

pre-dispose to air trapping can be lethal. This phenomenon can be responsible for the development of serious over-pressure in susceptible pulmonary structures, provided that gas in the pulmonary tree is not at all times free to equilibrate to ambient pressure. A typical hazard is breath-holding during ascent with scuba gear.

Workup

- (i) A thorough history and physical examination.
- (ii) A chest x-ray, including an expiratory film is recommended.
- (iii) Pulmonary functions test peak flow should be greater than 500 litres per minute, or greater than 75% of the predicted peak flow for size.

Absolute Contra-indications

- (i) Pulmonary blebs.
- (ii) History of spontaneous pneumothorax.
- (iii) Active asthma (opinion - childhood asthma with no recurrence is not necessarily disqualifying).
- (iv) Emphysema.
- (v) Chronic obstructive lung disease.
- (vi) Pulmonary thromboembolism.
- (vii) Recurrent thrombophlebitis.
- (viii) Pneumoconiosis.
- (ix) Silicosis.
- (x) Pulmonary fibrosis,
- (xi) Bronchiectasis.
- (xii) Benign and malignant chest tumours.
- (xiii) Granulomatous disease of the chest, TB, sarcoidosis and fungal disease.

6. GI SYSTEM

Abdominal pain can be confused with decompression sickness and any lesion that could predispose to gas trapping in a viscus must be a cause for disqualification.

Absolute Contra-indications

- (i) Chronic gastrointestinal disease such as ulcerative colitis, Crohn's disease and chronic hepatitis.
- (ii) Chronic liver disease.

7. MUSCULO-SKELETAL SYSTEM

Absolute Contra-indications

- (i) Muscular dystrophy.
- (ii) Muscular atrophy.
- (iii) Myasthenia gravis.
- (iv) Osteonecrotic lesions.

8. ENDOCRINE SYSTEM

Disorders of the endocrine system which leave the patient with obvious debility would be grounds for disqualification from diving.

Absolute Contra-indications

- (i) Insulin-dependent diabetes.
- (ii) Diabetics on oral hypoglycaemic agents, although some diabetics well controlled by diet alone, may be permitted to dive.

9. HAEMATOLOGIC AND IMMUNE SYSTEMS

Absolute Contra-indications

- (i) Sick cell anaemia.
- (ii) Haemophilia.
- (iii) Any blood dyscrasia or anaemia.

10. AGE

Although scuba training can be undertaken prior to 15 years of age it is recommended that certification be withheld until the age of 15 years is attained.

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This presentation is based on a paper by DD Hickey, and is presented for discussion.

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MEDICAL STANDARDS FOR SPORTS DIVERS

John Knight

Diving instructors who are paid by results have an economic incentive to teach everyone who comes to them. Sometimes economics overcomes common sense and a person with a problem that will make diving dangerous or painful and damaging is taught to dive. Some of these come to harm but by no means all.

Over the years many people around the world have died while learning to dive, very few of these have died from their medical complaints, but some have. It is these tragedies that a proper medical should prevent. I believe that most instructors now think that a medical for their trainees is a good idea. The problem in Australia is that they are not as yet convinced that it should be done by a doctor with a knowledge of diving medicine. As diving medicals in Australia are outside the medical benefit system many diving instructors send their pupils to their usual GP who, because he does not know the medical benefits rules, gives them an itemized bill so they can claim most of the cost from Medicare. And many of these doctors do not even look in the ears and check that the ear drums move!

In my opinion the doctor is not God who lays down inviolable rules. He or she is an expert adviser who can explain to the person consulting him the risks involved in that particular person going diving. To do this the doctor has to know about diving medicine.

There is a problem with the supply of properly trained doctors so I have produced a "Guide to the examining

physician",¹ which explains the essential points to be sought, to be given, with the examination form, to those doctors who have not been trained in underwater medicine. This suggests that if there is doubt as to a candidate's fitness to dive it is safer for him to be classed as unfit and be referred to someone with underwater medicine training.

Let us start with the conditions which I regard as absolute contraindications to going diving. They can either kill or maim or incapacitate. Going unconscious underwater is a good way of starting the drowning process. As a person loses consciousness the jaw muscles relax and as a result the regulator falls out of the mouth of the unconscious diver. This is very inconvenient as the diver has not stopped breathing! A full facemask makes going unconscious underwater much safer as then the diver has air to breathe not water. So any condition that can cause unconsciousness is an absolute contraindication to diving.

TABLE 1

ABSOLUTE CONTRAINDICATIONS TO DIVING

CONDITIONS LIKELY TO CAUSE

UNCONSCIOUSNESS

EPILEPSY
SEVERE HEAD INJURY
INSULIN DEPENDANT DIABETES

PULMONARY BAROTRAUMA

PREVIOUS SPONTANEOUS PNEUMOTHORAX
LUNG CYSTS
OBSTRUCTIVE LUNG DISEASE
LUNGS THAT EMPTY UNEVENLY
ASTHMA
PREVIOUS THORACOTOMY

BREATHLESSNESS

ASTHMA
OBSTRUCTIVE LUNG DISEASE
POOR EFFORT TOLERANCE
ANGINA
CORONARY ARTERY DISEASE

EAR CONDITIONS LIKELY TO CAUSE DAMAGE

INABILITY TO CLEAR THE EARS
PERFORATED EAR DRUM
PREVIOUS MIDDLE EAR SURGERY WITH
INSERTION OF A PROSTHESIS
PREVIOUS REPAIR OF AN INNER EAR FISTULA

I think that we can all agree that epilepsy is a condition likely to cause unconsciousness. I do not believe that anyone who is on medication for epilepsy, however well they are controlled at sea level and above, should go diving as we just do not know enough about the effects of the rise in ambient pressure on the drugs. Those who have stopped taking drugs and have not had a fit for some years are a different problem. I would advise against diving until they had been off drugs for 5 years and then have a perfectly normal electroencephalogram (EEG). If the EEG is not normal I would still advise against diving.

For those who have had contusional laceration of the brain or an immediate post head injury fit diving is absolutely contraindicated. If the patient has been unconscious for more than 24 hours he is in the same group as he will have suffered considerable brain damage. Intracranial surgery in the supratentorial region has an incidence of post-surgical epilepsy approaching 10%, and the onset may be delayed many years. I know of one diving death due to this cause. He went unconscious underwater and drowned years after his brain surgery having had his first fit only days before.

There is less agreement about the risks to the diabetic on insulin. There are many such diving around the world. I would not dive if I developed diabetes needing insulin and that is the advice that I give any insulin dependant diabetic who comes to me. The reason is that hypoglycaemia can lead to unconsciousness without warning, and even if the person does recognise his hypoglycaemia it is very difficult to inject oneself with glucagon through a wetsuit or have a drink of sugar solution underwater. If the person concerned was insistent I would want evidence that he undertook strenuous, prolonged exercise on land without hypoglycaemia before I changed my mind. If I did that I would emphasise the importance of not missing any meals before diving and the dangers of unconsciousness underwater. Hyperglycaemia is much safer than hypoglycaemia when underwater.

Pulmonary barotrauma kills. Depending on the position and size of the air embolus the diver may die immediately, go unconscious and drown, or have a period of unconsciousness and recover. While mediastinal emphysema can incapacitate it is a rare occurrence in divers, although it is common in experimental pulmonary barotrauma. Pneumothorax occurring under water usually becomes a tension pneumothorax as the diver rises to the surface. Divers have died from this, but again it is an uncommon presentation of lung rupture in divers.

Anyone who has had a spontaneous pneumothorax, one that occurred without warning, should not dive. He will be playing Russian roulette on every dive. Spontaneous pneumothorax is a condition that often recurs without warning.

Lung cysts are no problem on land but they are a danger underwater, or in caisson work, where the person is breathing at a higher than normal pressure. Many cysts have small communications with the airways which can allow gas in, and the high pressure gas can get in more easily than usual because of the increased pressure gradient. So going down is safe for these people but not coming up when the expanding gas in the cyst cannot get out fast enough. The cyst expands and at some stage reaches its elastic limits and the surrounding lung tears. As they cannot be detected on clinical examination I consider chest x-ray an essential part of the diving medical.

We can take obstructive lung disease and lungs that empty unevenly together. Obstructive lung disease means obstruction to the normal emptying of the lungs which can give rise to pockets of over-distended lung which might burst. Experience has shown that people with a forced expiratory volume in one second (FEV₁) to vital capacity (VC) ratio of less than 75% are over-represented among those who suffer air

embolism. So one uses a simple respiratory function test to measure the FEV₁/VC. I believe that those with this ratio between 65 and 75% can probably dive safely as long as they ascend at a much slower rate than the usual 60 feet (18 metres) a minute. It is really quite surprising how slowly one has to ascend to keep down to 60 feet (18 metres) a minute. I recommend that they come up no faster than 20 feet (6 metres) a minute, which is the rate I use. This involves watching one's watch and depth gauge all the way up.

People who have had a previous thoracotomy would be expected to have adhesions tethering the lung to the chest wall. This could give rise to differential stretching of the lung with expansion which would be likely to cause pulmonary barotrauma. However there are plenty of people who have had open heart by-pass surgery who have gone back to diving and as far as I know they have survived. Until there is more evidence of the safety of diving after chest surgery I will continue to advise these people not to dive.

Asthma is a real bone of contention among diving doctors. Some, like Carl Edmonds and myself, believe that it is dangerous for asthmatics to dive, others do not. I have heard of four people with asthma who went unconscious underwater during their training. They only survived because of the vigilance and competence of their buddies. On the other hand I know an asthmatic, who has to take various drugs every day to remain wheeze free, who dives every weekend and has done so for the past 7 years. One of Australia's senior diving instructors is an asthmatic. I incline to the belief that the really dangerous time for an asthmatic is when he is learning to dive and that there is no place for those who need drugs to control their asthma in diving schools.

Asthma has two problems. Not only do asthmatics have airway narrowing problems, producing those wheezes that the bystander can sometimes hear, which were discussed earlier. Asthmatics certainly do figure in the pulmonary barotrauma stakes. But they also suffer from incapacitating breathlessness at intervals with periods in between when they are well. Unlike asthmatics the people with breathlessness from obstructive lung disease are breathless with any reasonable exertion. I think that this is what keeps those with easily recognised obstructive airway disease from wanting to learn to dive. They find exercise exhausting. So do people with poor effort tolerance, angina and coronary artery disease. Incidentally no one with angina has appeared in my consulting room wanting to learn to dive in the ten years I have been doing diving medicals.

It is to detect those whose effort tolerance is low, which usually means that either heart or lungs are not in good order, that a simple exercise test, like the British Army 5 minute step test, is included in a good diving medical. Some people just cannot exercise to that level. This group should not dive. Some are just unfit and need extra exercise to tone them up to a safe level of performance. They should not dive until they have improved their effort tolerance.

Another reason that those with angina and coronary artery disease should not dive is that diving is quite stressful even before one gets in the water. Pulse rates of over 140 are not uncommon even in the young at the end of putting on wetsuit and gear. Then over the side into cold water which induces peripheral vasoconstriction and a sudden and sometimes very large rise in blood pressure. A couple of good ways to bully the heart to death if it is unhealthy.

American statistics on diving deaths, collected by Dr Lynn Eldridge and presented in 1979 at an Undersea Medical Society Meeting, show a large peak in the younger age groups. This is not surprising as the majority of divers are in that group. She divided the figures into those in cold water, less than 20°C, and warm, over that temperature. The divers of Tasmania, Victoria and southern New South Wales, and I expect all New Zealand divers are all cold water divers.

Figure 1 shows the deaths that occurred in cold water, that is less than 20°C. The black blocks are those deaths which were due to obvious non-cardiac causes. The majority were due to human error. These deaths are not going to be influenced by whether the diver has a medical or not. The cross hatched ones were those where there was evidence of a cardiac death at post mortem. The striped ones were, from the history, likely to have been cardiac deaths. The white were where there was insufficient evidence to classify the death as any other group.

Of the 138 deaths in waters less than 20°C the majority of the deaths were due to human error (68). The next largest group was those where the death was due to cardiac causes as shown at post mortem (25), or with a history suggesting that it was a cardiac death (17). There were 28 deaths in which the evidence was insufficient to classify the death. Oddly enough many of the cardiac and probably cardiac deaths occurred at the end of an otherwise normal dive. As far as I know the explanation for these deaths is still uncertain.

In cold (less than 20°C) water, definite cardiac deaths occurred in people as young as 25-30 age group (3 deaths). Three of these deaths also occurred in the 30-35 and 35-40 age groups, four in the 40-45, three in the 45-50, four in the 50-55 and one in each of the 55-60, 60-65 and over 65 age groups. Only one of the 8 deaths over 50 was not due to confirmed cardiac causes.

Diving in warm, over 20°C, water was much less dangerous, or is it just that fewer Americans go to the Caribbean where the warm water is? There were 58 deaths of which 32 were due to human error. Six were shown at post mortem to be due to cardiac causes while another 6 were probably due to cardiac causes from the history and 14 deaths could not be classified.

In warm water there was one definite cardiac death in the 25-30 age group, one in the 35-40, one in the 45-50, two in the 50-55 and one in the 55-60 age group. There was a smaller proportion of cardiac deaths which among other things makes warm water diving attractive to me! Of the over 50s who died, three died from a confirmed cardiac cause, three died from a probable cardiac cause and two from human error.

Some of those who died from cardiac causes had symptoms which should have deterred them from diving but the majority were asymptomatic.

This raises the question of whether the over 40s should have stress ECGs performed at diving medicals. I do not think so, as the number of false positives and false negatives in symptomless subjects makes this expensive investigation useless as a screening test. Every positive should be followed up with coronary angiography to exclude the false positives. The USAF tried this for a while but gave it up in favour of a screening by history taking and simple investigations. They are only using exercise ECGs for those with four or more predictive factors such as family history, hyperlipaemia, smoking, overweight, etc.

FIGURE 1
DEATHS IN COLD WATER (LESS THAN 20°C)

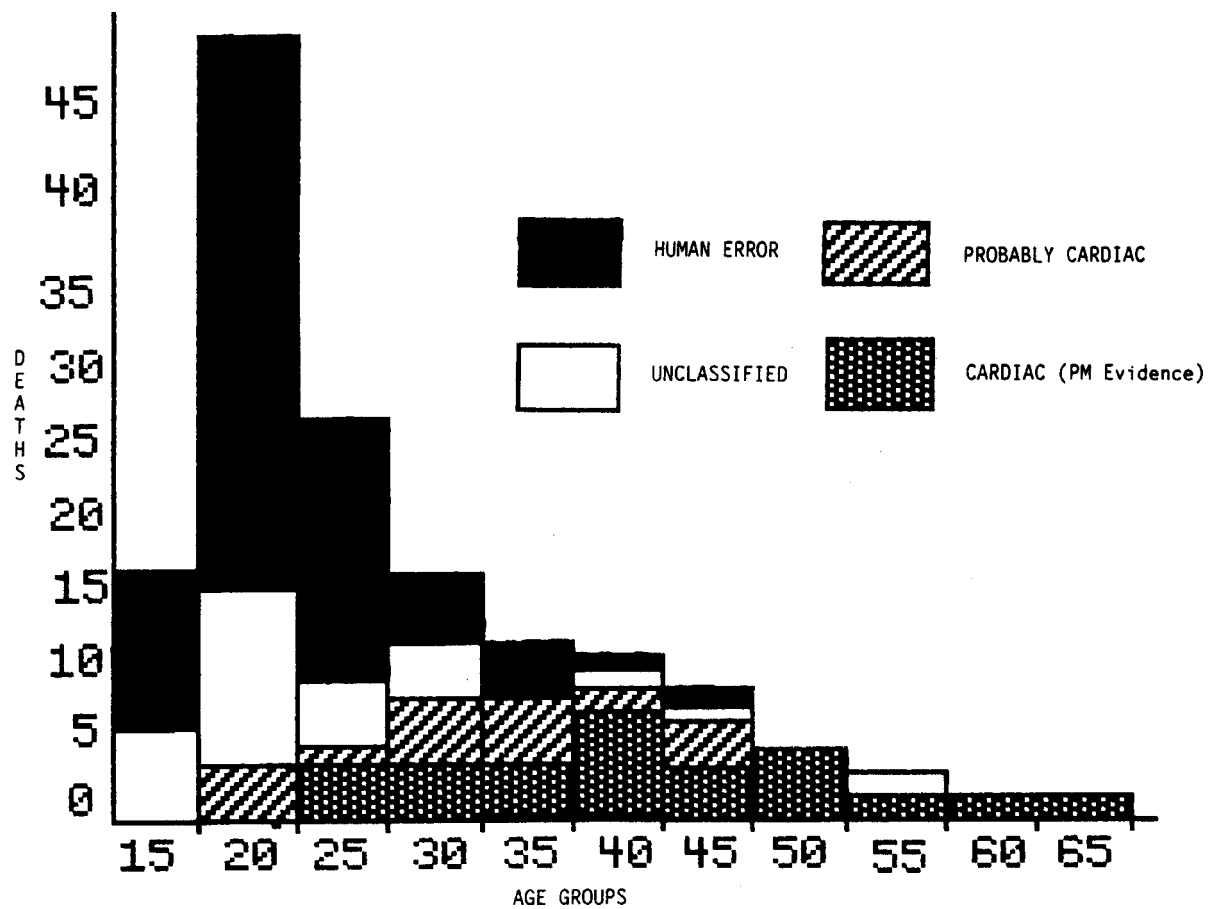
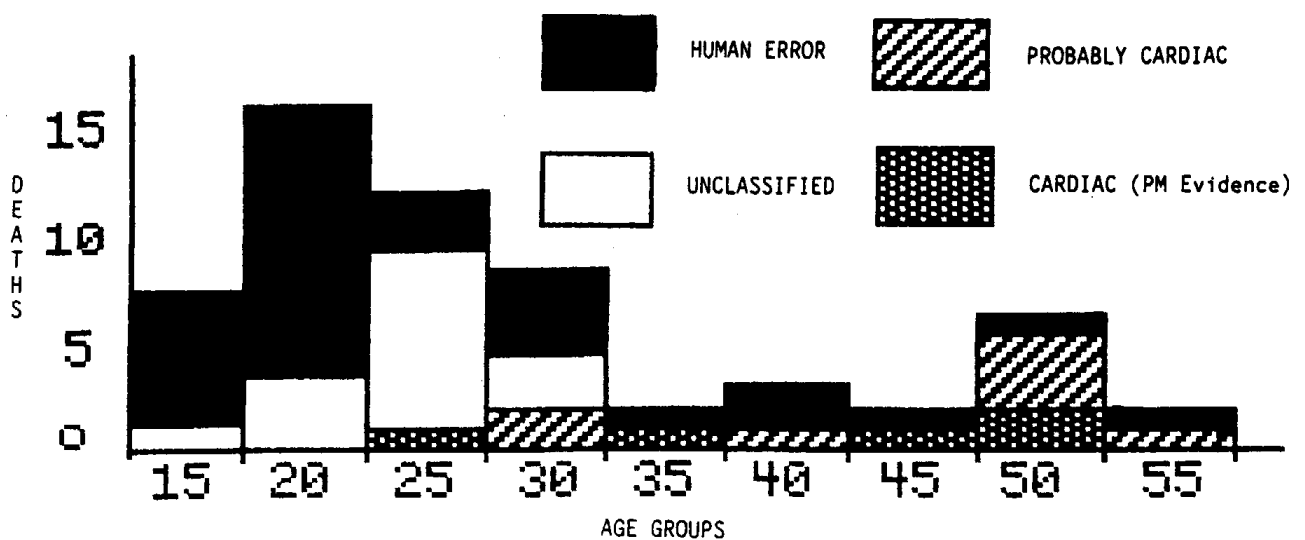


FIGURE 2
DEATHS IN WARM WATER (MORE THAN 20°C)



Redrawn from a poster presentation, by Dr Lynn Eldridge, at the Undersea Medical Society Scientific Meeting at Miami 1979

Divers damage their ears more than any other part of the body. If one cannot clear ones ears going diving is absolutely certain to lead to damage. So no diving for them.

People who have a hole in an ear drum will get water in the middle ear diving. This will be colder than the air in the middle ear on the other side, which leads to uneven caloric (hot or cold) stimulation to the two ears. The result is the rapid onset of vertigo and vomiting. In addition they are very likely to develop a middle ear infection after the dive. The perforation must be repaired and be shown to be mobile before the person can start diving.

One of the advances of surgery in the last thirty years or so is the ability of surgeons to restore hearing by various operations on the middle ear using the operating microscope. These operations are less successful the second time. Anyone who has had hearing restored by an operation, such as stapedectomy, would be an idiot to dive and risk that restoration.

Inner ear fistulae can leave one completely deaf in that ear. If the fistula has been repaired the patient should not dive as he has demonstrated that the inner ear window membrane is weak. It could go again and any hearing that had been saved would go too. Even more worrying is the thought that the other side might leak and lose the hearing in that ear. Bilateral complete deafness is a very large handicap. I would sell my gear if I developed an inner ear fistula. However I know one man who lives for diving and considers the risk of recurrence acceptable. But he is now fanatical about clearing his ears every two feet on the way down and whenever he changes depth.

TABLE 2

RELATIVE CONTRAINDICATIONS TO DIVING

FEV1/FVC RATIO LESS THAN 75%
POOR PHYSICAL CONDITION
PREVIOUS MYOCARDIAL INFARCTION
HEAD INJURY
HYPERTENSION
PREGNANCY

Relative contraindications are things that make diving dangerous either to the diver or her passenger. I have mentioned the people with low FEV₁/VC ratios who can usually dive safely by using a slow ascent rate.

Poor physical condition can be improved by exercise, diet and anything else that is necessary. Until they are able to swim at least 200 metres and undertake 5 minutes moderate exercise, for their own safety, they should not dive.

Those who have had a myocardial infarct, or by-pass surgery, should not dive until they have shown, to their cardiologist's satisfaction, that they have a normal effort tolerance. This will involve exercise testing on a treadmill under electrocardiographic control. Once they have a normal effort tolerance their cardiac condition is no longer a bar to diving. I know two people who have gone back to diving after bypass surgery and two years later have not burst a lung. Perhaps thoracotomy is not as dangerous as we think.

Hypertension is a common problem. The first decision is whether to treat or not. Those who are treated are

being given drugs that interfere with the normal action of the heart (beta blockers), reduce the blood volume (diuretics) and interfere with vasomotor control (antihypertensives). Usually as long as the dose required to achieve good control of the blood pressure is small the effects on effort tolerance will be acceptable. Those taking larger doses usually have poor effort tolerance, and may even develop orthostatic hypotension. Each person is a different problem.

Head injuries are pretty common in Australia. I am grateful to David Brownbill, Senior Neurosurgeon at the Royal Melbourne Hospital, for publishing a paper on "Neurological considerations in diving"² in the SPUMS Journal as he gave clear guidance about head injuries and diving.

Personality changes sometimes follow head injury and can lead to carelessness and lack of logical thought. Such people are better discouraged from diving.

As mentioned earlier severe damage to the brain and immediate fits are absolute contraindications as is unconsciousness for more than 24 hours.

A two year no diving period is indicated for unconsciousness for more than two hours, for post-traumatic amnesia for more than 48 hours, and for the post-concussive syndrome of sleep disturbance, personality disturbance, headaches or memory disturbance, headaches or memory disturbance for more than a month.

Three months off diving seems appropriate for those who are unconscious for between 15 minutes and two hours.

Four weeks disqualification from diving would be appropriate for mild head injuries with unconsciousness of less than 15 minutes. These are relatively common in Australian Rules footballers.

These days pregnancy is undertaken with the objective of a healthy baby. Whether diving in early pregnancy causes foetal abnormalities is still sub judice. In the meantime I believe that sensible women should give up diving just as they should give up cigarettes and alcohol for the duration of the pregnancy.

TABLE 3

THE DIVING MEDICAL HISTORY
ASTHMA, BREATHLESSNESS, CHEST PAIN,
DIABETES, EXERCISE, FITS, HEAD INJURY,
OPERATIONS, MEDICINES, PNEUMOTHORAX.

PHYSICAL EXAMINATION
BLOOD PRESSURE, CHEST, CRANIAL NERVES, EARS,
EXERCISE, REFLEXES

SPECIAL TESTS
AUDIOGRAM, CHEST X-RAY, RESPIRATORY
FUNCTION

I believe that a good diving medical examination must include a history with particular attention to asthma, breathlessness, chest pain, pneumothorax, diabetes, fits, head injury, operations and exercise taken. If the person never takes strenuous exercise he or she may never get symptoms. It must include the drugs being taken.

The physical examination should include checking the state of the ears and the patency of the Eustachian tubes, listening to the chest especially with the patient hyperventilating which often brings out otherwise hidden wheezes, blood pressure, reflexes, cranial nerves, and an exercise test.

The justification for chest x-rays is to detect cysts and other asymptomatic pathology which would make diving dangerous. The respiratory function tests are to detect those with a VC/FEV1% of less than 75% who are over-represented in the burst lung statistics. The audiogram is to establish a baseline in case the diver damages his or her ears at a later date and is deaf. New deafness after diving is significant.

The medical should include advice on how to clear the ears and emphasis on the need to do it every half metre (two feet for the pre-metric generation) all the way down and every time one descends that much. This is because the raised oxygen partial pressure in the gas in the middle ear increases the concentration gradient forcing oxygen into the tissues lining the middle ear and so the middle ear volume decreases faster than at the surface, leading to swelling of the middle ear lining and problems with the next dive or even on that one on the way back to the surface. Of course any other advice that the doctor thinks is necessary to enable the person to dive safely should be offered.

I believe that a diving medical is good value before learning to dive. Having done many routine medicals in the RN and the RAN, and never found more than a rise in blood pressure that had changed since the last medical, I am less convinced of the need for regular medicals. However I think that a diving medical could be good value after any illness that puts the diver to bed for more than a couple of days and if the diver develops symptoms, such as chest pain for shortness of breath on exertion, or a systemic disease such as diabetes (non-insulin dependant) or hypertension. In these cases the diver can be advised on the dangers of continuing diving or how to dive safely in the future.

OD Hickey has published a review article in Undersea Biomedical Research entitled "Outline of medical standards for divers"³ which goes into more detail than I have. It is however based on standards for commercial divers not for sports divers. It is well worth reading.

I would remind you of my opening remarks that the doctor advises the would-be sports diver of the risks and leaves it to him to decide what course he is going to follow. A brusque intimation of having failed the medical may take the budding diver back to the dive shop. There he will be told where to find a more accommodating, if less knowledgeable doctor. It is our responsibility to explain things to him so well that he stops wanting to dive.

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DIVING ACCIDENTS 1985: AN AUSTRALIAN VIEW

John Knight

By the end of October 1985 Project Stickybeak, which is run by Dr Douglas Walker, PO Box 120, Narrabeen NSW 2101, had heard of 10 diving associated deaths in Australia. Project Stickybeak is an unfunded, non-government, confidential enquiry collecting accident statistics and publishing an annual report on the deaths for Australia. The latest report appeared in the SPUMS Journal for July to September 1985.¹ Owing to great co-operation from the various coroners, police forces, justice departments and Attorneys General around Australia, the figures are reasonably complete. However, some of the details take a long time to reach Dr Walker because of legal proceedings and delayed inquests and sometimes because no one recorded what would be, to a diver, a significant fact. I must stress that the figures are provisional.

PROVISIONAL DIVING RELATED DEATHS IN AUSTRALIA

JANUARY TO OCTOBER 1985

SCUBA - 7 DEATHS

- | | |
|-----------|---|
| Male 21 | 1st dive after qualification.
35 m Low on air
20 m Out of air. Buddy breathing.
Both ran out of air. Both dropped weight belts. Buddy's vest inflated, victim's did not. |
| Male 46 | Dive to 80 feet. Problem at 10 feet.
Called for help at surface. No cause of death available. |
| Female 24 | 1st dive after qualification 35 m. Out of air on ascent. Could not drop weight belt as shifted weight had jammed buckle. Vest problem. Strong currents. |
| Male | 28 40 m dive using twin tanks. Separated from buddy who raised the alarm. Found with empty tanks. |
| Male | Sucked into pondage outlet. |
| Male | 20 Scallop dive to 20 m. Out of air. |

SNORKEL DIVERS - 4 DEATHS

- | | |
|---|--|
| 1 | Taken by shark when collecting abalone in shallow water. |
| 1 | Spearfishing. Cause of death uncertain. |
| 1 | Epileptic. |
| 1 | Washed out to sea. |

Dr Walker includes in his diving related deaths the deaths of snorkellers. Since 1 January 1985 four snorkellers have died.

The most dramatic was the death of a woman who was taking abalone with her husband in two to three metres of water. A large shark took a bite and she was