theoretical aspects. Tom Neumann and I and a few others did a survey of the literature on asthma, published in the Annals of Allergy,[6] from which much of this paper has been taken. The issue for this meeting is to try to define a class of asthmatics who can dive safely and to screen out those who should not dive.

Veale

The pathophysiology of the changes, in lung volumes and in compliance, with worsening asthma, suggest that full spirometry, which would include the measurement of FRC and residual volume and total lung volume, is necessary in the assessment of all asthmatics. Therefore doing simple spirometry in this group is quite inadequate.

Bove

In my institution the pulmonary department is on the same floor and within sight of the cardiology department. So, whenever I get an asthmatic diver referred to me, after taking a history and doing the examination, I walk them down the hall to the asthma team, and have them take care of the patient. If you give a person with asthma to a pulmonologist, you certainly do not get just spirometry. You get a very thorough pulmonary function testing, volumes and all. However I personally think that ordinary spirometry is probably enough to screen out the worst of the asthmatics and the subtleties that one gets by going further may not really give one much more useful information. In other words the asthmatics that show up during spirometry may be the ones that should be screened out and everybody who has normal spirometry probably can dive. I throw that up as an issue because I do not know the answer.

Veale

The other slight problem is that asthma is totally dynamic in that one may have perfectly normal lung function one day and be in a critical care unit two days later.

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A RESPIRATORY PHYSICIAN'S APPROACH TO ASTHMA AND DIVING

A Veale

Prescriptive standards are designed to overcome an area of ignorance. They are designed for people without knowledge to lead them to the right answers. If they do not fulfil that then they are bad standards. Prescriptive standards have been designed for the ignorant and uneducated by those who do not trust us and who refuse to accept responsibility and therefore assume that you and I do not accept responsibility, you and I being the doctor and the patient.

Prescriptive standards by their nature are an easy way out. For example how does the standard handle, a twenty three year old woman who has hypoparathyroidism, who is, I submit, at much greater risk of death than perhaps some of the people with past asthma. But it is not in the standard so one is able, with a clear conscience, to certify this person as "fit to dive". A fourteen year old with a slipped femoral epiphysis may have some risks from diving. I think prescriptive standards are a cop out for those that are not prepared to think.

I must put the medical risks into perspective. Many, many, many, many more people are killed through poor training or absent training or poor practice or absent practice than by medical factors. As we get older medical risks become much more important in the genesis of morbidity and mortality. Training has been long forgotten. Equipment failure from ones buoyancy compensator which has not been serviced for twelve years and lack of practice after an interval becomes a more important. There is a little blip of medical factors in diving deaths that occur at the beginning, but it is pretty small. I think we have to remind ourselves constantly at this sort of meeting that what we are concentrating on here is nothing more than a pimple.

I think every diver should have a medical examination before diving. I think it should be a proper medical examination, not a Mickey Mouse medical.[1] I think it should be done for you in Australia according to AS4005.1. I think that this standard should outline the

elements of history, examination and investigations that should be performed on every diver. I think any diver identified as having a problem within the standard should be seen by a diving medicine trained doctor, and I think we should never use the words fitness to dive, pass or fail, ever again. They are unscientific, unworkable and a load of old rubbish
.

We have to remember that the administration of inappropriate concepts cost us a lot. Divers do not tell the truth. We, as doctors, lose dive industry respect and they no longer seek our advice on particular issues. I think, too, that we lose the respect of scientific colleagues. So what then should our divers expect of us? I think that they should expect that the medical examination should be performed in a competent manner. The medical should be valid as detecting the potential risks. The doctors should be knowledgeable and articulate in assisting the patient in assessing the risk to themselves, and if they are not able to do that they should know to whom to refer. Doctors should be supportive in the diver's decision and then act to minimise the risk. In other words, this is a matter of risk assessment and informed consent.

There are wider issues in risk assessment than just to the individual, who may die, may become seriously frightened of the water, his wife might have problems. There is also the risk to the dive buddy to be considered. If one has just had somebody disappear from the buddy pair then this can lead to significant long term problems. The buddy may be placed at physical risk in trying to rescue an asthmatic on the surface for example. There are risks to a training organisation and these are legal risks to their reputation and for both of those read income. There is one body where there is limited risk and that is the rescue organisations who exist only to retrieve people and the more people they retrieve, the more likely they are to survive, however included in this are risks to recompression attendants and others that are on the receiving end, and those who are in a single engine helicopter who have to fly off shore to retrieve somebody. There is an issue of cost to insurance companies, government and armed services, and there is a risk to doctors both in terms of medico legal settlements and to our reputations. All of these need to be taken into account in the risk assessment.

Risk assessment involves two people who have a knowledge of the problem. It cannot be done by the doctor alone. Here are two examples where the medical risk is identical. A twenty two year old who has just won a grant of two million dollars over five years to study the sand living population off Castaway Island develops asthma with a bit of a chest infection. If I was this person I would be here next week. However, as a forty year old diver with seven children, a wife who is bigger than I am, a $250,000 mortgage with a big business loan I might elect not to dive. The medical risk has not changed, but my assessment of that risk, as an individual, has changed.

Who should do the medical? I actually believe that the patient's normal GP is the best placed to do the initial examination. They have got past records, and in the case of asthma, which is an intermittent disease that may not be present when the diver sees a remote doctor as a one off examination. I think that there should be some guidance about what should be performed in the examination because these general practitioners may have no knowledge of what is important in diving medicine. I think the term contraindication and relative contraindication should be replaced by indications for referral, and it should have no other implications than that. Anybody identified as having an abnormality, whatever that might be, should be seen by a trained diving medicine doctor, who would interpret the abnormality in the context of thorough training. They may wish to request additional investigations to help them to assign risk more correctly, and if they are not able to do that then they may wish to refer to somebody who may be able to better stratify risk. And because the specialist knows a hell of a lot about the disease and not usually a hell of a lot about diving except for Fred Bove and myself, our addresses will be available afterwards, the diving medicine trained doctor would be able to interpret the specialist opinion in the light of diving medicine knowledge. And I think that this sort of scheme is practicable and workable and that having everybody seen by a diving medicine trained doctor is impractical.

I think that this conceptual change can occur only if the medical form changes. At the moment we put our career on the line by saying that this person is fit or unfit to dive. That implies to a lawyer that if we say that somebody is fit to dive, that they are at no greater risk than somebody without that condition in the environment, and as you know, for every doctor who stands up and says there is no increased risk, there are ten paid doctors who will say the opposite. I think that this is allowing us to assume a medico legal risk where the risks properly belong with the patient and with their training organisation.

In my initial attempt at a revised medical I included a statement that the examination has been performed according to whatever Australian standard is in force. When one has explained the medical risks, identified how those risks may be minimised to the patient, it is important to have some statement about the patient's understanding of that discussion and one should document carefully in the medical record what the discussion was, and then whether you felt it was acceptable. I would put this in the medical certificate because I think many diving medical problems become apparent only after the diver has been diving for a few times.

Particularly ear and sinus related problems. I have not yet had somebody that I could not train to clear their ears adequately. But if you try and teach that before they have an understanding of the pressure dynamics of diving, or if they read it from a book, it is very hard to do. It is also

important to get them early before they have learned bad habits which may later rupture a round window.

Medicals should be done before starting the course. Many intending divers come to me part way through the course after they have paid their money and after our discussions they decide not to proceed. There needs to be some statement to the training organisation that allows the budding diver to get a refund. The annual medical I have no strong feeling about. I think, personally, that it is only worth doing as one gets older.

For screening to be useful there has to be a method of diagnosis. The diagnosis has to usefully change what we do. Changing what we do should change outcome and then we have to decide does the changed outcome justify the costs.

A study done in Auckland on a large number of seven year old school children showed that 27% of people, with no wheeze or who had never wheezed or with only wheezing in the past, had non-specific bronchial hyperresponsiveness. There was a statistical relationship between the degree of hyperresponsiveness and the degree of symptoms.

Malhotra and Wright showed that transthoracic pressures of not a lot could rupture lung. But this effect could be prevented by binding the thorax and binding the abdomen.[2] Now that says that pulmonary barotrauma is not a pressure phenomenon but is due to alveolar over distension, lung over distension. Colebatch looked at a group of divers who had suffered a cerebral arterial gas embolism and showed that they had areas of varying lung compliance, but so did a lot of the control groups.[3] Pearson and a number of others at a range of different times showed that the only abnormality of lung function associated with or that could predict cerebral arterial gas embolism in the submarine escape training tank was small lungs.[4] Asians, Indonesians, and particularly short navy men. The FEV_1/FVC ratio did not, the FEF_{25-75} did not, nor did gas trapping as shown by residual volume/TLC ratio.

Macklin and Macklin did a superb scientific study showing the alveolar over distension in unrestrained calf lungs would result in alveolar rupture.[5] Because it was unrestrained calf lungs it cannot be applied in the restrained situation within the chest. However, they did predict a number of interesting things such as that pulmonary barotrauma would be more likely in those who were hypovolaemic and that was subsequently shown in an intensive care unit, and the reason for that was that alveoli abut pulmonary vessels and if the vessels are contracted and small due to hypovolaemia, then the relative shear forces between the alveolar base and the blood vessels increase. However, I do not believe that is important when talking about pulmonary barotrauma in diving .

This may be more relevant. The bronchovascular bundle moves out through the lung from the central airways right to the peripheral part of the lung and it is surrounded by air containing alveoli. What we tend to forget is that bronchial smooth muscle does not actually run in a circular manner, but spirals down the airway. In the proximal airway there are multiple layers of smooth muscle. But as it near the periphery it becomes first a single layer and then a discontinuous single layer. During an episode of bronchospasm the airway thus has a tendency to shorten. If, at the same time, the lung is over inflating either generally or regionally, the bronchus is being pulled apart so that there is an increased distractional force on the airway. It makes sense that in areas of weakness in the wall the inside mucosal lining may rupture out through the wall and if it ruptures into the peribronchial space the person develops mediastinal emphysema, if it ruptures through into the pulmonary vein then one might get arterial gas embolism. Alveolar rupture is unlikely to explain the sort of radiology that shows the heart, brain, thoracic blood vessels full of air. But this mechanism might because bronchial air will be under some positive pressure and the vessel is large. Have we ever seen this in a diver? The answer is no, but we have seen this in asthmatics. Often, a bronchial duct will rupture and I have a slide, which we keep in a safe because it is the only one I have, which shows an alveolar duct permeating through the wall of the bronchus with peribronchial air. We have not found one breaking into a vessel. So this is as much speculation as the other things one has heard. The reason why pathologists may not ever find this is that this may be one terminal bronchial anywhere amongst millions, and there may be no sign. So that may be one of the contributors. These things lead to the comments that diseases which cause air spaces within the lung, regional gas trapping or areas of regional poor compliance may increase the risk of pulmonary barotrauma.

So we now come to asthma. What might the risks of asthma be on the diver? Well the first, and the one that was most often touted at the beginning, was pulmonary barotrauma. Secondly, and significantly underrated initially, was the fact that an asthmatic might develop asthma during the dive. We have heard already that asthma can be induced by cold air, by dry air, by hypertonic saline and by exercise. Thirdly, they might have a significant limitation of exercise, and close to half of those nine asthmatics died of drowning in the series by Edmonds and Walker.[5] There may be a physical risk to the buddy on the surface and there may be a risk of the drugs increasing the risk of decompression illness. This has been shown, in the case of aminophylline, in laboratory animals where bubbles which would otherwise have been filtered out by the lungs can appear in the pulmonary vein, which is not the case in the absence of aminophylline. The work has not been repeated with a β–agonist but there is no reason why this should not also apply to a β–agonist.

Then like all good doctors, having got a good theory we tried to think about what the mechanism might be, and then how we might prevent it. Unfortunately we forgot the intervening steps. What are the actual risks? Can the risks be reduced by better targeting and is it worth doing?

I think it is possible to put asthmatics into various bands of risk while diving. I have absolutely no idea where the line should be drawn between any of these bands, but one can generate a list of increasing severity. I think there is no doubt from the data that we have available, that having atopic asthma, a past history of asthma or a wheeze with a respiratory infection but normal lung function will place people in the low risk group. There is equally no doubt that some people, who have abnormal lung function between episodes, particularly if there is a high residual volume, marked bronchial hyperresponsiveness, or if they have been in a critical care unit, probably should not dive. Where do we put the bands in between? People with daily symptoms are likely to be at greater risk than if they do not have daily symptoms. People who require continuous medication for control may be at greater risk than if they do not require medication for control. But that is not to say that somebody who uses ventolin twenty times a day in order to stay well and who would be better on a prophylactic medication might be at lower risk. I think we can in every disease state roughly categorise people in some sort of hierarchy of risk.

This is a statistical exercise which I think is quite important to have clear in ones mind. Twenty five percent of New Zealanders have had wheeze at some stage of their life. If one assumes a population prevalence of five to eight percent of adults having current asthma, then if we took an unselected population off the street and turned them into divers we would expect five to eight percent of the divers to have asthma. We would expect about five to eight percent of the dead divers to have asthma if asthma did not contribute to death. We observe, if we take the most, the worst figures available which are those of Edmonds and Walker[6] of nine percent of dead divers having a history of asthma, and if we then take the low range of population prevalence at worst it might be that an asthmatic diver has twice the risk of dying that a non-asthmatic diver has.

If we said that most sensible adults who had asthma and wheezed were a bit frightened of diving because of their efforts on the surface, then perhaps only one percent of divers have asthma. If asthma did not contribute to death then one would expect one percent of the dead divers to have asthma. We observe 9%, therefore the relevant risk is nine times.

If we assume that doctors are very good at screening out asthmatics in the medical examination, maybe only 0.5% of divers have asthma, which might raise the relative risk to eighteen times. If we assume that every intending diver was sent to respiratory function lab and did ten challenge tests to ensure that nobody with hyperresponsiveness became a diver, then maybe the prevalence amongst divers would be 0.1%. I do not think one could ever get it much lower than that because this is an intermittent disorder. That means that the relative risks might be ninety times. Now in New Zealand we train 7,000 new divers each year. They perform ten dives each on average in their first year, so that is 70,000 neophyte dives done in a year. If one includes all the old buggers, then there are lots of dives done, of which ten to twenty die and eighty end in a recompression chamber. For those of you who are not good at mathematics, I must remind you that even ninety times a very small number is still a very small number.

So, in summary, I think the current Australian standard has to go before it gets set in stone. I think there needs to be a new medical consent form. I think we need to be assessors of risk and provide informed consent. I think our divers should have the confidence to come back to us after they have had a bypass, or after they have had abdominal surgery, or after they have had a pin put in a leg, without the fear that we will make them “unfit for diving”, therefore not tell us in a situation where really someone should know, like the thyrotoxic who had hypoparathyroidism. I think that we have to get some science back into the diving medical.

Discussion

Knight

I dislike AS 4005.1 too although I was responsible for getting it through the committee. The problem is your assumption that every GP is interested enough to learn something about diving medicine so that he remembers to look in the ears. We found that this was not so, which is not surprising seeing that diving medicine only gets a mention in one or two medical schools.[1] That was the medical reason for producing a standard so they had a list of things to do. The problem of changing a standard is that the person wanting to change it has got to influence a number of groups, the doctors, which you have done, the instructor organisations, who do not want proper diving medicals, that you may be able to do, and the government regulatory bodies that sit on this committee who really do not know very much about it except that they know that people die when they are diving and that is bad for the tourist industry. I would gladly resign my seat on the committee that looks after AS4005.1 to Andy Veale if he would like to take over and start the process of changing it, because I think he is quite right. It does need changing, but one has got to remember the inbuilt traps in the fact that Australian medicine does not produce any training in underwater medicine in its undergraduate course.

Veale

I quite agree. The comment that I would make is that it should be relatively easy, I hope, to modify the standard. I think GPs without a knowledge of diving medicine do need guidance about what is important. I have no argument with that. Where the problem occurs is in them saying that there should be absolute contraindications, relative contraindications etc. I think they should be indications for referral. The other comment I must make is that I have resigned sixteen of my seventeen committee memberships, the last one just before I came and I am definitely not picking up any others, particularly with government attached to them.

Acott

My incident monitoring study is a demographic picture of what is going on in the recreational diving industry. In the first 1,000 reports I have had about twenty reports involved asthmatics. Some of these people have ended up in the morbidity ranks, but the majority of them involved rescue services when they got breathless on the surface and could not get back to the boat.

Davis

I was asked to pass onto this meeting and this workshop this letter from New Zealand Underwater, which is an encompassing body in New Zealand which does not represent any particular training body these days.

"We ask you to put forward our feelings that within New Zealand the status quo remains as is, to be more precise the potential diver visits their own GP. If there are any doubts about their fitness to dive they are referred to a doctor on the list supplied by SPUMS. This referral is made by either the GP or the instructor. The printed SPUMS list of members trained in underwater medicine is also used as a referral by New Zealand Underwater when receiving enquiries from GPs for further information. Any variations to the above system would be seen as fixing something which is not broken. We are convinced that there is a very low or non-existent number of diving deaths or injuries which could be remedied by altering medical examinations in any way."

Unidentified speaker

Changing the Australian standard obviously needs to be done because it is a load of nonsense at the moment, but one of the things that I have had trouble with in Perth is trying to get respiratory physicians on side. Although a lot of them are dead keen, most of them have read the Thoracic Society guidelines and say “Oh well, we cannot let asthmatics dive. Will there be some mechanism for taking back information from this meeting to the Thoracic Society and say that we need to get into to the 90s rather than staying in the 60s?

Gorman

Do you know the names of the authors of that policy? I know one of them was Anderson. Another one was not Pork, it was

Veale

I have to tell you that the Thoracic Society of Australia and New Zealand (TSANZ) document on diving medicine I found the most difficult negotiation that I have ever taken part in, except coming to this meeting without my wife. The starting position of the TSANZ was that every patient, or rather intending diver, should have full pulmonary function including challenge testing and that is only a slight exaggeration. It really was a very difficult thing to get it as moderate as I thought the statement was, and at that stage the DAN data had only just begun to come available, reporting in an abstract that the relative risk may be as high as two times, but with a wide confidence interval. I think the data is much better now, and the reason that this was not put out as a TSANZ position paper was because of the lack of data. It started off as a TSANZ position paper, which as you know are extremely well researched and authoritative, it became a discussion paper when it became apparent that the data was hardly available

Unidentified speaker

Which asthmatics, if any, would Dr Veale see fit to certify to dive at present?

Veale

I do not think we should certify anybody fit to dive. It is an archaic concept of the ignorant. I think that one can advise asthmatics with current symptoms and certainly those with abnormal lung function that they are probably at a much higher risk than if they do not have those things present. I think one can say to somebody who has features that suggests bronchial hyper-responsiveness, like night cough, cough or wheeze with exercise, that they are almost certainly likely to be at a greater risk of getting into trouble on the surface and placing their buddy at risk. I think that the others are at lesser degrees of risk, and as I indicated, I think that whether the individual accepts that risk or not depends much more on their circumstances than our current level of knowledge.

My current practice is that I sign the bottom of the form that says this person is fit or unfit and if somebody has asthma, I do not certify them fit, and that is because we, if we did so, we would be laying ourselves open to an indefensible medico-legal claim.

Unidentified speaker

I would just like to make a simple statement in support of your views. The only mammals fit to dive are whales, dolphins and seals. Man is a land based, one atmosphere air breathing mammal and by definition is not fit to dive. We should be making a risk assessment.

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This paper is an edited transcript of Dr Veale's lecture, to which he has not objected.

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ASTHMATIC FITNESS TO SCUBA DIVE

Peter Chapman-Smith

New Zealanders enjoy their marine environment. With more trained scuba divers per capita than any other country, and many untrained ones too, diving is a major recreational sport as well as a means of food gathering for many. Sadly between 55 and 76 cases of significant diving illness are treated annually in NZ, with a steady trickle of fatalities annually. These occur more during summer with other deaths from snorkel or free diving.

Asthma occurs in about 10% of the general population and has been said to be associated with approximately 10% of scuba diving deaths in New Zealand and Australia between 1980 and 1987,[1] the actual cause of death often being unclear. But the more recent data certainly has much lower figures of association.

Conventional diving wisdom has declared that asthmatics should not scuba dive at all. The potential risk of barotrauma to the lung from inadequate emptying of the small airways and reduced lung compliance of ascending divers who suffer from asthma may well be unacceptable. The suggested increased risk of pulmonary barotrauma (PBT) on ascent for asthmatic divers is based on consideration of, reduced lung elasticity, greater residual volume, greater resistance to exhalation, variable expiratory time constants of exhalation from alveoli leading to small airway closure with air trapping (closing volumes exceeding functional residual capacity), while exertion, hyperventilation, breathing cold dry air, saline mist inhalation through a faulty regulator, anxiety, increased gas density, increased effort of breathing and wetsuit splinting of the chest (which can be claustrophobic) can all precipitate or worsen asthma. Pulmonary barotrauma is occasionally associated with lung cystic changes. There is a greater risk at shallow depths where the volume changes are larger and rapid ascents are more risky. It is clinical experience that many cases of PBT occur without obvious cause. The potential outcomes include pneumothorax, arterial gas embolism, or mediastinal emphysema. Fatal at worst, with minor to major long term disability at times. Recompression treatment can be difficult and may not be successful. Serious stuff from a leisure sport and quite reasonably diving physicians have taken a conservative view for decades. It is fair to say that there is little hard clinical data to support this advice, and to my knowledge no one has yet demonstrated by section at post mortem the actual pathology of such pulmonary barotrauma.

In the UK a more liberal view has embraced selective risk assessment, with low risk asthmatics allowed to dive if not suffering symptoms for 48 hours before diving.

And how long after wheezing does the label of "asthmatic" linger with one ? All that wheezes is not necessarily asthma. Certainly asthma may also be over diagnosed and over treated in general practice. Bronchial hyperreactivity is well accepted as an entity and of course many asthmatics ignore our advice and continue to dive anyway. Some do so for long periods and are apparently none the worse for it. However, some join the morbidity and mortality figures as well, the non-survivors are not present to put their case.

Prospective dive trainees ideally require a medical clearance from a diving physician. Purists suggest excluding all those with with a history of asthma in the preceeding 5 years, bronchodilator use within 5 years, expiratory rhonchi heard on auscultation, high pitched rhonchi on hyperventilation with the mouth open, high pitched rhonchi 5-10 minutes after exercise and poor respiratory function tests. These are discussed in Sandra Anderson's paper (pages 233-248). An asthma provocation test causing more than a 10% reduction in FEV_1 (a 20%