell and Glanvill (20) has been published in the open literature. A similar type of study was performed by DAN in 1991. Using the DAN newsletter, *Alert Diver*, an advertisement and an accompanying questionnaire were published to solicit information from diving asthmatics. A total of 304 questionnaires were received for analysis. There were a total of approximately 60,000 dives reported by 292 divers, who had experienced a total of 13 cases of decompression illness: 10 DCS and 3 arterial gas embolism in 7 individuals, from which one can calculate an approximate risk of one episode per 4,600 dives. The risk of DCI in recreational divers is not known, nor can it be estimated for these divers because no information is available on the dive profiles. However, this risk exceeds the probability of DCI estimated for recreational divers by Wilmshurst (1/15,000–1/20,000 dives) (21,22), Gilliam (1/11,097) (23), and Hahn (1/52,600) (24).

A recent update of DAN data, including all cases collected from 1987 to 1994, is shown in Table 1. The random DAN members listed in the Table 1 represent the 696 questionnaires that were returned a few years ago, in whom 5.3% had asthma and 1.87% had current asthma (defined as wheezing within the past year or currently taking bronchodilators).

Table 1: Asthma in 696 Randomly Selected DAN Members and in 3,359 Cases of DCI in the DAN Database

Condition	Random DAN Members (%)	DCI-II (%)	AGE (%)	Odds Ratio AGE (95%)
Asthma	5.32	3.92	6.65	1.25 (0.8–2.1)
Current asthma	1.87	1.67	3.09	1.65 (0.8–3.6)

Although the estimated probability of experiencing AGE is 1.25 times higher for asthmatics (odds ratio of 1.25) and 1.65 times higher for current asthmatics, the ratio 1.0 is included in the span of the 95% confidence intervals, and therefore the estimate of the risk does not reach statistical significance.

What is the interpretation of these data? It is correct to say that there is no evidence for an increased risk of DCI in asthmatics who dive. However, it is not correct to conclude that there is no risk. To do so it would first be necessary to establish the confidence with which one can exclude such a relationship. If the same proportions are maintained in future years, in order to exclude asthma as a risk factor relationship with 95% confidence, about 4 times as many asthmatics would be needed as currently exist in the database. At the current rate of accident data collection this means that a statistically significant answer might not be available for another 25 years. Absence of proof does not imply proof of absence. Furthermore, there is no assurance that the asthmatics who are diving represent a random selection of the asthmatic population. The divers are very likely to be self-selected as low risk: those who experience complications probably stop diving. Thus any calculation of risk using this approach reflects not the risk of diving with asthma, but *the risk of diving for those asthmatics who are already diving*. This type of analysis is therefore not likely to be conclusive, since it will underestimate the risk for a randomly selected asthmatic from the general population. The small increase in risk suggested by the estimates in Table 1 may be misleading, and belie a considerably higher risk for some other asthmatics who are not currently diving.

Given that some asthmatics have apparently been able to scuba dive without complications, the relevant question is therefore not, Can asthmatics dive? but rather, *Which asthmatics can dive?* Based upon the evidence accumulated thus far, Neuman et al. have suggested some liberalized guidelines (25). They suggest that asthmatics who have abnormal airways resistance or lung volumes should not dive, although there are no published data on the physiological responses of the lung in asymptomatic asthmatics with normal lung function to the diving environment, particularly water immersion. Neuman has further recommended that diving be prohibited after an acute asthmatic attack, until airway mechanics are normal by formal testing. This recommendation may sound acceptable in theory, but it is one which is difficult to follow in practice. Furthermore, there is too little experience with these recommendations to know whether they are safe or not. In view of the conservatism of most diving doctors regarding asthma, the degree to which physicians or divers are liberalizing their own practices is uncertain. This may also apply to practices in the United Kingdom, where the British SubAqua Club has had less stringent guidelines for several years.

Since the epidemiological data are not helpful, it is therefore necessary to return to physiological principles. Here, unfortunately, the information is also lacking. There are no objective data on the degree of airways obstruction among diving asthmatics. Except for a few studies of gas exchange in asymptomatic or mild asthma (12,13) demonstrating the existence of bimodal distributions of perfusion (suggesting a population of gas exchange units prone to gas trapping), there are few data pertinent to the effects of diving on airway mechanics in this disease. We know a great deal about how diving affects the lungs, but we know almost nothing quantitative about how diving affects the asthmatic lung.

Conclusion

There are theoretical reasons why gas trapping could occur in asthmatics and cause

pulmonary barotrauma and gas embolism during ascent from a dive. Anecdotal evidence supports the existence of this phenomena in some asthmatics. There are trends in the epidemiological data suggesting an increased risk of DCI in asthmatics. However, the numbers are not sufficiently large for statistical significance, for either confirmation or exclusion of asthma as a risk factor for DCI. Moreover, epidemiological data collected thus far are fundamentally flawed, in that there is reason to believe that they represent a biased population. Even to answer the question of which asthmatics can dive, the epidemiological data contain no clinical information with which to characterize the reported asthmatics, and therefore derive an appropriate recommendation.

Physiological data are also lacking. Several physiological/pathophysiological questions remain, for which answers are needed before liberalized recommendations can be validated:

- What is the effect of immersion and increased airways resistance on the asthmatic lung with differing degrees of bronchoconstriction?
- Can it be correctly assumed that the severity of airways obstruction measured using conventional spirometry is predictive of the risk of pulmonary barotrauma in asthmatics?
- For asthmatics, during ascent from a dive, can the possibility of "micro-embolization" (perhaps subclinical) of gas into the arterial circulation be excluded?
- What are the clinical and physiological characteristics of those asthmatics who are currently diving and who have not experienced DCI or PBT?
- If asthmatics can dive, what recommendations should they be given with respect to the management of their asthma and their dive patterns, particularly ascent rates?

Despite the impetus to disseminate more liberal recommendations, there is no strong evidence with which to challenge the traditional recommendation that asthmatics should not scuba dive.

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DISCUSSION

Dr. Elliott: Thank you, Richard. The case is to be put for discussion, and what I would like to do now is to invite two of our panelists to comment on where we've got to so far.

Dr. Bove: The debate starts later, but Dr. Neuman asked me to mention that some pulmonary function testing is no more than peak expiratory flow rate measurements and a point for debate is whether that measure is adequate. So I don't want to continue with that now. In my own practice many of the divers who come for initial evaluation don't mind paying for the pulmonary function test, because I think they feel, and we feel, it defines some aspect of safety.

This is not what I wanted to address. As we go through this debate this afternoon, there will be some consideration of what the information from the testing means. And I want to point out, since I am a cardiologist, and try to provide care for my own patients based on information from the cardiology literature, several important observations which have been made in the area of cardiology as models for how one makes proper decisions in patient care.

We did randomized studies on the treatment of acute myocardial infarction in the 1980s when

we randomized people to thrombolytic agents and no thrombolytic agents. That was a pretty gutsy thing to do because there was some evidence that thrombolytic agents were good, but we decided that to really get an answer we had to randomize. We found that the mortality in the patients treated without thrombolytics was 13%; it was around 6 or 7% in the patients treated with thrombolysis.

There were measures. There was testing of left ventricular function, testing of enzymes, and everybody felt that these interim tests would give us the answer. The fact is the tests were not adequate end points. The mortality was the important end point.

Heart failure and use of angiotensin converting enzymes (ACE) inhibitor raised similar issues. Through a number of randomized studies, we found that the 2-year mortality for class 4 heart failure went from 60 to 35%.These conclusions represented solid, good clinical data which we now use as a mainstay of therapy. Others such as atrial fibrillation and use of anticoagulation: 5% down to ½% risk for stroke and mortality. Again, a randomized trial with controls to define the end point in statistically significant and important data.

The other study I was going to mention was the use of Beta blockers post-myocardial infarctions. Again, a large study, 10% reduction in 1 year mortality. These studies established standards of practice.

All standards of practice that we use have come from carefully done, randomized clinical trials. And I will tell you the other extreme. About a month ago a statistician presented data from an insurance database, suggesting that the use of calcium channel blockers in hypertension caused acute myocardial infarctions. This was an abstract presented at a non-peer-reviewed meeting. It wasn't published except in abstract form but was seen by the lay press, and within about a day of that hitting the newspapers, I started getting calls from my patients who had stopped taking calcium channel blockers for blood pressure. My comment was, I cannot practice medicine from headlines in the newspaper. We have to use good clinical outcome data.

We have not seen good clinical-outcome data in this asthma debate. The reason for that is that it is very difficult to get a good clinical trial underway. The interest in cardiac diseases is much greater and we can get funding to do these clinical trials.

I would caution everybody to look carefully at the data that we have. The result of a test is not an appropriate outcome. One must look at mortality or morbidity, and make some conclusions based on good, clinical and statistical observations.

Dr. Moon mentioned that we don't have data that define an increase in risk. The lack of data raises concerns that we are making a type 2 error, that is, we are making a negative conclusion because of lack of data. We don't have data that show there is a significant increase in mortality or morbidity from asthma and diving at this point. For my medical practice I would like that kind of information.

So to a point we are guessing, and I would ask everyone to look carefully at the outcome data that we have so that we can reach some reasonable conclusions.

Dr. Harries: Thank you, David. I would just like to tee up this afternoon's discussion by being thoroughly provocative in the most friendly way, of course, and by drawing the battle lines as I expect them to be. I will start by making one or two comments. The first is to Dr. Gorman. I was interested about using histamine provocations as indicator of exercise debility. This strikes me as rather like testing an apple by taste to be sure it isn't an orange. "Failure to prove an association beyond doubt is not proof of its converse." Of course the failure to disprove association beyond doubt is not disproof of its converse. It's a complicated argument but it

doesn't get us any further, I felt.

I was also worried to discover that there are still people prepared to use β-agonists in the treatment of asthma, without using inhaled steroids. This is rather like papering over the cracks on the wall and then trying to persuade your surveyor that there is no crack there at all.

This afternoon's discussion is going to center around whether diving with asthma is going to be a danger. We've been told that asthmatics are not at special risk from pulmonary barotrauma and we'll probably visit that again this afternoon.

It strikes me that the question boils down to whether the ability to exercise and work is impaired by asthma developing in the water. And if it does, whether adequate treatment of asthma removes that problem.

Dr. Elliott: All the panelists are now on the dais and each will be asked: What do you perceive as being the greatest obstacle toward achieving consensus today?

Dr. Neuman: I'm not sure if it's the greatest obstacle, but I certainly see a portion of this debate being philosophical insofar as whether it's up to the individual to be given an assessment of risk as best we have it and letting that individual make the decision whether he or she chooses to underwrite that risk. We ought to be worried about the risks to the people who have to perform the rescue and, as far as buddies are concerned, each individual must let his buddy know as well.

So to a certain extent, I see this as a philosophical issue as to who underwrites the risk of anybody with any kind of limitation diving?

Dr. Elliott: Des Gorman.

Dr. Gorman: Thank you, David. It was interesting that for most of the SPUMS workshop on asthma the debate was concentrated on whether diving medical assessment assistance should be a prescribed process or a discretionary process. That is a question—whether doctors should be risk advisors or policemen.

The group of asthmatics that we're starting to struggle with conceptually in our part of the world are the people with active asthma but who, on medication, are exercise-tolerant. From a traditional military, commercial, and recreational diving viewpoint, we have discouraged these people from diving. Is this a valid prohibition for someone who is demonstrably "non-asthmatic" in the context of regular inhaled steroids?

The other area where some debate may be needed to reach consensus is in the nature of the data we need to collect to determine the risks of diving for asthmatics. In my opinion these have to be collected on people entering diving, not after their diving course, because I suspect even this is a survivor population.

Dr. Moon: I think the way to approach it would be to divide the problem into two. There are two problems. One is exercise tolerance and the degree to which one can perform under water, and that issue really applies to any potential respiratory disability, not specifically asthma. And the other is the risk of pulmonary barotrauma.

The second issue is that the actual level of risk needs to be addressed, and then finally the philosophical issue as to what level of risk is tolerable, and that leads back to Des' comment about advice rather than being a policeman.

We are perhaps uniquely positioned in this country in that we can give all the advice that we want, but eventually one has to come to the point of whether one is going to sign the form and approve the diver for diving or not. And perhaps we could address how to get around that one.

Dr. Francis: I think that the problem we face is, to a large extent, one of our own making.

Many of us have been trained that asthmatics should not dive and it's a practice that we have all tended to follow during our diving medical careers. The feelings that brought about the idea that asthmatics were unfit to dive were based on ideas that seemed reasonable at the time. It is unfortunate that there is a lack of evidence to support those thoughts, particularly with respect to pulmonary barotrauma.

So we've actually caused the problem to some extent, and now we're trying to get out of it. It's going to be difficult because in large parts of the diving world, particularly military and commercial diving, asthmatics have not been allowed to dive, and so we have no good data on how they perform. And, if we carry on with the idea that asthmatics are not allowed to dive, we will never get the data.

So I think we're going to have to get diving asthmatics, if you like, "out of the closet," and study them very carefully. And the question is, how do we get them out into the water? We also need to separate sports divers from those who are employed to dive, because the criteria which apply are different. Those are the major problems.

Dr. Harries: We spent some time this morning discussing how acute obstruction to airflow limits aerobic performance and how, if it were treated correctly, it didn't. We also talked about methods of making a diagnosis and methods of treatment.

Mild asthmatics should be allowed to dive because there's no evidence to suggest that they would be in any difficulties if they did. Obviously, those with severe asthma will have problems. If one is going to approve diving for asthmatics, at what level is one going to say to a more severe asthmatic, no, you mustn't. That is going to be difficult.

Dr. Mebane: The science of epidemiology began in London about 200 years ago when an astute physician began to notice a correlation between individuals with cholera in his practice and the supply of water from a certain water pump. This came about through case studies. So case study was a valid tool in epidemiology for many years. The accumulation of databases is a more modern development, and I would make a plea for return to case study. Every database in diving which now exists, of course, is flawed by selective bias. In studying rare diseases it is not possible to accumulate a large database, so we will probably never have a database large enough to make any conclusions. I make a plea for the intensive study of individual cases and perhaps there is gold to be mined in that resource.

Dr. Farrell: I have little to reiterate that recreational divers are a different population from professional divers. To reach some form of consensus, we need to split them into two groups, the amateurs and the professionals.

Dr. Bove: I mentioned my interest in clinical trials this morning. If we look back in the training of physicians, we've been told many things about how to practice medicine which, when examined in detail, do not have adequate scientific basis. This discussion on asthma is another example. The conclusions were drawn from some understanding of basic physiology without clinical outcome observations to correlate with the test data. This is not the only example of having made perceptions of treatment patterns for disease in the presence of inadequate data.

We are learning in this last two decades or so to take careful looks at the data based on true clinical outcomes, and not the hypothetical outcomes that one would conclude from the basic experiments that might be related.

One of the major obstacles we have is that we still are not used to going back and carefully looking at the origins of the conclusions that we use for practicing medicine. To me that is a key issue which is relevant, not just to this issue, but to many of the things we do in medicine.

I make a plea for being critical about the conclusions that you make in terms of medical information and how you apply that to your practice in any area. I think this is a good example of using inadequate data to draw conclusions that don't have support. So if we can get by that, I think we can then decide, number one, that we will deal with asthma, number two, we will develop guidelines, and ultimately have some way of dealing with the individual who walks into your office and says, "I have asthma, is it okay to dive?" Because right now, I think we have many different answers to that question.

Dr. Elliott: Thank you all very much. In a moment I will open it up for general discussion but I would like to add the idea that we need to debate this in two parts. What are the current criteria in the way of diagnosis and assessment? And what data do we need to collect in the future?

I have prepared a number of overheads which will address the first question, but not the second. Also, one of the speakers this morning picked up another very important factor, which is, in conducting an assessment for fitness, it's not just the asthmatic, it is also the doctor. At a 4-day meeting in Edinburgh last year on the assessment of fitness to dive, perhaps the most important conclusion was that didactic prescription is out. The cliche is that rules come in black and white but people come in shades of gray. Thus the doctor who has to interpret any guidelines we might produce this afternoon must fully understand the hazards that the diver will confront. In my view too many diving medical examinations are done by doctors who know nothing about diving. So I would like to add a controversial question, what are the standards of competency that we expect from the medical examiner in interpreting the guidelines that we do produce, and what training objectives must be met for him or her to relate the clinical findings to the hazards of the underwater environment?

So now we can start the debate from the floor.

Dr. Saltzman: The international audience may not appreciate that there is a surplus of lawyers in the United States, and we live in an increasingly litigious society. Medical liability is a major concern. Physicians are historically risk adverse, and it's much easier for a physician to tell a patient not to dive than to use rational criteria that might allow a yes answer. It is very important to develop a consensus statement that can be used as a support system for physicians so they can use rational thinking to determine the disposition of this question.

Dr. Daugherty: David, you mentioned the Americans with Disabilities Act, and for American commercial divers there is one more factor besides the physician's assessment of risk or his estimation of whether this would affect the health or welfare of the worker or others. After the employer is presented with that assessment, he has to determine if he can make a reasonable accommodation. For other disabilities this might be something for a person in a wheelchair who works at a bench or a desk and might involve changing the equipment or raising or lowering something.

So if an asthmatic diver presented and wanted to work as a commercial diver, after the physician has made the assessment, the employer then has the duty of deciding if he can make a reasonable accommodation for this person, and if he can legitimately say that he cannot, only then can he refuse to employ the diver under the Americans with Disabilities Act. So there is one more element after the doctor has puzzled it through in his own mind.

Dr. Youngblood: I have two points. The first is that I would like to disabuse the panel of the concept that recreational divers don't involve any dangers or liabilities to third parties. In America, they certainly do, and I will give you what I can now call a case study instead of an anecdote, where a Board Certified anesthesiologist, with childhood and adult asthma, answered

the questionnaire on his diving test, but didn't admit to having asthma. On his first open water dive, despite being asked to put his regulator in his mouth, he jumped in with his snorkel in, and apparently inhaled water and went on to drown from there, by all signs, acute bronchial spasm from salt water aspiration.

Now, he died, and his wife sued the boat company and won. Sued the two owners of the boat company, despite the corporate veil; sued the urologist who was his dive buddy and failed to resuscitate him; and won all of them. It cost the third parties about three and a half million dollars. So don't kid yourself.

This particular case brings me to something that Des mentioned and was actually misquoted on, I'm afraid. He didn't mention the methacholine challenge as being, as I interpret it, a useful one, but the hypertonic saline challenge seems to be a very practical thing that we need to evaluate further, because the data that I saw from Australasia were the deaths from drowning on the surface in asthmatics.

I would wager that a great many of the cases assumed to be cardiac arrythmias or drownings, may have occurred in asthmatics who aspirated salt water, i.e., doing their own provocative hypertonic saline challenge test. If you're actually swimming in the media of the challenge test, it might be wise to test that medium before you swim in it.

Dr. Bove: Just a comment: had this individual, who aspirated water and drowned, not had asthma, the same result of that lawsuit would have occurred. It had nothing to do with bronchospasms. I'm not sure that you can use it as an example because my guess is that it could never be established if bronchospasm was the reason he died. I think if you look at the deaths from diving, you'll find a lot of people who have drowned like that with no history of asthma at all, and they still win the lawsuits because somebody let them jump over the side or the snorkel was twisted wrong or who knows what.

Dr. Youngblood: My point is that if some fail their salt water aspiration test in a clinical setting, then they would probably fail in open water.

Dr. Bove: I'm not sure that's a foregone conclusion. I mean aspirating water is different from a fine mist of saline in the airways. Aspirating water is a predrowning event which will cause significant problems with the airways, whether or not you have asthma.

Dr. Torre: If that diver was in fact able to tell the truth and admit he had asthma and was then referred to get proper screening, he found out he did not have good exercise tolerance. He could have received appropriate treatment *before* he dove, and it may not have happened either. So our present standards, which "encourage" withholding important medical information, actually make it more dangerous to dive.

A couple of other points. Dr. Mebane was talking about case studies for why these asthmatics may die. We may not have the case studies with asthma in scuba divers, but we certainly have plenty in non-diving asthmatics. The single most important reason for asthmatic deaths is the improper, i.e., under use (none, too little, or too late) use of anti-inflammatory drugs as controlling (maintenance) medications, generally associated with the overuse of β-agonist bronchodilators as the main treatment for asthma. And I would bet if there were sufficient case studies of asthmatic divers, the mortality would statistically follow the same pattern.

Those people who rely on β-agonists more than once or twice a week have persistent asthma, and if they're not on anti-inflammatory drugs, may be at much more risk. The point I'm trying to make is the necessity for utilizing some kind of criteria (whether it's exercise or methacholine challenge or histamine challenge or saline challenge, or how often you have symptoms or falls

in your peak flow or how often you have asthma at night) to assess the measure of asthma control.

It doesn't matter which challenge test or clinical measure above one uses, if you're in control, i.e., you're taking the right amount of anti-inflammatory medication, etc., you're at risk of having a problem on the surface (bronchospasm secondary to exerciser aspiration of hypertonic saline) that can lead to drowning is going to be much smaller. The fact is that asthmatics under control don't die from asthma. Now, whether that will be proven beyond doubt in scuba again might take another 25 or more years to know. But the "persistent" asthmatics on the surface (in addition to those scuba diving) who do not have appropriate anti-inflammatory medication and therefore abnormal tolerances (whether it's methacholine or exercise, etc.) are at much more risk to die, and again the single biggest cause for asthma deaths is inappropriate use, i.e., under use of anti-inflammatory medicine and overuse of bronchodilator medication.

Dr. Gorman: David, I would like to comment about the guidelines that you're trying to develop. To a certain extent, though, they're driven by the type of fitness certification the doctor is to sign. It is impossible for any person to be literally fit to dive.

I've had a long chat with PADI, for example, as one of the stakeholders in this context about whether they find it acceptable to have a different sort of Fitness Certification, in which there is an acknowledgment that the specific risks for that individual have been fully discussed and understood. In response, PADI has said that it would find such a system to be both workable and desirable.

Dr. Elliott: I'm happy for this debate to continue, but we need to establish the other areas we will have to spend time debating.

Dr. Neuman:: I wish to respond to David Youngblood's views on hypertonic saline. That test is limited because there are too many false positives.

Dr. Harries: I want to support again what you have just said. I said this morning the methacholine challenge, histamine challenge, and saline inhalation are methods of quantifying the degree of bronchial hyperactivity; in other words, the severity of the asthma. An exercise test merely flags up whether your patient, the diver, is potentially asthmatic, that's all. Yes or no. It's a much more pragmatic test because it tests what you are after. Does this person develop problems when exercising (*not* if inhaling saline)?

Dr. Lissauer: In the United States we define a junior diver as one between 12 and 15 years of age, and that junior diver is not permitted to dive with another junior diver, only with an adult diver. My question is, would you send a junior diver, be it your own child or somebody else's, to dive with an asthmatic? That's question number one. Question number two: you're certifying an "asthmatic," whatever that means, and that person now wants to become an instructor. What do you do with that person? Thank you.

Dr. Lundgren: I'd like to touch on Tom Neuman's problem that he brought up, namely philosophy. I think it's a very important one. It's much more generic, perhaps, than applying just to the diving and asthma question. But I keep being amazed at the phraseology, "shall we allow this patient to dive?" "Doctor, am I allowed to dive?" et cetera. I think it's a totally wrong approach to the question, and it invites litigation.

I don't think the doctor has any business whatsoever to tell the patient what to do or not to do. It's akin to the person walking up to the trauma surgeon, saying, Doctor, should I go downtown after dark? And then suing the doctor when he gets shot. It is for the physician to explain the dangers—that should be done carefully, no question, and preferably in the standardized

phraseology that would be somewhat common to the medical community—and then it's up to the prospective diver to decide whether he wants to take that risk or not. What is one guy's thrill is another guy's deadly threat.

Dr. P. Bennett: Somewhat along the lines that Claes was talking about, I think there are three people involved here. We're concentrating on the physician's involvement and the physician's decisions on whether that individual asthmatic is fit to dive. That is important for that individual; it may be important for the physician. The real trouble is when he goes to the instructor. If you go to the Caribbean and dive, you will be given a piece of paper which asks, have you ever been—whatever—pregnant, had diabetes, or had asthma? And if you mark asthma—or diabetes or whatever—then you're likely to be told, I'm sorry, you can't dive. That's the problem, because when the informed diver says, wait a minute, I don't think there's any problem with asthmatics diving, I don't see why you won't let me dive. We get a lot of calls from people in this kind of situation.

So when you write your criteria, they have to be not only for the physician, but also the instructor in the field. They must be simple so he can say, look, here's a consensus, it is my advice to you that you shouldn't dive because there's a certain amount of risk, it's twice what it is normally or whatever the case may be. It's your decision to make; I can't make it for you. DAN never says to anybody about to dive, "you cannot dive." We're not the dive police force. We just say, here's the information; you are a responsible diver; you must take the information and decide whether the risk is high or low for you and whether you're prepared to dive under those circumstances.

Dr. Elliott: That is a good point, Peter..

Dr. Bove: David, to start the debate, I'd like to throw out the premise that we have no data that show that asthmatics are at increased risk in diving.

Dr. Elliott: A good idea; we will do that.

Dr. Moon: David, could I just make a suggestion. I think we've all got our own degrees of risk aversion which are unlikely to change this afternoon. Perhaps if you change the title to "Consensus guidelines for management of asthma" to "Statement on asthma," and simply spend the time reviewing the literature that we have seen this morning and make positive or negative statements evaluating the evidence.

Dr. Elliott: That is another good suggestion. Like the statement just made by Peter, it is particularly applicable for the recreational diver, but we must not forget that there are thousands of working divers as well.

Dr. Francis: What we're dealing with is a spectrum of disease and so, if we are going to have a pass/fail criterion, we're going to have to put a boundary line somewhere on that spectrum. This will be extremely difficult to do and, from what has been said, the best idea is not to put a line anywhere.

Dr. Elliott: When we were debating this in Edinburgh, it was obvious that there were some people who believed that 76% was okay for the FEV_1:FVC ratio whereas 74% was failure. In commercial diving in Europe this had become a magic number. This view has at least been modified and it is now said that this ratio is only part of an assessment.

Dr. Harvey: We may have to treat these divers as patients. Some are going to get decompression illness and so what are the effects of their medications on pulmonary oxygen toxicity, central nervous system oxygen toxicity, perhaps even narcosis?

Dr. Desola: We must agree that the question, "Doctor, am I allowed to dive" is not a good

approach to fitness for an asthmatic to dive. We need an answer to that question, because in many countries, and most of the Mediterranean ones, the doctor must sign the paper: "I, doctor; my name, allow this patient to dive." This question must be answered.

Dr. Kay: I would like to include the category of diving scientist, which hasn't really been addressed. We talk about sport and we talk about commercial divers , but I think the diving scientist is neither fish nor fowl. They do not receive direct money for the engineering feat, the archeological work, the coral research, or whatever the academic is doing underwater, and this is not the same thing as a commercial diver. So I'd like to include diving scientists as a separate category.

Dr. Elliott: Could I answer that one myself? As Chairman of this meeting I try to distance myself from the detail of debate, but in Europe we have the European Diving Technology Committee, which is a 15-nation committee of government, employers, and trades union representatives which is looking at all aspects of the "working diver." A working diver is anybody who works for a reward. Thus the definition includes anyone who dives in the course of their normal work. This includes the diving scientist and many instructors of recreational divers. Recreational divers and, for that matter the "technical diver," are *not* working divers.

Health and safety legislation for all workers in Europe, including divers, tends not to be prescriptive but "goal setting." This applies to all aspects of diving, not just medical. In the U.K. there will be approved codes of practice for six categories of working diver.

First there's the off-shore divers, predominantly the oil industry divers, and next the harbor/inshore and inland divers who do mostly construction work. The next category, the military divers, have their own code of practice or diving manual.Then there are the diving scientists. I don't like the word scientific diver—the diving scientist. They already have an international code of practice. Police divers will also have their own code of practice in the U.K., and finally there is the professional instructor of recreational divers.

These are all working divers and the discussion at Edinburgh was "Do the same medical standards apply to everybody?" The conclusion was that for those aspects of fitness which will affect in-water safety, the same standards must apply.

Dr. Heimbach: This meeting is being attended by top-of-the-line specialists in diving medicine and respiratory medicine, as it should be, and it has been brought out that there's a spectrum in severity in asthmatics, but there is also a spectrum in the quality of care given to potential divers in both the assessment of their asthma and the care of their asthma.

With a tendency, at least in the United States, toward increasing care by generalists rather than specialists, I have some concerns about whether asthmatics will receive proper care for their asthma to make them qualified for diving. I agree with what I've heard that in most cases they can be, but the question is will they be and, even if guidelines to do those are well established, will they be followed?

In addition, who is to judge whether these guidelines indeed have been followed? Then the asthmatic will report to the dive shop and say "yes, I'm an asthmatic, but I've been under care of a physician and my asthma is well controlled." Now, who makes the decision as to whether it truly is safe for him or her to dive?

These are questions which need to be answered. I'm all in favor of trying to achieve a way that we can get asthmatics to dive safely, but this question truly needs to be evaluated.

Dr. Elliott: Thank you, Dean. This particular can make some firm recommendations and maybe make a statement about how to assess risk in this population, but it is not possible for

this group to decide how those statements and guidelines will be interpreted outside the medical community. That must be a multi-specialty decision.

Dr. Farrell: I agree totally with the comment about the quality of asthma care. In the U.K. most asthma is managed by general practitioners or family physicians. We have British Thoracic Society guidelines which effectively lay down how to manage asthma divers but they are not universally followed.

Dr. Goldmann: In the 50 miles surrounding my service area, there are approximately 45 dive shops. Seventy-five percent of my referrals for diving evaluations came from three of those shops last year. There are shops that are interested in dive safety, and there are shops that are not. I would ask the panel to consider that, while we may not be dive police, there are certifying agencies in this country who will be looking at whatever we come up with. So, whatever evolves over these issues has to be usable by those organizations.

Dr. Peterson: I would ask the panel to address the most recent upgrade in classification of asthma from the NIH, and specifically to address the gradations therein, such that those who are not as familiar with current diagnoses and treatment of asthma could perhaps be brought up to date when they are considering the statement from this morning.

Dr. Elliott: Yes, certainly those grades are to be published as part of the proceedings of this meeting.

Dr. Torre: All three sets of guidelines I mentioned earlier—the NHLBI published in 1991 (NIH publication no. 91-3042), the International Census Report in 1992 (NIH publication no. 92-3091), and the 1995 GINA (Global Initiative for Asthma) workshop report (NIH publication no. 95-3659), which I discussed earlier, can be obtained for reference by calling NIH at 301/251-1222 and requesting the appropriate publication number.

As far as the step approach to asthma treatment based on the guidelines is concerned (wether they are helpful in determining fitness to dive) the expected outcome for all but the most severe asthmatics who follow the plan is: symptoms less than one week, normal exercise tolerance, normal or near normal pulmonary function tests and therefore, according to the data presented, as low a risk as possible for diving.

Dr. Bove: I take your point. But I suspect the categories we saw today are simply a way of allocating care, not too many risk factors in this context.

Dr. Torre: I basically agree with that. I don't think we have anything specific to grade risk at the present time other than the clinical criteria. I don't think any of the tests will allow us to actually grade risks, so it seems to me we are going to have to use the clinical criteria, including pulmonary function tests, to make some reasonable guesses about risk, and then decide how to advise individuals based on that assessment.

Dr. Elliott: We are trying to come out with an international statement, because although the NIH may mail however many doctors there are in the States, this Society is worldwide.

We seem, at last, to have come to a point where there is nobody waiting at the microphone. So maybe we should now begin to go through some of the statements. We have said that we need to come up with statements on asthma rather than guidelines. These also need to reflect the international nature of the Society and should recognize the separate aspects of underwater safety for recreational and working divers.

We will be looking at the questions that have been precirculated to achieve these statements. There seems to be a feeling that there may not be as much risk with asthma as we had perceived.

That is the major part of what we want to do today. Then we need to see what we can do in the

way of trials and collecting data from around the world. Who can do this? We need more data when this asthma topic next comes up for debate.

I would like us also to consider that perhaps only selected doctors should do the medical assessment of a diver. Also we should consider the question that Dr. Harvey raised. Could we do that first, before we debate these various overheads? Are there any comments from the panel upon the potential secondary effects of the various medications which the asthmatic may be using during diving? Particularly during any recompression?

Dr. Bove: The medications we deal with are the β-agonists, the steroids, probably some antihistamines of one sort or another, and anti-cholinergics. I'll have to ask for some advice, but I think the inhaled steroids do not produce major systemic effects, but we probably don't have enough real data. The only study that has been done on systemic steroids for oxygen toxicity, and that would pertain to active doses of steroids in the presence of hyperbaric oxygen treatment, a possible but not a likely scenario.

The antihistamines on occasion will interact with nitrogen and augment the sedative effects of nitrogen narcosis but, again, this is not a well proven phenomenon although something that one should at least warn divers about when they take sedatives like the antihistamines.

As for the β-agonists, I don't think there are any data on them at all, other than people with coronary disease getting angina sometimes from β-agonists.

Dr. Neuman: Yes, as far as the antihistamine is concerned, I think people have always been diving with Actifed, and I don't think that's an issue. On the other hand, there is a theoretical issue of the effect of β_2 agonists on the pulmonary vascular tissue. They are all vaso-active in the pulmonary system, and they're all bronchodilators as far as musculature of the bronchi are concerned, but they're also pulmonary vasodilators. They all are. That's one of the reasons that you can worsen some VQ relationships in the acute treatment of asthma with β_2 agents.

A theoretical concern would be if in fact there is an increased risk of type 2 decompression sickness with asthma in diving and, if that relationship is secondary to the arterialization of gas, one could be concerned about the arterialization of venous gas emboli through the pulmonary vasculature by the dilatation of the pulmonary vasculature from β_2 agonists. That would not be a concern with steroids for people who are managed with steroids, but certainly it is at least a theoretical issue with β_2 agonists.

So β_2 agonists can clearly worsen VQ relationships through dilating pulmonary vasculature and, as such, might be a risk for the arterialization of otherwise asymptomatic emboli.

Dr. Elliott: We are getting into a very difficult area here because the whole history of fitness to dive is based on theoretical arguments. The navies of the world started off by not accepting for diving lots of people who probably would have dived very safely, for purely theoretical reasons, a perception that they might be at increased risk. While I accept that we must put that forward, I'm not sure that we want to emphasize too much the purely theoretical risks without evidence.

Dr. Mebane: For the sake of the record, I'd like to remind everyone that in the United States an examination for taking scuba is not required unless there's some disagreement between the instructor and the prospective student as to fitness for diving. That is, if they both agree, the physician will not be involved.

The second point is that in the United States there are probably many millions of people who have mild asthma who never see a physician. They go to their local chain store, buy an inhaler of epinephrine, and take care of it themselves. So what is the physician to do who is faced with

one of these individuals who has admitted to some asthma, who does not have ongoing medical care, and now wishes to become a diver? What is the responsibility of this physician who probably does not have a patient relationship with that individual? How does that affect certification and how does that affect the ongoing care of a chronic illness? That needs to be covered.

Dr. Elliott: Fine, thank you. Are we all happy with that? Good.

It is now time to move to the possible consensus statements. Please bear in mind that these were prepared between us before today so some may already have been overtaken by our discussion. The first is:

Which of the following is the major problem for an "asthmatic" who dives?

(a) gas retention on rapid ascent perhaps due to a mucus plug ± collapse of a lobe or on rapid ascent due to airway constriction leading to pulmonary barotrauma and/or gas embolism.

(b) a greater risk of dissolved gas DCI (DCS).

(c) limited excercise capability under water and on the surface.

(d) the drugs used for the treatment of asthma may reduce the effectiveness of the pulmonary bubble filter.

Are there any disagreements that those are potentially major problems and I am sure that the first will be that there is no real evidence about (a).

Dr. Bove: The only thing that one can support is (a) and (c), a limited exercise capability.

Dr. Elliott: Would anybody disagree with that? First of all let's take it from the panel and from the floor. Fred has put forward the fact that only a limited exercise capability is the major problem for "asthmatic" divers.

Dr. Mebane: I don't disagree, the point is that all three cases I described died on the surface.

Dr. Farrell: If people are dying on the surface it surely means that their diving education and diving technique are faulty; it should be extremely easy for them to be buoyant on the surface.

Dr. Francis: If I can just say that, apart from (c), we don't have any good data at the moment to support these. However, what is also clear is that we don't have adequate data to discard any of the others. As part of our study on asthmatics, once we let them dive, these are the things we should monitor.

Dr. Elliott: Limited exercise capability is known whereas the other three are theoretical.

Dr. Moon: I think we can deal with (c) very quickly. One way we can look at this is to examine the relationship between maximum voluntary ventilation (MVV), which is the amount of gas one can move in and out of the lungs in a 15-second period, normalized to 1 minute, and the maximum exercise ventilation which typically in the average person is about 50%. As you say, when exercising to the maximum extent possible, your ventilation is approximately 50% of your MVV. Now, measuring MVV for 15 seconds is not the same as determining your long-term ventilatory capacity. If you ask someone to hyperventilate for 1 minuted or 5 minutes there is a reduction below the 15-second level. Now, what happens to exercise ventilation in the water? Well, as soon as one jumps into the water, there is an immediate reduction in the MVV due to blood flow redistribution. As you descend through the water column, your airway resistance goes up approximately according to one over the root square of density. When we take all these factors into account at the same time, your sustained MVV to a depth of, let's say, 130 ft is approximately half of your 15-second MVV at the surface. Now there are other things that go on in the lungs as well which impair pulmonary gas exchange; there are ventilatory

perfusion abnormalities and there is some evidence for gas phase diffusion impairment.So that would suggest that you would need, to be able to exercise maximally at a depth of around 130 ft, absolutely normal surface MVV.

Dr. Gorman: I accept (c) as within our SPUMS policy. In the assessment of fitness to dive they need to demonstrate an exercise capability and then to demonstrate fitness to dive in salt water, which is why so many Australians vacate the salt-water provocation test.

Dr. Neuman: To polarize things a touch more, I would say that for (a) and (b), although we don't have evidence to prove it one way or another, the bulk of evidence clearly suggests that those are not major issues. In any event, in (c) I think there is clear evidence that it is an issue as we can agree. I would put (d) in a category of completely unknown, whereas (a) and (b) are leading toward not being a problem.

Dr. Francis: I just want to comment on what Patrick Farrell said, and that is that one does not have to be submerged to drown; it can happen at the surface.

Dr. Torre: The issue with (c), exercise capability, whether underwater or on the surface, is to measure the asthma whether controlled or not controlled. There are people, women in particular, who are overweight, out of shape, and have heart disease, who are still diving and nobody is saying to them "don't dive" and they have more impairment of exercise capability than a controlled asthmatic. As far as (b) goes, the bronchial dilators generally increase perfusion before they increase ventilation but, theoretically, if you're wheezing before you dive you probably shouldn't be diving anyway. Using the β-agonists to alleviate wheezing may increase perfusion before ventilation. If you're using it with a normal lung to start with and as a prophylactic, the ventilation perfusion differences aren't going to be significant.

Dr. Elliott: Certainly, both in recreational and commercial diving, exercise tolerance is considered, though not necessarily accepted, as part of the assessment. This is regardless of clinical diagnosis and, in fact, Fred and I debated once whether the ability to do 13 METS should be the only assessment for diving! If they can do 13 METS then "of course they're fit to dive."

Mr. Beyerstein: I want to make a couple of clarifying statements, so please bear with me. I'm speaking from the commercial diving point of view. Dr. Torre mentioned that we have the Americans with Disability Act, which has unlimited liability, and that means, of course, that there is no cap on the settlement that the jury can award. On the other hand, in the offshore segment of the industry we can also work under the Jones Act, which also has unlimited liability and there is no limit to what a jury can award. So we are caught in the horns of a dilemma and, as far as the ADA regarding diving is concerned, we have not been challenged in the past because there is a large body of medical literature out there that supports these decisions for denying a person's fitness for commercial diving. So I'm urging you to be very definitive about the statements you're going to make now if they are different from what has been accepted before. Differentiate between what is speculation and what is fact.

We have had problems of the old bathroom scales and obviously the ADA would not accept "overweight." We had to come to a mechanism for handling that and we started using functional capacity evaluation. That provided a mechanism for the doctor to say "I would recommend you have a functional capacity examination." It would need a fixed job description which was defensible. *We* are looking to you to give us a decision. Is this person fit to be employed as a commercial diver or not? If you don't give us something clear, or don't give us an alternative as a way of defining whether this person can meet the physical criteria or not, then you're going

to bring on law suits from both sides of the fence, both after and before employment. If we hire somebody you have passed because it should be all right and we avoid the ADA, we may then get it later when it goes wrong. So I just want to clarify your responsibilities, gentlemen. We look to you for answers.

Dr. Bove: You're opening premise is incorrect. There is *no* body of literature that supports the decisions on asthma. All we have is a whole lot of anger, unsupported hearsay, and opinion with no support data. If somebody can quote "Dr. So&So" somewhere and maybe say asthma is OK, you've got to say "Dr. So&So" doesn't have the data to support that premise.

Mr. Beyerstein: Let me just state that there is a lot of literature a plaintiff or defense lawyer can use. He can say that "in Bove's book asthmatics should not dive." It's very simple. That's what I mean by a body of literature.

Dr.Gorman: I think it should be good to keep clear of decisions by the examining doctor. The risk assessment should be done by the diver and his employer.

Dr. Lundgren: Hear, hear!

Dr. Elliott: Yes, that I agree with in principle but I don't know how practical that is, particularly if you are considering somebody for a fitness to return to diving in a particular category. One may be considering a police diver who is not going to go deeper than 30 ft or somebody who is doing a totally different type of diving and there is indeed the need for the doctor to make that medical assessment and advise the employer. He hasn't got the know-how to make that judgment himself.

Dr. Francis: I agree that it is up to us to determine the level of risk and it is up to the employer of the diver to determine whether that level of risk is acceptable.

Dr. Daugherty: With regard to Tom Neuman's polarizing comment, if you question (a) and (b) as being relevant, why do we assume that severe asthmatics are at greater risk than mild asthmatics?

Dr. Faesecke: I would like to remark on the terminology "Fit to Dive." This requires the doctor to take a prognostic approach which says that somebody will perform underwater to the employer's expectations. This is not the job of the doctor. In Germany, the doctor says, "I have no objections that you dive," "I have total objections," or "I have objections under certain circumstances." But he does not declare someone fit to dive, and that is why we don't have any legal cases against doctors.

Dr. Elliott: The question of fit to dive is merely a succinct title, it is "the medical assessment of fitness to dive" and the fitness refers to not working effectiveness but to in-water safety in this context. So it is a very circumscribed area and is what we are really concerned with here.

Dr. Heimbach: I would take extreme issue with that and would state that it is the task of the occupational medicine physician specialist to do exactly what you're objecting to, that he judges the medical capability of the medical state of the individual in relation to the particular environment. You deny the total specialty when you say that the physician is not in a position to judge risks and make statements as to whether somebody with a particular medical condition is to work in a particular occupation.

I would like to discuss with the panel the statement that was made a few speakers ago about the Americans with Disabilities Act and its impact in terms of potential litigation. As most of you know, I have just stepped down as President of the Aerospace Medical Association, and part of what I wrestled with last year was the ADA's other actions, which was to try to reverse a fitness standard about insulin-dependent diabetics. Here we are talking about issues that are

well-documented in the FAA regulations and still they are going to be challenged. I'm not arguing against but in support of what you said. If we don't get busy and change out-dated material and literature, the courts and juries will make the medical decisions for us.

Dr. Bove: I would like to return to what was just said relative to the issue of where the physician's responsibility lies. We need to differentiate between the physician who is employed by an organization that employs the diver and the private practice physician. The first is hired by the system to assess the diver, whereas, in the sport diving environment, the doctor is not hired by a system but by the diver. We must make those distinctions.

Dr. Torre: About the severity of asthma, statistics are that the risk of air gas embolism is about 1 per 100,000 in a regular population. The risk perhaps in the asthma population might be as much as 3 per 100,000 and 2 out of these 3 were wheezing at the time. The conclusion is that if he actually wheezes you might be a greater risk than if he is not actually wheezing.

Dr. Watt: I entirely agree that exercise capability underwater or on the surface is a risk factor and we have firmly allocated that as a sort of positive one for agreement, but actually we are applying rather different criteria here because the information we've got to confirm that is entirely unacceptable. We have no information about the exercise capability of the people who have dived before their accidents, and I think you need to consider that in relation to two other pieces of information. One is that when you look at people who have died suddenly from asthma in other circumstances, a lot of them do not have a significant history of severe asthma in the past. Many of them have not been in contact with their GP or medical adviser in the days or hours before their sudden death. So what we may be seeing in people who are having acute sudden death from asthma in the water are those who would have died on the surface anyway. The other piece of information is that there is a small population who have quite significant exercise-induced asthma and they are diving perfectly successfully without any illness. So if you go 15 years into the future we could be having the same sort of argument, but setting completely different standards and accepting people who have got exercise-induced asthma. I think the problem will be getting more and more difficult.

Dr. Elliott: At the Edinburgh meeting where you had a paper it said that the exercise underwater doesn't get up to that level of self-induced asthma. Is that correct? Then the other point, which was made very forcibly at the same time, is that we do not know what level of exercise in required in a life-threatening situation and for how long it needs to be sustained.

Dr. Watt: I think that's a slightly different problem, but there are all sorts of other pieces of information that can impinge on the ability to exercise in water and relating that to the person's performance doing an exercise test at the surface. I'm not at all sure that it is logical to extend the information from normal people's relationship between ventilation and their FEV to the asthmatic population. This is because there are people with asthma who have no definitely impaired lung function, who are able to achieve very high levels of physical fitness, and presumably they are able to achieve a greater proportion of the FEV. The other point is that even if you assess somebody and decide that their ability to exercise on the surface is adequate, it doesn't tell you how they are going to behave when you use a breathing apparatus on them and, from other areas, particularly on the assessment of firefighters who have developed asthma. A particular problem in getting these people back to work when their asthma is well controlled is that they are unable to tolerate the breathing apparatus. So there are a lot of practical problems.

Dr. Moon: The person on dry land may well be able to achieve quite a high exercise capacity,

even in the face of lung disease, because there is a relatively large reserve. Dr. Harries has just told me that this would not apply necessarily to Olympic athletes, but the average person has about 50% reserve in the sense that maximum exercise induces a level of ventilation which is only about half of our maximum exercise ventilation.

Under water, with relatively moderate exertion, one achieves one's maximum voluntary ventilation at reasonable depths, so I would again suggest that we get away from (c), we simply make a statement that, for a person to be able to sustain moderate exertion under water, he must have absolutely normal pulmonary mechanics on the surface.

Dr. Harries: Can I just clarify a comment I made? The comment that the lung is not a limiting factor in aerobic capacity is because maximum ventilatory capacity can still be increased voluntarily for a short period of time. That's variously said to be a maximum sustainable ventilation and it is said to be between 50 and 80% of MVV. Trained athletes get maximum sustainable ventilatory capacity very close to MVV, but they of course are able to ventilate at enormously high levels by comparison with you and me. So I think we're looking at a slightly shifted population there, but it doesn't change the fact that once one develops airway obstruction, this will have an impact on aerobic capacity. There's no doubt about that.

Dr. Bove: Yes, I'm not sure I agree with you, Dr. Moon. There are numerous studies, and I think we've all seen them, of underwater exercise, carefully controlled with oxygen consumption measurements, comparing underwater oxygen consumption with the fitness of the individual based on surface measurements. My impression was that they correlate. I would be interested in hearing from somebody who recalls the data, but my impression is that if you demonstrate a certain exercise capacity on the surface, it correlates with the exercise capacity submerged. And I think it would probably be better to use exercise capacity than just a single ventilation parameter to predict exercise capacity in the water.

Dr. Moon: Fred, I was saying something a little different, and that is that on the surface one has some ventilatory reserve, whereas at depth and immersed in water, at moderate to high exercise levels it is possible to reach one's ventilatory capacity. So all I'm saying is that in the event of impaired ventilatory capacity at the surface, it is quite likely that under water one is likely to be impaired.

Dr. Bove: I'm not sure I believe that. I'd rather say that the exercise capacities correlate. Claes, could you make a comment on that?

Dr. Lundgren: I am trying to caution that too religious an attitude toward predictive exercise capacity based on accurately measured MVVs is fraught with problems. Another laboratory and ourselves have published data which demonstrated higher exercise ventilation under water than MVV at the same depth. Now that has to do with CO_2 levels and so on.

Dr. Moon: Not to make a big deal about this, because I think it's a very small point, you're absolutely right, Claes, but the degree to which exercise ventilation can exceed MVV is by a very small amount. As I remember it was around 10% and so for clinical purposes I go back to my original suggestion, that if patients with lung disease are to dive, they must have normal ventilatory mechanics.

Dr. Elliott: Fine. I have a problem as the chairman because I see the group getting away into a very useful debate and I have been tempted to say, hang on, we haven't got that far yet. However, all this will help to foreshorten this particular debate when we come to it further down the agenda.

But I would like to get back to where we were as soon as we have had the next few questions.

Dr.Torre: For the question of limited exercise capability: If you really measure an FEV_1 or a peak flow before, 6 to 9 minutes into, and again 10 minutes after, and obtain a normal result, you've eliminated the whole problem. If the FEV_1 after exercise is normal, they should be able to respond as well as anybody else under the water.

The comment about sudden asthmatic deaths, for people who don't know they have a problem—if you look at most of the autopsy data on those people, they generally have a large number of inflammatory cells in their airway, indicating severe asthma histologically (that was undiagnosed). The same type of person frequently enters the physician's office with no symptoms, but for a long time has been acclimating to lower pulmonary functions by slowly limiting activity—slowly enough that the difference was either not perceived or more easily denied. Again, this type of patient has an increased amount of inflammatory cells by bronchial-alveolar lavage. The slower the pulmonary functions decrease over time (which can be picked up if you're doing any kind of screening), the less you realize your limitations. They may seem to have a sudden asthma-related death, but the underlying inflammatory component of asthma was progressive, not sudden. This particular attack may have been "sudden," but the asthma has been progressing slowly enough that these people were not aware of the problem.

Pulmonary function studies would have demonstrated this in almost all of these cases. The exception is anaphylaxis (whether allergic or exercise induced) which included a pulmonary component, but that's a whole separate issues.

Dr. Harries: Yes, the problem for the asthmatic is not just that they may develop bronchial constriction as a result of exercise but that, if they're poorly controlled, their FEV_1 is well below the predicted at the time they begin exercise.

Dr. Torre: Right, that's what I'm saying. The comment before, that you can be "normal" and have a sudden asthma attack and die, is generally not typical. You can think you're normal, but you're not. If you were doing pulmonary function studies, those people wouldn't be normal to begin with. The FEV_1, even alone, would most likely have picked it up.

Dr. Harries: Except that no one is disagreeing with that and nor are we. I don't think anyone has disagreed that if you treat asthma adequately and you're dealing with a relatively normal patient with relatively normal ventilatory function, it should not necessarily restrict them from diving.

Dr. Neuman: The issue may be an important one in that one of the studies that was done by Peter Wagner, looking at the distribution of ventilation and perfusion of asthmatics, is quoted often as why asthmatics shouldn't dive. The quote is "because even asymptomatic asthmatics have marked abnormalities distribution ventilation and perfusion." Yet if you look at that paper and you look at the pulmonary function tests of those individuals, they had markedly abnormal pulmonary function tests. So the simple issue of symptoms of the asthmatic does not define normalcy by any means.

Dr. Kime: I'd like to congratulate everybody. I have been listening to the same question and the same answer for the last 15 minutes. Your agenda is fairly large. I would like to suggest that maybe we move on to some new issues and allow us to argue the small points at the cocktail party this evening.

Dr. Saltzman: I'd like to suggest an obvious experiment; patients with asthma who are symptomatic or otherwise should be studied on scuba gear, immersed in water, to observe their response to positive pressure breathing gases.

Dr. Elliott: Fine, but who will fund it? Taking a cue from Dr. Kime, I suggest we go rapidly

through one or two of the other overheads. Most of these are so simple that they'll be passed on the nod. The first of these says---

"Current policies are effective at reducing apparent asthma-related instance, but they also exclude unnecessarily, many potential safe divers."

Does anybody disagree with that statement?

Dr. Torre: Current policies are not effective at reducing asthma-related incidents, they increase them, because people are forced to lie about their asthma and they go into the water untreated and have more problems. So current policies, I think, are the opposite...

Dr: Elliott: *"Asthma is an absolute correlative contraindication according to different guidelines. Determined individuals have evaded medical scrutiny and disqualification. These few persons provide sufficient evidence that asthma is not a problem in diving."*

The panel has seen all these questions before, so I would like an immediate answer please.

Dr. Moon: David, perhaps we could get some consensus on the panel as to what is an acceptable risk. I would say that we don't have enough evidence to answer the question, but if the DAN data are taken at face value and are representative of the general diving and asthmatic populations, then one can say with 95% confidence that the risk is less than four times increased in asthmatics. The question then becomes a philosophical one. Is a four times increase in risk acceptable or not?

Dr. Gorman: I'd agree with his comments, David. I think you could change that to read "These few persons provide sufficient evidence that asthma is not uniformly lethal in diving." I think that would be a reasonable interpretation.

Dr. Elliott: Very good. We'll put that in.

Dr. Bove: Richard, I thought you did not have significance to be able to make the statement you just made. Aren't they all P non-significant?

Dr. Moon: Yes, the issue is the confidence with which one can state different levels of risk. Certainly the risk is less than four times increased. I would agree, but . . .

Dr. Elliott: But it's very vague. At least we're defining what data we need to collect in the future.

Dr. Francis: Another point is that these few persons are self-selected. We are not dealing with a general population here. They're highly selected and they may provide some evidence.

Dr. Elliott: That overhead applies only in the recreational area.

Dr. Bove:: David, I think you should just take the second sentence away.

Dr. Elliott: Take the second sentence away. Okay. Noted. *Delete* "These few persons provide sufficient---"

Dr. Neuman: Everybody keeps saying that these folks are self-selected and that it's a very unusual population. Well, that may or may not be true. I will grant you there is some self-selection, but when you look at the incidence of asthmatics in the diving population, it very closely mirrors the incidence of asthmatics in the whole population.

It is difficult then to say it's dramatically self-selected, that 90-95% of the asthmatics have selected themselves out. I think we're looking at most of the asthmatics and, although there may be some self-selection, the evidence would suggest that there is not a dramatic self-selection.

Dr. Macris: I'm from Guam where I've been practicing diving and military medicine for a long time. For those of us who have relatively large diving populations, I tend to agree with Dr. Neuman: we see a lot of reactive disease and no incidents. I feel that diving and asthma are only relative contraindications. I can't say that it's absolute. I'd rather see this panel have the

responsibility now of saying it's relative because of the lack of information, or else the lawyers will make decisions for us.

So number one, I believe we've crossed the line now. We cannot say absolute, and that would take a lot of pressure off the physicians who practice.

In a small island community, if I say no, the diver will find someone else who will say yes. If the panel says it's relative: you can dive if you're well controlled, then we accomplish goals on both sides

Dr. Youngblood: I'd like to pose a question in a slightly more practical vein. Since we can't decide the relative risk, how would the insurance carriers look upon this? In aviation, if you have different experience or risk, you're assigned a different premium. Do we feel this is so evenly matched in divers that asthmatics will pay the same DAN insurance premium as those who don't have asthma? Perhaps insurance companies should fund Dr. Saltzman's study.

Dr. Elliott: Insurance companies don't fund any research because they don't mind if the premiums do go up.

Dr. Bove: The insurance companies do actuarial studies to look at risk and they don't have the data. If you mention the word scuba diving, they think there's a risk. I think we've spent more time beating that one down than—but they clearly don't have data for asthma, so I'm not sure that they would make any conclusion without good actuarial results.

Dr. Elliott: This next one we have discussed already.

"The history of childhood asthma is not significant if there had been none since. And a gap of 5 years without medication is sufficient."

As far as the second one is concerned, the numeral three was inserted this morning.

Dr. Bove: David, I guess I would advocate the here-and-now approach rather than the historic approach. You could argue that an individual who wheezes 3 months out of the year but never goes to the physician because they don't want to get identified, would meet the criteria that you have here and could still be an asthmatic who is abnormal on testing..

Dr. Elliott: Okay, but are you happy with the first statement? Panel? Childhood asthmatic history is not significant if it stopped.

Dr. Mebane: One of the problems with that statement is that when one encounters an individual 25 or 30 years old who says that he had childhood asthma, one does not really know what he had. They may have had bronchiolitis; they may have had a viral infection. So childhood asthma is a vague term and difficult to evaluate in an adult.

Dr. Neuman: Well, maybe it's not a totally sufficient statement, but I think all of us would agree that if somebody came to us and said they had a history of childhood asthma, that they've never wheezed since, that they've never been symptomatic since, and you have no reason to believe that they've got ongoing symptoms—such a person I think would not be a concern to anybody.

Dr. Elliott: The feeling I got was that these are merely starting points from which one has to make a proper assessment. But we've said that they are insufficient statements without further qualifications.

We now come to another, which will take considerably longer to debate.

"Hyperactivity is stimulated best by submaximal exercise, by cold air, by histamine and methacholine."

This statement has already been debated and so we should get through it very quickly.

Dr. Harries: What you need to do is to provide evidence that someone is at risk by

demonstrating that they bronchoconstrict as a result of one of these challenges. All I'm saying is that the exercise challenge seems to be the most pragmatic because that's what you're worried about. The response of ventilation to exercise is easy to do and easy to plan.

Dr. Elliott: There seemed to be no argument with the elimination of histamine and methacholine. Does anybody want to retain them?

Dr. Harries: The methacholine and histamine challenges are research tools used to measure the degree of hyper reactivities. They are complex tests to do and doesn't really provide any more information.

Dr. Gorman: David, I think we shouldn't overlook one of the advantages of hypertonic saline. It has a huge advantage in explaining risk, because it's immediately understood by the candidate. Telling the candidate that they responded to histamine and shouldn't dive is often difficult, but showing them how they responded to exercise gives a very functional demonstration of a diving-related stimulant.

Dr. Elliott: Does this come into diagnosis or management?

Dr. Gorman: I think it comes into risk assessment.

Dr. Bove: David, I'm a little concerned in the word "best" because best is a subjective term and everybody's got a different way of looking at it. I wonder if instead, something like, "the consequences of airway hyperactivity are best evaluated by ..." I for one would like to see exercise testing as the---

Dr. Elliott: And among comments during the coffee break there was the feeling, please, that they would like members of the panel to come out quite clearly and say, even though it's obvious and it's been debated already, that the exercise test is probably best. Then hypertonic saline can be used, but it's more really as part of a personal assessment.

Dr. Neuman: I would like to register my objection to hypertonic saline. I know how to do it properly. And I don't think it is a useful test because it is too sensitive. It gives too many false positives and so is not meaningful in the context of diving.

Dr. Elliott: Can we dispose of this quickly: Would you consider the hypertonic saline as supplementary to the exercise, rather than a replacement?

Dr. Gorman: That's my practice at the moment.

Dr. Harries: If you put a bronchoscope down the airway of a semiconscious patient whose airway hasn't been properly anesthetized, they'll develop bronchoconstriction. That doesn't tell you they've got asthma.

Dr. Neuman: That's what I'm saying. It's too sensitive a test. You can make a stone bronchospastic given enough stimulants.

Dr. Gorman: You're exaggerating now?

Dr. Torre: Can the wording on that just be something like "the best way to determine clinical relevance for hyperactivity for the scuba diver is exercise?"

Dr. Francis: David, before you throw that one away, can we just get at some sort of agreement of what we mean by hyper-reactivity.

Dr. Elliott: What do we mean by hyper-reactivity? Who would like to start?

Dr. Francis: Well, we use a value of 20% in our practice.

Dr. Harries: That tells you PC-20 is the concentration of histamine or methacholine that will result in a 20% fall in FEV_1 from start level. All that tells you is a concentration of histamine required to give you that amount of bronchoconstriction. It tells you what degree of bronchial hyper-reactivity you've got. All that exercise is telling you is that you've got a patient with

bronchial hyper-reactivity. And you're not quantifying it.

Dr. Francis: What percentage change in FEV_1 constitutes hyper-reactivity? That's what I was asking.

Dr. Harries: Bronchial hyper-reactivity is a concept. It is a description of increased sensitivity of the airways to a multitude of unrelated stimuli. And the two which are commonly selected are methacholine and histamine. But you can equally well use cold air, or you can use distilled water mist—or yes, you can irritate the airways with cigarette smoke. But the point about methacholine and histamine is that they provide a quantitative measure of the degree of hyper-reactivity.

That is not what really interests us. You want to know whether your patient is at risk from developing bronchial constriction, and the challenge that they are required to undertake is an exercise test—when they're performing underwater.

Dr. Elliott: The next overhead is again not particularly well worded. It says.

"Ventilation capacity in obstructive airway disease is best assessed by exercise capacity."

Dr. Bove: I would only ask the obvious question. If you gave me a patient and said assess his ventilatory capacity, why wouldn't I first do a pulmonary function test to find out his ventilatory capacity?

Dr. Harries: Because if you have someone you're worried might have asthma, and they present to you with normal pulmonary function, that only answers half the question. What you want to know is what happens if you stress them? Do they then develop bronchial constriction and is it significant? Because if it is, then you're going to need to provide treatment to ensure they don't get into trouble when they exercise. That's the point.

To put it another way, you can have someone who can be a relatively severe asthmatic who presents to you at a time when their respiratory function is normal, and if you then stress them with an exercise, you suddenly find that they're not normal at all.

Dr. Elliott: Any more debate on that?

Dr. Moon: I think it is quite straightforward. One of the criteria must be normal ventilatory mechanics before and after exercise.

Dr. Francis: Exactly. The question is what amount of variability is acceptable?

Dr. Bove: I may be playing on words, but I thought I just heard that we shouldn't do pulmonary function testing to assess ventilatory capacity, we should do an exercise test. What you just said was, we do pulmonary function testing before and after exercise to assess ventilatory capacity.

Dr. Moon: If they're abnormal before exercise, then you don't need to do the exercise.

Dr. Bove: Well, I'm still not sure because I'm hearing two different things. One is you can assess ventilatory capacity with exercise, and the other is no, you have to measure ventilatory capacity with a pulmonary function test. We're getting two different statements about how to answer the question.

Dr. Elliott: Okay, let's start again.

Dr. Harries: We're not making different statements at all. If your ventilatory capacity is abnormal when you pitch up for your test, that's it. You've made the diagnosis, you have someone who's not fit to dive until their ventilatory function is converted to normal with treatment. But the fact that they turn up with normal ventilatory function means you're only halfway through the assessment. You've then got to find out if, as a result of an exercise test, they stay normal. If they do, fine. If they've got asthma, they may bronchoconstrict and then

develop abnormal function as a result of an exercise test. So we're not disagreeing at all.

Dr. Bove: What do you mean by ventilatory capacity?

Dr. Elliott: That was stated this morning as best done by the flow-volume loop. Is that generally accepted by the group?

Dr. Harries: It's a very useful test; it's a better indicator than a change in peak flow, and it's a better indicator than change in FEV_1, although both are acceptable. The point I was making this morning is that you can have divers who currently have positive exercise tests as defined by a 15% fall in lung function after the test. But you can have individuals who have less than 15% fall either in peak flow or in FEV_1, but who have a greater than 15% fall in mid-expiratory flow for the reasons I explained. As you develop air flow obstruction you get small airways collapse—it's a rather more sensitive way of picking out those who are likely to be abnormal. Better than just the peak flow alone.

Dr. Moon: Mark, it's a little more difficult for some to get office space and machines for mid-expiratory flow. Would you accept FEV_{25-75} as equally sensitive?

Dr. Harries: Yes, perfectly reasonable. There's a lot of very cheap software now which will give you those values.

Dr. Bove: I'm trying to figure out what to do when the next patient walks into my office. It sounds to me that we should do some kind of pulmonary function test, and we should have the patient exercise, and then we should repeat the pulmonary function test. Is that what you're saying?

I understand, but the first answer to the question was that we don't have to do pulmonary function test. That was the first thing I heard, and I'm just trying to clarify: we should do pulmonary function test, but we shouldn't do them as isolated resting test, we should do them before and after exercise.

Dr. Neuman: Yes.

Dr. Bove: Okay.

Dr. Francis: Fine. Back to my original question. What are we measuring and how much do we accept as being within normal limits? We have agreed that FEV_1, peak flow, are all acceptable. We have a figure of 15% variability with exercise, which may indicate abnormality.

Dr. Elliott: I think the answer to that question is that in a naval or occupational context, one may be interested in pass/fail criteria, but in the recreational context, these are merely indicators that all is not well, and the physician will then give appropriate advice. I don't think that as a panel we're going to vote on pass/fail criteria.

Dr. Francis: Okay, that saves a fight anyway.

Dr. Elliott: If we're dealing with the recreational diver we are only giving advice. There is no hard borderline as there might be with a military or employed diver. Okay, let's take a string of questions and please keep them brief.

Dr. Davidson: The exercise we're talking about, is it the Bruce protocol, the Masters two step, or what?

Dr. Harries: There isn't any agreed protocol for exercise testing for airways reactivity as far as I know. I may be quite wrong. I look around for people to frown at me. What you're trying to do is see if you can provoke bronchoconstriction. You're looking for the person who's at risk and so you want to pick the stimulus that's most likely to do it. Three ingredients in the exercise test are important. One is running outdoors. I don't know why, but running on a treadmill is not acceptable and exercising on a bicycle doesn't do it as well because you're usually indoors. So

running outdoors, free running, and vigorous running—that means about 80% of your maximum heart rate (which is 220 minus your age in years). You run for between 3 and 5 minutes, come back, wait 5–10 minutes and you measure. It's not critical, but if you measure before 5 minutes after the test, you'll miss things. If you don't get them exercising hard enough you'll miss people with problems, and if you don't get them running out in the open air, you'll miss. That's all I'm saying. It's a pretty crude test. You're just looking for the people who are at risk.

Dr. Neuman: I think the practical answer to that is that an oxygen consumption well above the level expected to be needed in whatever situation you envision; 13 METS is one level of exercise that has been suggested.

Dr. Potkin: I'm curious—are we advocating exercising everybody who wants to get a diving clearance? Because you said, if PFTs were normal, they would need to be exercised. I don't think that it's financially reasonable to exercise everybody who wants to get clearance.

Dr. Harries: No, only to asthmatic ones you're worried about or the ones who give a past history of asthma, you want to know if they're still at risk. If someone has no past history of respiratory diseases, there's no problem.

Dr. Lepawsky: Having normal resting and exercise pulmonary functions, do you ever want to see a ventilation perfusion study done? If you have normal resting pulmonary functions and exercise pulmonary functions, do you want to see a ventilation perfusion study for any reason?

Dr. Elliott: The panel response was no.

Dr. Torre: Many of us feel we don't even know what normal is, depending on the population. If you look at the standard deviations, some people feel it's really less than 65%, which many people feel is really not appropriate anyway. But you're going to take a compromise. I would really much rather see FEV_1, rather than 25–75. It at least correlates better with reality. Although the 50% mark may be ideal, with FEV_1, I think it's a better test than 25–75 for clinical relevance.

The other thing is, the FEV_1 can be measured for $120.00 by everybody, so it's just a screen without doing the exercise pre and post. It's not a bad idea to have an FEV_1 just as part of your screening physical anyway.

It also depends on where you're getting it done. Different places use different methods, and while running outside may be the ideal, it's not always easily done. I can tell you in New Jersey, there's no way I'm going to get an exercise test done outdoors in the middle of winter—or for that matter, in the middle of summer. It is reasonable to get it done on a treadmill if you're using 15% instead of 20, you're a little more sensitive. If you're using the typical 80% of maximal and doing your FEV_1 before, 5 minutes into it, and then 5–10 minutes after you're done, you've got the three parameters and between those three you should be able to pick up most of the clinically significant stuff without trying to do it outdoors in the snow and the rain and the ozone.

Dr. Weaver: If it's a premise that airways obstruction is not a risk factor for diving, why is there so much focus on FEV_1 and mid-flows, et cetera? If a person can perform 13, 15, or 16 METS of energy expenditure on a treadmill, why does it matter if that person has mild or moderate airways dysfunction? If we accept the given data that implies fairly strongly that "asthma," whatever that is, is not a serious factor.

Dr. Bove: It seems to me that the way to do it would be to start with a very simple exercise test; if the person reaches a certain goal, you wouldn't do anything else, and if he had significantly limited exercise, then you'd do the FEV_1. You wouldn't have to do it before because you don't care before what it was. You care what it is after.

Dr. Gorman: We have to be very careful. While we accept exercise tolerance may be the major risk for the asthmatic, I've heard nothing today which dissuades me from being concerned about air trapping and pulmonary barotrauma, nothing at all. Theoretically it makes a lot of sense, and I see enough pulmonary barotrauma in breath-hold divers to know that it's just a matter of heterogeneous compliance. You don't need lungs to behave like balloons to cause pulmonary barotrauma. So I think there's still a need to pay attention to air trapping. I accept it hasn't been proven, but goodness me, there's some very good reasons why it is a persistent theoretical risk.

Dr. Neuman: From a practical point I think the point that Dick made earlier is indisputable, that just by getting in the water your MVV drops by 15%. You go down to 100 feet in dry circumstances, and you're MVV is down to 50% of normal. So far we haven't even talked about the added resistance of the breathing apparatus. And so to generate an oxygen consumption that's anywhere near reasonable, you essentially need normal pulmonary function at the surface. Once you start getting down to a significantly abnormal pulmonary function at the surface, you're just not going to have the ventilatory reserve to generate sufficient oxygen consumption at depth.

Dr. Weaver: And that's why I'm asking about function—exercise, treadmill with a certain amount of energy expenditure is probably the gold standard, and pulmonary function.

Dr. Moon:: But if that's the case you have to exercise them at depth, at that kind of gas density, immersed, and with some sort of underwater breathing apparatus. And if you did that, I would agree then, that the FEV_1 no longer becomes necessary.

Dr. Weaver: No, but we have other information. We all know there are older divers who have smoked for many years, who have obstructive airways disease, and they're out there diving. Your own data, the Divers Alert Network, and others would certainly imply what is killing people. There are more people dying from lightning injuries in a year in the United States than from diving. So it seems that, if airways dysfunction is killing divers, it ought to be well represented and should have been known about years ago. I'm not sure that case has been made.

So therefore, we accept that a person who's 55, 60 years old, is obese, who can't even manage 8 or 9 METS of energy exposure, can dive because "they never had a history of asthma." Right? I mean, we're all agreeing to that? And all of a sudden now, we take a 25-year-old person who can do 14 METS of energy exposure, but happens to have moderate airways dysfunction by pulmonary function studies or reductions in mid-flows. That makes no sense.

If you look at data behind this, it seems that we should perhaps be much more liberal in our recommendations for recreational divers and let the diver take the element of responsibility.

Dr. Gorman: I'd like to comment that I don't think asthma should be the only indication for exercise tolerance testing. I actually agree with you, but the other way around: If I saw an obese, middle-aged male, sure I'd put him through an exercise tolerance test. I could then explain sensibly to him what his risks were in diving.

Dr. M. Bennett: If you are looking for someone like that, Des, you've found him.

The question that has mystified me a little bit is that we have heard that these pulmonary function tests are indicated for people who are symptomatic and yet, as we discussed this morning, these symptoms don't always come to the attention of the examiner. I don't really see how those two positions can be sustained simultaneously.

Dr. Francis::David, I wish to make a point which harks back to the meeting in Edinburgh. What we're doing here is to walk back from what, historically, has been an absolute ban on

diving for asthmatics. If we're going to do that, it's quite sensible to do it in steps and we should study carefully the population we are affecting. So if we come up with criteria now that are less than a complete ban, but are still perhaps relatively conservative, and we study the population and see what happens, we can later relax the criteria a little bit more, perhaps.

Dr. Elliott: Okay, important, but we must move on.

"Safety is not significantly diminished for those established and previously healthy recreational divers who acquire adult onset asthma and can still meet the exercise requirements."

Is that a reasonable statement? I hear Yes, yes, yes.

The next may cause a little debate, but we have covered it already,

"Chronic asthma, when quiescent is acceptable, even if on inhaled steroids.".

Dr. Harries: You have to add the rider, "provided their respiratory function is acceptable."

Dr. Elliott: I'm not sure if the next is an appropriate, but---

"Acute asthma as evidenced by cough, wheeze, dyspnea, or impaired exercise capability is an always immediate contraindication, but how soon after it has resolved can recreational diving be resumed?"

Dr. Neuman: As a starting point, how about "when peak expiratory flow is back to baseline? A large number of asthmatics now monitor their own function with peak expiratory flow meters. They're cheap, they're reasonably reliable, they're fairly reproducible, and many asthmatics adjust their medication based upon their peak expiratory flow long before symptoms develop.

Dr Potkin: I would say when pulmonary function is normal. I wouldn't limit it to flow.

Dr. Elliott: The reason it's peak flow is because it's so easy for individuals to do it themselves. *"We can conclude that safety is not significantly diminished for the asthmatics wishing to take up recreational diving who meet defined criteria."*

Now we've talked about advice and risk assessment, we might want to rephrase the words, but let's stick with the words of the overhead

"Individuals with exercise-induced or cold-induced asthma in whom this condition is completely controlled by medication and/or individuals with normal maximum expiratory flow rates and normal static lung volumes."

Dr. Neuman: I'd like to second what Dr. Harries has said about the systemic steroids. If we're talking about function, it ought to be function and not how we achieve function But I would like to add on the bottom of that overhead, "after exercise."

Dr. Elliott:: Okay. Any more on this overhead?

Dr. Bove: Yes, David. I don't quite understand because I thought for the last half hour we had talked about the need to assess exercise capacity as far as safety is concerned, yet this does not mention anything about exercise capacity. Is that coming in another statement or should it be incorporated here?

Dr. Elliott: These overheads are part of the same package of questions which were precirculated. They were not meant to be mutually exclusive or anything like that. So, as it adds little to what we have already said, we could drop that one. That completes all the overheads.

Before we go any further, are there any other statements that anyone feels we should debate? In view of everything we said today, are you happy with the reiteration of the overheads we have modified? Are there any supplementary statements you might like to make?

Dr. Bove: You didn't bring up the physician qualification. Do we need that?

Dr. Elliott: I have on my list "trials" and "doctors," but I don't have any overheads on those

questions. Okay, so the collection of information and the training of the doctors---

Dr. Heimbach: I was confused by something Richard Moon said, when you added pulmonary barotrauma, I guess I didn't understand what your point was. Would not normal expiratory flow rates mitigate against the danger of pulmonary barotrauma?

Dr. Moon: Dean, I don't think we have the data to make a statement on that. The measurement of expiratory flow rate is a relatively crude test in terms of knowing what regional lung flows are doing. As a first approximation, I think the data that we have suggest that "asthmatics" can make ascents from a dive, as Des says, without it being uniformly fatal. Given the number of person dives that have been reported among asthmatics of varying severity, the risk would appear not to be tremendously elevated, without actually quantifying what that phrase means.

On the other hand, the data are not of sufficiently high quality or quantity to make a pronouncement on the risk. I would leave that issue open. In 5 years time we may be able to come back and say that we know that there is a twofold or so increased risk in people with normal ventilatory mechanics, and then the individual physician can do with that what he wants. At this point, we can't put a number on it. There is a suggestion of an increased risk, but it's not uncomfortably high.

Dr. Francis: I'd just like to hark back to the data that I showed this morning. These were from those who were not asthmatics and were people with normal expiratory flows. The evidence there was that expiratory flow does not appear to be a risk factor, it is slightly lower than normal, whereas vital capacity may be more important as far as pulmonary barotrauma is concerned.

Dr. Moon: ...and that is pulmonary barotrauma during free ascent training.

Dr. Lundgren: David, is that previous overhead off limits now?

Dr. Elliott: No, you can go back because, otherwise, it'll be another 5 years---

Dr. Lundgren: In the interest of intellectual honesty, shouldn't we be a little more precise in that statement where it says something to the effect that risk is not significantly increased. Is that meant to be taken literally, as statistically significant?

Dr. Elliott: No. As I said at the beginning, we're not dealing with probability, we're dealing with qualitative assessment.

Dr. Lundgren: My concern here is that it might be taken as being a statistical statement. So I would suggest that it be rephrased so as to make clear that we don't have the material to make a statement one way or the other.

Dr. Elliott: Right. Thank you.

Dr. Goldmann: On that last overhead, I was wondering how static lung volumes fit into what the panel feels is an important consideration, because that's the first time I have seen them as a consideration?

Dr. Bove: I think it would be reasonable only because if you start to see significant alterations in static lung volume, it would be a clear sign that they have anatomic damage to the lung.

Dr. Harries: Lung volumes are a difficult issue because one can only do them in an office or a lab with very carefully controlled conditions. So, in view of the impracticality of any recommendation based on lung volumes, it should be taken out.

Dr. Youngblood: It bothers me that we say in the last slide that it is safety which is not significantly diminished, whereas I would prefer the subtle warning that risk is not significantly increased.

Dr. Elliott: The important part of the debate for the last few minutes, please, is for us to

address the problem of what data should we collect, internationally, so that when we are reviewing this same topic in 5 years time, we have actually made some progress.

Dr. Bove: SPUMS is developing a database, DAN has a database. I would say that we ought to recommend that these organizations get together and develop them together.

Dr. Elliott: The Institute of Naval Medicine also has a database. So that together covers Europe, the Antipodes, and the Americas, and we have representatives of all three organizations on the Panel. Perhaps members of the Panel could say what data on recreational divers they would be collecting, given the opportunity. The point has already been made that one should start with the individual before he or she begins diving because many of them will self-select to drop out before they get on to diving regularly.

Dr. Gorman: I understand that this year, in the United States, there will be something like 700,000 people undergoing some form of diving tuition. In Australia, it's something in the range of perhaps 20,000–30,000. An enormous number of people are coming to the conventional recreational instructor to undertake basic diving tuition. I think there is a big loss from diving of people with asthma, and so the capture point has to be pre-diving. If we do nothing else but get an accurate asthma history, even with only the most fundamental spirometry data imaginable, and then cross-sectionally survey the same populations just 6 months, let alone a year later, and find out how many are still diving, you start developing very powerful data about the self-selecting nature of the population. You'll have some idea of where they are in the spectrum.

That would be a very good place to start and it has the huge attraction of being capable of being implemented. It would require some cooperation or coercion of the recreational diving industry. I think they would go for it. There are commensurable reasons why they'd want to see the consumer base increased.

Dr. Bove: If one were going to do this, one would be doing a prospective study which would be best modeled in something called logistic regression. It's the standard way to determine outcomes and risk factors. My guess would be that you'd need to study confounding variables, besides just asthma. So you'd probably have to collect 150-200 pieces of information on each individual, but to try to decide on that now would not be impossible.

Dr. Elliott: We certainly cannot decide on detail now, but I am concerned that these tapes that we're recording will be stored away, and the report will be on the shelf. Then we'll meet again in 5 years time and maybe nothing will have been achieved. Am I looking at 16 sloping shoulders? Is anyone prepared to say, right, my organization will take this on.

Dr. Gorman: Well, David, SPUMS is already committed. No matter what occurs, this is what we intend to do.

Dr. Elliott: Okay, so that's now only 14 sloping shoulders.

Dr. Moon: I will offer the services of DAN to create a registry and be prepared to record any data that physicians could send us.

Dr. Elliott: Thank you. Now, I do know that it is not reasonable to ask the Institute of Naval Medicine because their database is for a totally different purpose. In the European group, Patrick, would either yourselves or Alessandro Marroni in DAN Europe be appropriate for collaborating with the American and the SPUMS exercises to look at commonality of protocols and so on?

Dr. Farrell: We currently have the prospective study which has now been taken on board by the UK's Sports Diving Medical Committee. They're setting that up as a database, possibly with

DDRC in Plymouth.

Dr. Elliott: Is there a forum, more permanent than the top of this table, though? This is the way I was hoping it would be going. Or do you see these as being three totally independent studies with everyone doing it differently?

Dr. Farrell: No, it is very straightforward, really. We need a common database and we have all got computers. We need to know how we're going to collect the basic information in the same form for databases.

Dr. Elliott: So, from Europe, from the DAN, and from SPUMS we have the willingness to collect this data together? That is a good outcome, in which case the next time we debate these questions we'll have something really to base them on.

Can we now consider whether it is appropriate to give a priority to the minimal knowledge that a doctor must have about diving before his signature on a "fit to dive" certificate reflects reasonable competence?

Dr. Gorman: It is a central tenet of the South Pacific Undersea Medical Society that doctors should have an understanding of underwater physics and physiology before making an assessment of diving fitness. Some argue that one could have a general screen performed by untrained general practitioners, but our survey of the quality of those screens in Australia suggests that they are worth slightly more than nothing at all, on a generic basis. Even if you had such a screen, someone with a past history of asthma would simply have to be referred to the next level of assessment of risk anyway. So SPUMS would argue very strongly that assessment of risk for an asthmatic to enable that person to make a sensible decision about diving, really requires physician insight.

Dr. Mebane: A physical exam is not required in the United States unless there is a problem. I would like to see something similar to that in the UK, where there are medical referees. When a person with a medical problem that would seem to contraindicate diving is seen by their own personal physician, the form would state, "call DAN for consultation." It should also point out that it's free, of course So between the two physicians they should be able to come to some appropriate conclusion.

The demand for this type of service is so small in the United States that it's unreasonable to expect any given physician, primary care or not, to be an expert in diving. It is so small a category of illness that the average physician will never have expertise in diving. They will go through a medical career without ever seeing a diving accident. A consultation, which can be by telephone, can be perfectly adequate.

Dr. Elliott: Yancey, you said previously that nobody has a medical unless a problem has been identified. Who's responsibility is it to identify that problem? Are they competent to do so?

Dr. Mebane: No, they're not competent. The way it has been set up is that the instructor and the prospective student sit down and look at a questionnaire. If they both agree on the physical fitness of this student, or the lack of it, and there is no disagreement between them, the physician is never involved. The physician is involved only to resolve a controversy.

Dr. Elliott: I think we all agree quite firmly that a degree of competency is required in making the diving fitness assessment. Without saying how it's to be done, we might put that into the final statement.

Dr. Heimbach: I have some problems with the referee system. I do a lot of assessment of diving fitness in San Antonio, in that we have our dive shops well trained to refer questionable persons—particularly those applying for diving training—for evaluation by ourselves. And one

of the reasons is that I don't charge for this, so there's no hesitation for these people to come.

What we see many times is the diving instructor picking up a problem that was missed by the potential student's generalist who gave him his original diving medical exam. The fact that a referee enters into this when there's a controversy is not where I see the problem. The problem is that we have too many people being cleared, and the referee would never be called. I don't think the referee approach is the right answer because it solves the wrong problem.

Dr. Elliott: I think it's true to say that Australia, New Zealand, Malta, and France are the only places that require a recreational diver to have a signed medical examination.

Dr. Gorman: It varies for Australia, David. In Queensland, for example, there is a requirement that the doctor have appropriate experience. In New Zealand there's a requirement that there be an examination, but no requirement the doctor be trained. They use a two-tier system where, if the initial doctor finds anything he's not certain of, the diver has to be referred to another one.

Unidentified Speaker: We're fortunate in our area in that, if any of the divers check asthma or diabetes or any questionable problem, most instructors will not accept a medical release form unless it is signed by Tom Neuman or myself. This doesn't occur in the majority of other places around the country, but as we come up with these guidelines, what we need to remember is our responsibility as physicians to educate these divers. A general practitioner who doesn't dive or who has no knowledge of diving physiology may be able to follow a written suggestion or guideline, but may not be able to explain to that diver the pathophysiology of what could be going on in diving. For example, why it is, if they're having a little bit of wheezing that morning, they should probably not make a dive that day.

Dr. Lim: I am worried in the sense that, after this consensus, what will happen to the asthmatics who actually have approval to dive. Should they sign a release form, that "you are hereby informed that these are the risks that you accept before you go diving?"

Dr. Elliott: The answer to that is yes. You at least need to make an entry to say that you have discussed the risks of continuing to dive in this condition.

Dr. Gorman: This is what we are developing with the instructional agencies at the moment. This process of discretionary assessment can apply only in the context of sports certification.

Dr. Elliott: So the answer is yes.

Dr. Lim: I have a comment regarding asthma in relation to barotrauma and DCI: we should also say that there are no data, but that it is accepted that for asthmatics there is an increased risk at this moment in time. Am I right?

Dr. Francis: The answer is that the data are inadequate at the moment to tell us whether this is an increased risk or not. Theoretically there are reasons why it may be an increased risk. Sadly, we've got no data to support that.

Dr. Lim: Second, is asthma now considered as a relative contraindication to diving. If yes, the central test for approving asthmatics is spirometry after exercise?

Dr. Moon: Yes, that is correct.

Dr. Lim: Can I just conclude: We are in agreement that the exercise test is within 80% of maximum, whether by road running or a treadmill on site, after which we use FEV or MEF?

Dr. Moon: Well, several have suggested that the best one is reduction in mid-expiratory FEF_{25-75} flow (MEF) but FEF_{25-75} is probably as good and is probably more widely measurable. Also FEV_1 has some utility.

Dr. Lim: So, if the lung function test after exercise is normal they can dive, whether the

divers themselves have previously shown asthma on many occasions?

Dr. Moon: Yes.

Dr. Elliott: Thank you, Dr. Lim, for summarizing it so well.

Unidentified Speaker: What pre-treatment is appropriate? Could it be the same as that given to those playing football or basketball?

Dr. Moon: I think that is an individual medical decision.

Dr. Harries: We discussed this morning the differences in philosophy and the feeling in the European Thoracic Society that the way to manage bronchial hyper-reactivity is to get your subject established on twice daily inhaled steroids. Short-term release, lasting only 3 or 4 hours, is what you get with a bronchodilator and is not an adequate long-term solution.

The question about chromalin or sodium chromoglycate as we call it, is more difficult. Sodium chromoglycate is very good at inhibiting exercise-induced asthma in children. It's relatively ineffective in adults.

Dr. Elliott: Thank you. Well, I think we've come to the end of the debate. I would like to give the panel the opportunity for any final comments they'd like to make.

Dr. Moon: It is incumbent on any of us who are going to certify fitness for asthmatic divers to discuss with them fully the issues, including safe diving practices, particularly with regard to ascent rates.

Dr. Mebane: Diving is very important to us individuals in this room but, in the overall picture of medical care, it's a tiny fraction of the whole problem. So we need to speak with our colleagues who are not diving physicians and offer our services. A busy practitioner seeing 30–60 patients a day for major medical problems is not really interested in doing a physical examination for someone to start diving. It's up to us to seek out our colleagues who may be in primary care or other areas where they will see these divers and be sure our services are available.

Dr. Neuman: I'd like to say two things. One is to stress what Dick just said. Most accidents come from not adhering to basic safe diving practices. We should stress that with every diver we ever speak to and whenever we speak to groups of divers, whether it's about asthma, diabetes, epilepsy, or hangnails, we must stress that safe diving practices are the key to diving safety.

The other thing is that we are embarking upon an area where the risk is still not as clearly defined as we would like it to be. It is incumbent upon every physician who deals with asthmatics who may dive to document in their charts that he/she has explained to the patient that there may be additional risk associated with diving with asthma; and that the patient is willing to underwrite that risk.

Dr. Gorman: In addition to that, you need to make sure that the certification you send to the other stakeholders in this process demonstrates that acceptance risk as well. I refer here to the potential dive instructor who has to be involved in this risk acceptance process.

And the final thing I'd add is if as a physician you are going to have patients who are asthmatic who are going to dive, you mustn't see this as a once in a lifetime assessment of their fitness for diving. SPUMS felt very strongly that if you're going to have asthmatics who dive, they need to be reassessed at some regular period, perhaps annually, and have their risk reassessed and reexplained.

Dr. Bove: There are a couple steps that we still have to complete. We've been trying to change the standard of practice in the United States and elsewhere. The steps we go through are

to identify the problem, conduct surveys, publish in the peer-reviewed literature—all things that you need to change consensus. The third step is that the interested professional societies need to make consensus statements.

This workshop may become a consensus statement of the Undersea and Hyperbaric Medical Society. Herb Saltzman also mentioned that we ought to ask the American Thoracic Society to review these guidelines and make a statement, and we ought to ask the Allergy Society to see these guidelines and make a statement. These three societies encompass many, many physicians, and they address problems of asthma. If all three buy in and make the consensus statement that we recommend, we will have made a major impact on the standard of practice in the United States at least.

The next step is that change in practice has to be clearly stated to all parties involved, and in particular I think, to the training agencies for sport diving, all the various medical societies are the other, and probably the lawyers at some point are third. Once the standard of practice is established by the professional societies, then the lawyers don't have a way to go back and argue against that.

Dr. Elliott: Good. Thank you for that. The only slight addition to that I'd like to make is the consensus itself should be time limited and should not exceed 5 years and that it should be reviewed, possibly, in 3 years. That needs to be clearly stated on whatever document we all agree as a result of this meeting. James, you want a final word?

Dr. Francis: Yes, just a quick one, and that really is to thank you very much indeed for initiating this debate. It is, I think, unique among UHMS workshops that I've attended in that there appears to be a clear way ahead. If the consensus agreement turns out to be policy, it must be coupled with adequate surveillance of the divers involved. If that cohort study gets off the ground, then I would suggest that the time to reconvene is once there are some results from the cohort study so we can review the policy, and maybe, if there's no problem, relax it a little bit more.

Dr. Elliott: I hope that next year, when we meet in Anchorage on diabetes, we might be able to get a bunch of speakers who are as good as those we had today. I'm particularly delighted that we've looked at the extent of the topic within the limitations of the available information.

I want to thank all the speakers, the panelists, and those who spoke from the floor for their contributions. I particularly want to thank our guest speaker, Mark Harries, for having crossed the Atlantic specially for this meeting.

Together we have, in one day, made a start in tackling a problem which, with continued effort, is capable of being clarified for the benefit of many.

CONCLUDING STATEMENT

The following statements were prepared for review by the Panel during the meeting from a pre-circulated list. These were reproduced for the audience as overheads and most were amended during the discussion. A few were not on overheads but have been taken directly from the text. Since then, as part of the editorial process, each statement has been sent to each member of the Panel for final review. However, not all the Panelists replied, and so the following cannot be regarded as consensus even though it is the probable view of the majority. Nevertheless, it can be regarded as a basis for a formal consensus yest to be agreed..

1. The following may be problems for an "asthmatic" recreational diver.
   1.1. Although still a theoretical risk with no hard evidence, it was agreed that there may be greater risk in asthmatics with normal pulmonary mechanics than in the general population of gas retention leading to the pathological conditions of pulmonary barotrauma or air embolism. If present, this risk is likely to be low relative to other causes of decompression sickness.
   1.2. It is agreed that evidence that there may be a greater risk than in the normal diving population of dissolved gas decompression sickness needs to be reexamined critically.
   1.3. Limited exercise capability underwater.
   1.4. The drugs used for the treatment of asthma may reduce the effectiveness of the pulmonary bubble filter.
2. Current policies may seem to be effective at reducing apparent asthma-related incidents but not only may they exclude unnecessarily many potentially safe divers, but also paradoxically they may increase the hazard for those asthmatics who do dive because these policies discourage appropriate assessment for asthmatics who do dive.
3. Asthma is an absolute or relative contraindication according to many guidelines but determined individuals have evaded medical scrutiny and disqualification.
4. A history of childhood asthma alone is not significant if there has been none since.
5. Hyper-reactivity can be stimulated best in an evaluation by sub-maximal exercise. If quantitative assessment is required, it may be triggered also by histamine or methacholine.
6. Ventilatory capacity is best assessed by exercise capacity.
7. The diving candidate who has some "asthmatic" history is best assessed by first demonstrating a normal pulmonary function at rest (FVC, mid-expiratory flow, FEV_1, FEF_{25-75}) and then again after exercise.
8. Safety is not significantly diminished for those established and previously healthy recreational and/or professional divers who acquire adult-onset asthma but who can still meet the requirement of having normal pulmonary mechanics before and after exercise (para 7).
9. Chronic asthma, when quiescent and with adequate lung function, is acceptable even if cortico-steroids are required.
10. Acute asthma, as evidences by cough, wheeze, dyspnea, or impaired exercise capability, is an obvious immediate contraindication, but recreational diving can be resumed when pulmonary function (FVC, expiratory flow, FEV_1, FEF_{25-75}) has returned to baseline.
11. There are insufficient data to exclude a slightly increased risk for asthmatic individuals who wish to participate in recreational compressed air diving. The degree of risk is not disqualifying, however, providing manifestations are completely controlled and pulmonary function is normal (para 7).
12. It is concluded that the degree of competency in making a medical assessment of fitness to dive is enhanced if the examining doctor has relevant knowledge or experience of the underwater environment and its associated hazards.