The Editor's Offering

A very Happy Christmas and a Prosperous New Year to all our readers and many thanks to those who have helped make the publication of the South Pacific Underwater Medicine Society Journal possible. These include our peer reviewers, our proof readers, Drs David Davies and Dr John Couper-Smartt, who appears to have deserted Adelaide to sail his yacht in the Pacific, our authors and very importantly our SPUMS Administrator, Steve Goble (<stevegoble@bigpond.com>) who keeps our membership lists up to date and provides the mailing house with the names and addresses needed for posting.

The past year has been a challenging one for the Society and the Journal. The President's report on page 119 tells us of the financial problems which faced the Society at the end of 2000 and the successful correction of these by the Madang Annual General Meeting. With the bad news out of the way the good news is that on 2001/1/1 the Journal was added to Elsevier Science's medical database, EMBASE (www.embase.com) and the Journal became an indexed publication.

Another medical database, called *Meditext*, this time in Australia, has been started by co-operation between RMIT University in Melbourne, the Australian National Library in Canberra and the Copyright Agency Ltd (CAL). As the National Library has to be supplied with a copy of each issue of Australian based publications they have access to a large amount of data. They will be supplying scanned copies of every medical article to RMIT Publishing who will have all of them accessible and searchable on the web. Medical Journals usually own the copyright of everything published in their pages. Until now the assumption was, on the Society's part, that the Journal owned the copyright of everything on its pages, except the reprints for which copyright permission was obtained from the original publisher. With recent changes in the copyright laws in Australia and with the Journal joining *Meditext* the Journal can no longer rely on vague and assumed agreements. One American firm which supplies reprints recently lost a court case because they did not have the copyright owner's permission to issue reprints of a particular paper. It was an expensive loss. CAL and RMIT publishing have helped the Journal design a Standard Conditions of Publication to be signed by all authors before their work can be published in the Journal. This gives the Journal non-exclusive licence to publish in print and electronic form, gives the Journal the right to sub-licence to third parties, makes clear the details of royalty payments and acknowledges the author will always be acknowledged as the copyright owner of the article. Extra work for the Journal staff but a better deal for authors.

This issue contains a paper by Chris Acott covering 457 incident reports reported to him, among the first 1,000 incidents reported to the Diving Incidents Monitoring Study (DIMS), dealing with equipment faults and failures. Thorough pre-dive checking, regular maintenance and proper training in the use of equipment and safety procedures would have eliminated most problems, but some require redesign of equipment, such as inflate and deflate buttons close to each other which leads to pressing the wrong button, or use of different materials to avoid the problems.

Dr Peter Glanvill, in THE WORLD AS IT IS tells us about his diving career, much of it without any knowledge of his patent foramen ovale (PFO). It was only after two diving accidents that he was investigated and a large PFO demonstrated. He opted to avoid operation and leave things to nature and returned to diving when given a copy of the DCIEM tables, which are more conservative that the BSAC's tables. By sensible diving he has avoided any further DCI by staying shallow and well inside the no-decompression limits.

Much of this issue is taken up with discussions on pulmonary fitness to dive. But what is that? James Francis discusses the various attitudes in the English speaking countries and reminds us that the vital requirement is to be able to supply adequate oxygen for the exertion demanded underwater. No one suggests that anyone should dive during an asthmatic attack, but asthmatics do dive when their symptoms are mild and are forced to suppress their asthma history to be passed fit to learn to dive. Cathy Meehan discusses her experience with screening protocols and Paul Thomas his with testing to detect asthma in divers. The discussion after the last two papers brought out the lack of data about asthmatic divers' problems in the water and brought up the question whether there was any evidence to support banning asthmatics from diving. The UK decision to allow quiescent asthmatics, 48 hours without asthma, to dive if their peak flow was within 10% of their best, does not appear to have increased the number of divers developing pulmonary barotrauma around Britain. So read all about it.

The Journal of the Royal Naval Medical Service occasionally publishes clinical papers about diving problems. The one reprinted on page 238 is said to be the first report of internal carotid occlusion due to blunt trauma, a scuba cylinder, occurring in a sports diver.

In July 2001 another diver who had developed neurological problems after a dive, which were not due to decompression illness, was reported in the British Medical Journal (Vol 233 28 July page 242). To read about it go to <www.bmj.com/cgi/reprint/323/7306/242.pdf>.

To encourage volunteers to take over the Editorship of the Journal there is a book review of the Australian Editing Handbook and a paper on the development of the Journal.

ORIGINAL PAPERS

457 EQUIPMENT INCIDENT REPORTS

Chris Acott

Key Words

Accidents, equipment, incidents, morbidity, recreational diving, safety.

Abstract

Diving is an equipment orientated sport and identification and elimination of problems associated with the use of that equipment is an important part of diving safety.

There were 457 incidents involving equipment in the first 1,000 incidents reported to the Diving Incident Monitoring Study (DIMS). One hundred and thirty six of these incidents resulted in morbidity, therefore, 30% of the equipment problems caused harm. They constituted 28% of the total morbidity reported.

A meticulous pre-dive check, the use of back-up equipment, additions and alterations to equipment design and manufacturing materials, regular servicing, post-dive maintenance, recalibration of all gauges and adherence to strict standard diving safety practice will minimise equipment problems.

Introduction

Safety in diving is dependent upon an adequate understanding of the associated risks. Diving is an equipment-orientated sport and the identification and elimination of problems associated with equipment use is an important part of diving safety. While it is inevitable that some equipment will malfunction, other problems will be due to; a lack of understanding of equipment function, poor equipment design, poor servicing, equipment misuse or inadequate post dive maintenance. Previous reports of diving equipment malfunction/failure have shown that these are at best inconvenient and at worst lethal.[1-4]

An accident is often the product of unlikely coincidences or errors occurring at an inopportune time when there is no "system flexibility".[5] It is reasonable to assume that error prevention will also prevent accidents because it is easier to predict and prevent errors rather than accidents.[6,7] It must be noted, however, that most errors occur repeatedly, cause no harm and are recognised and corrected before they progress to an accident.[5]

Incident reporting is the study of error and unintentional events. It is a method of identifying and analysing error in the context of contributing and associated factors.[7,8] It is not a new concept, having been first used in the 1940s to improve military air safety, although the idea had its foundations much earlier in 19th Century Britain.[9] It is now an established part of safety in aviation, the nuclear power industry and anaesthesia.[10-15]

Incident monitoring focuses on the process of error, regardless of outcome, and has no interest in culpability or criticism. Monitoring of incidents can not identify the absolute incidence of error, but will show the relative incidence of errors or identify "clusters" of errors.[6-8,12,13] In Australia the Anaesthetic Incident Monitoring Study (AIMS) was introduced in the 1980s and provided evidence of unsuspected weaknesses in past anaesthetic training which have since been corrected.

The safety implications of the application of incident monitoring to recreational diving include the identification of the most common and dangerous errors and their contributing factors. Identification of such errors may suggest corrective strategies which may lead to the reduction or elimination of their effects.[16-19]

Method

A diving incident form was designed in 1988 and has since been modified.[16] These forms were distributed throughout Australia and New Zealand. A diving incident is defined as any error or unplanned event that could or indeed did reduce the safety margin for a diver on a particular dive. An error can be related to anybody associated with the dive and can occur at any stage during the dive. An incident can also include equipment failure.

Divers are encouraged to fill out one of these forms as soon as they have witnessed or have been involved in an incident. Anonymity is assured by the design of the questionnaire.

Data on all incidents associated with equipment problems (including poor design, poor servicing, a lack of servicing or recalibration, ignorance of the equipment's function and equipment misuse) in the first 1000 incidents reported to the Diving Incident Monitoring Study (DIMS) were examined.

For the purpose of this study equipment misuse occurred when a piece of equipment was used in a manner for which it was not designed or specified. Included in the reports examined were incidents in which true equipment malfunction (defined as: "when a piece of equipment fails to perform in the manner specified by the manufacturer, providing it had been maintained and checked prior to use in accordance with the manufacturer's recommendations.") occurred. These true equipment malfunction incidents have been discussed previously.[4]

Results

There were 457 incidents involving equipment in the first 1,000 incidents reported to the Diving Incident Monitoring Study (DIMS). One hundred and thirty six of these incidents involved morbidity, therefore 30% of the equipment problems involved harm. These harmful equipment problems constituted 28% of the total morbidity reported. Tables 1 and 2 list the number of reported incidents and morbidity associated with each reported piece of equipment. Previous published data concerning "true equipment malfunction" (TEM) is also included in Table 1

TABLE 1

MORBIDITY ASSOCIATED WITH EACH PIECE OF EQUIPMENT

Equipment	Number of divers	Morbidity (%of cases)		TEM (morbidity)	
BCD	154	48	(31%)	24	(7)
Regulator	52	18	(33%)	20	(3)
Contents gauge	37	10	(27%)	33	(9)
Weight belt	33	4	(12%)		
Alternative air source	31	9	(29%)	4	(0)
Mask	28	15	(54%)		
Tank	22	1	(4%)	1	(0)
Fins	21	0	(0%)	5	(0)
Computer	11	6	(54%)	11	(6)
Compressor	10	5	(50%)		
Wet suit	10	4	(40%)		
Depth gauge	9	2	(22%)	3	(2)
Dive tables	9	6	(67%)		
Surface signaling device	8	0	(0%)	3	(0)
Exit ladder	5	4	(80%)		
Light source	4	0	(0%)	1	(0)
Compressor air hose kinked	3	2	(67%)		
J valve	2	0	(0%)		
Snorkel	2	1	(50%)		
Scooter	1	0	(0%)		
Surface line	1	0	(0%)		
Compressor air hose rupture	1	1	(100%)		
Knife	1	0	(0%)		
Video camera	1	0	(0%)		
Shot line	1	0	(0%)		
Totals	**457**	**136**		**105**	**27**

Note TEM = True Equipment Malfunction.

TABLE 2

MORBIDITY ASSOCIATED EQUIPMENT PROBLEMS

Decompression sickness 48 cases	17 BCD problems 6 computer problems 6 dive tables problems 4 contents gauge problems 4 alternative air source problems 2 weight belt problems 2 mask problems 2 depth gauge problems 2 compressor problems 1 compressor air hose rupture 1 wet suit problem 1 regulator problem
Salt water aspiration 27 cases	9 regulator problems 7 mask problems 5 alternative air source problems 4 BCD problems 1 snorkel problem 1 contents gauge problem
Cerebral arterial gas embolism 24 cases	12 BCD problems 3 regulator problems 3 contents gauge problems 2 weight belt problems 2 mask problems 1 compressor problem 1 compressor air hose kink
Pulmonary barotrauma 18 cases	10 BCD problems 3 regulator problems 2 contents gauge problems 2 mask problems 1 wet suit problem
Near drowning 3 cases	2 BCD problems 1 regulator problem
Ear/sinus barotrauma	2 BCD problems
Mask squeeze	2 mask problems
Contaminated air	2 compressor problems
Crushed finger	2 exit ladder problems
Diver unconscious on bottom (hypoxic)	1 compressor air hose kink 1 regulator hose rupture
Not specified	1 BCD problem
Fractured toe	1 tank problem
Lacerated finger	1 exit ladder problem
Hypothermia	1 wet suit problem
Lacerated scalp	1 exit ladder problem
Coral sting	1 wet suit problem

for comparison. These TEM problems accounted for 105 (10.5%) of the equipment problems reported to DIMS. Of these, 27 (25%) resulted in harm to the diver.[4]

In addition to the 154 Buoyancy Control Device (BCD) incidents studied in this report (Table 3) there were 11 BCD incidents which have not been included in this analysis of equipment problems because they were considered to be related to poor diving technique. These incidents were caused by divers frequently using their BCD power inflator to maintain their buoyancy. This diving technique led to nine out-of-air and two low-air problems. Four of these nine incidents resulted in morbidity.

Discussion

There are no regulations or standards that govern recreational diving equipment. Snorkels are sold without data on their dead space or resistance to breathing. Depth and contents gauges are sold without calibration data although they are assumed to be accurate at the time of purchase. Torches are also sold as pressure-resistant and waterproof without any data to validate these statements. Regulators are arbitrarily recommended to be serviced annually irrespective of use. There are also limited data available concerning individual regulator function at various depths and under increased workload. It is also often assumed by divers that a BCD will float an unconscious diver safely on the surface. Unfortunately this is not always true of modern BCDs. The lack of standards has also allowed ergonomically poorly designed equipment to be available and sold; for example many BCDs have inflate and deflate buttons co-located on the BCD inflator hose, these have been confused during an emergency leading to further problems.

Incident reporting data are qualitative and not quantitative although data obtained are often used in a quantitative manner. Frequently reported errors may represent what is perceived as being important by the reporter, however the data obtained may show the relative incidence or clusters of errors associated with the use of a particular piece of equipment. This study shows that equipment problems are not uncommon in recreational diving and that they are associated with a high incidence of morbidity. They accounted for 46% of the incidents reported and 28% of all the incidents that involved morbidity.

One hundred and five (10.5%) of the first 1,000 incidents conform to a definition of true equipment malfunction.[4] TEM occurs when a piece of equipment fails to perform in the manner specified by the manufacturer, although it had been maintained and checked prior to use in accordance with the manufacturer's recommendations. The DIMS TEM data (23% of the total and 20% of the morbidity) are consistent with published data where TEM accounts for 8 to 10% of incidents and accidents in systems requiring interaction between equipment and human beings.[10,12,20]

Errors or problems involving BCDs, shown in Table 3 were the most commonly reported incidents in the first 1,000 collected. Data concerning these incidents has been previously reviewed.[21] Nearly a third of these incidents were associated with morbidity. These data are disturbing considering that a BCD is regarded as an essential part of equipment necessary for safe diving. However, all of these incidents could have been prevented by use of one or more of the corrective strategies on page 193-195.

TABLE 3

154 BUOYANCY CONTROL DEVICE (BCD) INCIDENTS

Problems (14 different types)

1 The inflation mechanism failed:
   a the power inflation mechanism was not connected;
   b there was not enough air in the diver's tank to inflate the BCD;
   c the inflation mechanism jammed;
   d the diver was not able to locate the inflator;
   e the inflator hose was punctured;
   f a separate air cylinder used to inflate the BCD was empty;
   g the separate air cylinder used to inflate the BCD was turned off in an emergency while trying to activate the inflate mechanism.
2 The inflation mechanism spontaneously activated.
3 Diver did not know how to use the oral inflator.
4 There was confusion between the deflate and inflate buttons.
5 The inflation mechanism was not connected.
6 The BCD leaked.
7 The diver did not know how to deflate the BCD.
8 The dump valve malfunctioned.
9 The BCD was uncomfortable to wear.
10 When fully inflated the BCD restricted the diver's respiration.
11 The BCD was too small and provided inadequate buoyancy.
12 The deflation rate of the BCD was inadequate.
13 Inflation rate was slow at depth.
14 BCD too large.

Misuse

a Full inflation of the BCD was used to retrieve the anchor at the end of the dive.
b Full inflation of the BCD was used to raise a heavy object.

Major contributing factors

a Lack of knowledge of the functions of a BCD
b Failure to check.
c Poor design
d Lack of diver maintenance

1 the purchase or hiring of a BCD should be accompanied by an education program (verbal and video) which stresses the function of each part of the BCD ;
2 a change in design so that inflation and deflation buttons are separated and cannot be confused.
3 a change in design so that the hose deflation button can be used while a octopus integral with the power inflator is being used by a buddy.
4 a meticulous pre-dive BCD check should always be performed;
5 all introductory recreational diver training programs should put greater emphasis on the importance of buoyancy control;
6 a BCD should be washed with fresh water after every dive;
7 a BCD should perhaps be serviced annually; and
8 choosing the correct size BCD.

In addition to these corrective strategies data concerning the function of a regulator at depth or when the air supply is low should be made available at the time of purchase. This may eliminate ignorance of the time taken to inflate a BCD at depth due to a poorly functioning first stage or when the air cylinder contents are low.

Choosing a correct size BCD is important. This will eliminate problems of inadequate buoyancy, restriction of respiration while partially inflated, becoming dislodged during diving and covering the weight belt which reduces access to the weight belt during an emergency.

Trainees, in particular, should be taught to achieve buoyancy control without the use of a BCD, how to slow an uncontrolled ascent and to overlearn the response of weight belt release in an emergency.

Regulator problems are shown inTable 4. First stage failure and low-pressure hose rupture did not necessarily occur when the air supply was at maximum pressure. In the reported incidents regulator first stage failures and low pressure hose ruptures occurred at depth. Diaphragm first stage regulators are more likely to fail than the piston type because they have an upstream valve that can fail to operate so shutting off the diver's air supply. Measures that should reduce the occurrence and minimise the effects of these incidents include the use of an independent redundant air source such as a pony bottle, a visual hose inspection before every dive and the consequent replacement of all doubtful hoses.

Poor servicing of regulators was highlighted in the reported incidents. Free flowing second stages frequently followed the annual service. There are no regulations governing service standards. Divers should test their recently serviced equipment before use and return it to the service person if the service was found to be inadequate.

TABLE 4

52 REGULATOR INCIDENTS

Problems (11 different types)

1 Free flowing second stage.
2 First stage failure.
3 High-pressure hose leaking or rupture.
4 Foreign body in second stage.
5 Second stage allowed the inhalation of water.
6 Mouthpiece worn and fell apart.
7 Increased resistance to breathing at depth (not associated with buddy breathing).
8 Second stage dislodgment from the diver's mouth during the dive.
9 Swivel connector between high-pressure hose and mouthpiece ruptured.
10 First stage connected incorrectly to the tank's pillar valve.
11 A moisturising filter between the high pressure hose and second stage malfunction.

Major contributing factors

a Poor servicing.
b Lack of servicing.
a Lack of diver maintenance.
b Failure to check.

Visual inspection of the regulator mouthpiece (and replacement if required) before each dive would eliminate problems associated with a worn or torn mouthpiece. Divers should be encouraged to use only a mouthpiece which is comfortable to wear and well fitting. This will reduce jaw fatigue and accidental displacement during a dive. Recovery of a displaced regulator is assisted by having a line from the second stage clipped to the BCD.

Some unbalanced first stage regulators perform poorly at depth. Divers may also not realise that when two are breathing from one first stage regulator (either balanced or unbalanced) in a shared air situation, even when the air cylinder contents are not necessarily low, the regulator may malfunction. It is important, therefore, that regulator performance data for each depth and under the situations described should be available.

The addition of unnecessary extras (for example a humidifier) to the low pressure regulator hose only increases the chances of malfunction.

Table 5 shows contents gauge incidents. The use of an alternative air source (a bail-out bottle or a separate redundant air cylinder and regulator) may enable a diver who has experienced a regulator failure or any other cause of an out of air situation to ascend safely.[19] However, in some incidents redundant systems were not checked as

TABLE 5

37 CONTENTS GAUGE INCIDENTS

Problems (5 different types)

1 Inaccurate gauge.
2 Hose leak.
3 Unable to read the gauge because of poor visibility or red colour numerals.
4 Misreading the gauge because the diver did not understand the units used.
5 Diver did not understand what a fluctuating analogue needle indicated during inspiration.

Major contributing factors

a Failure to check.
b Lack recalibration /servicing.
c Lack of understanding.

TABLE 6

31 ALTERNATIVE AIR SOURCE INCIDENTS

Problems (2 types)

1 Redundant air source or pony bottle.
 a not turned on at beginning of dive.
 b filling mechanism failure.
 c not in an accessible position.
 d depleted during use.
 e inadequate contents.
 f used at beginning of dive incorrectly.
 g empty, not checked prior to diving.

2 Octopus 2nd stage regulator.
 a not accessible in emergency due to poor positioning.
 b free flowing.
 c not working.
 d low pressure hose rupture.
 e depleted air supply quickly when used in emergency.
 f difficulty in breathing from it and main regulator at depth during emergency air sharing,
 g difficulty in breathing from it and main regulator during emergency air sharing,
 h hose and 2nd stage became snagged,
 i not purged during emergency use causing salt water inhalation and panic,
 j low pressure hose too short to be used in an emergency by another diver,
 k placed incorrectly in diver's mouth during emergency.

frequently as the diver's major air supply. In these incidents the additional air supply was noted to be either:

1 turned off, or
2 leaked, or
3 empty at the time when needed; or
4 had an inadequate supply of air to allow the diver to ascend safely.

Table 6 shows alternative air supply incidents. Smaller emergency air bottles, such as Spare Air, which require a filling mechanism to enable them to be filled from the major air supply, were available but not used in some incidents because the filling mechanism was unavailable or had failed to work. These smaller bottles also contain only a limited amount of air and frequently became depleted during emergency use. Air consumption calculations using, the standard 70 kg male, reveal that to ascend to the surface from a depth of 20 m at 10 m/minute, assuming that the emergency has doubled the diver's minute volume from a quiet 20 l/minute to 40 l/minute, would require a surface volume of 160 litres. The larger Spare Air (3 cu ft) contains 84 litres when converted to surface pressure so is obviously inadequate. It would require a pony bottle of 6 cu ft capacity (168 l at surface pressure) to provide enough air for this ascent, provided it was at full pressure when first used. A safety stop for 3 minutes at 5 m would require another 235 litres of surface air, if the diver's minute volume dropped to 30 l/minute. The total needed to reach the surface now becomes 495 l, which rounds off to 500 l. A 2.5 kg (or l) water volume (20 cu ft) cylinder, holding 560 litres, is required.

The addition of another 2nd stage, octopus regulator, to the first stage regulator is considered part of safe diving practice.[22,23] This octopus, however, needs to be:

1 positioned so that any diver wishing to breathe from it has easy access;
2 frequently serviced;
3 fully functional;
4 have minimal resistance; and
5 easily purged.

Some divers have the 1st and 2nd stages of their regulators serviced but often do not service the octopus 2nd stage because it is used infrequently. It should be serviced at the same time.

The combination of a 2nd stage regulator and a low-pressure BCD inflator has no merit. These combinations are extremely difficult to use during an emergency ascent and have resulted in confusion while a diver is trying to breathe from the mouthpiece and deflate the BCD at the same time. These combinations are also not frequently serviced.

The failure of a contents gauge, which measures air cylinder pressure, has been reported to be the major cause of out-of-air problems and morbidity in other published studies.[1,19] Currently, contents gauges are not required to be recalibrated or serviced after purchase. Gauge inaccuracy was reported at every stage of a dive, although the majority were confined to the latter stages when cylinder air pressures were low. Measures that could minimise the effect of these incidents include:

1 an audible alarm (set at 50 bar) in the tank pillar valve and the contents gauge;
2 a thorough pre-dive contents gauge check using a protocol has been developed from the first 125 incidents,[17,19]
3 recalibration of contents gauges with the annual regulator service;
4 dive planning that includes depth, time and air consumption calculations; and
5 divers should be taught to compare their contents gauge readings with those of their diving companion before and during a dive to assess remaining air and gauge accuracy.

Training programs need to emphasise depth, time and air consumption calculations. These calculations must be included in pre-dive planning. This will help to prevent out-of-air situations associated with the use of smaller tanks. Haste, inexperience and inattention cause divers to not realise that reducing the size of the air cylinder will mean that:

1 less air is available;
2 adjustments to buoyancy will have to be made/calculated;
3 there will be a decreased length of a dive;
4 there will be a decreased amount of air available should an out-of-air situation develop in another diver and air has to be shared; and
5 less air will be available when the audible alarm is activated.

Problems with weights and weight belts, shown in Table 7, have been reviewed extensively.[1,3,24] In addition to these problems (being snagged on other pieces of equipment, being unreleasable, and not being ditched in an emergency), incident reporting has highlighted other areas of concern:

1 weights dropping from the weight belt when being handled when leaving the water; and
2 weights dropping from a BCD pocket after placed there in a hurried attempt to adjust buoyancy.

The importance of too much tongue overlap causing problems (being wrapped around the belt to prevent rapid release, being snagged by rocks causing accidental dislodgment and the inevitable uncontrolled rapid ascent) also featured in the incidents reported and need to be emphasised during training. Trainees should be taught:

1 how to control a rapid ascent;
2 how to secure a weight belt correctly;
3 that a weight belt should not be overlapped by any other piece of equipment which will prevent its rapid release;
4 how to handle the weight belt at exit; and
5 how to jettison it correctly in an emergency by holding it out from the body so when it falls it is clear of all other equipment.

TABLE 7

33 WEIGHT BELT INCIDENTS

Problems (11 different types)

1 Dislodged during dive (not secured correctly) causing a rapid ascent.
2 Being dropped at the exit.
3 Weights dropping from belt at exit.
4 Tongue overlap becoming snagged and causing weight belt dislodgment.
5 Forgot weight belt.
6 Weight belt dropped during emergency but became snagged on other equipment (knife; BCD harness).
7 Weight belt covered by an overlapping (large) BCD preventing accessibility during an emergency.
8 Weights placed in BCD pocket fell out.
9 Weight belt buckle not securely fastened.
10 Weight belt was unreleasable due to the overlapping tongue being twisted around the rest of the belt.
11 A change in position of the weight belt during the dive prevented emergency jettisoning.

Major contributing factors

a Failure to check.
b Inattention.
c Haste.
d Insufficient training.

Over 50% of incidents involving mask problems caused morbidity (Table 8). Flooding or dislodgment caused panic in many incidents. Five out of the 6 incidents involving mask flooding and panic resulted in diver harm; 2 of the 3 reported incidents involving mask clearing and panic caused harm. Six of the 10 incidents in which the diver's mask was dislodged resulted in harm, although only 1 of these incidents was associated with panic. Mask problems have been reported as a contributing factor in 5% of recreational deaths.[1] Not only should mask clearing be emphasised during training but also the ability to continue a dive without a mask, should it become displaced, is an essential skill that needs to be mastered by ALL divers.

Table 9 shows air cylinder incidents. An annual inspection of air cylinders for faults is an important safety measure. An undetected cylinder fracture could have explosive and fatal consequences. Checking that the air cylinder is securely fastened in a backpack or BCD is part of a pre-dive check. From the incidents reported this is not commonly performed. Incorrectly connecting the first stage to the pillar valve is an indication of inexperience and anxiety and should alert more experienced divers, including the dive leader, to monitor that diver very carefully.

In the incidents involving surface supply (Table 10)

TABLE 8

28 MASK INCIDENTS

Problems (10 different types)

1 Mask squeeze.
2 Flooding causing panic.
3 Flooding not causing panic.
4 Clearing causing panic.
5 Mask strap broke.
6 Mask dislodged causing panic.
7 Mask dislodged without causing panic.
8 Unable to clear mask because of bad technique.
9 Mask leaking.
10 Uncomfortable to wear.

Major contributing factors

a Inexperience.
b Inattention.
c Failure to check.
d Anxiety.

from an air compressor (hookah diving) the compressor was left unattended in many. This resulted in it running out of fuel causing an out-of-air situation. In all of these incidents the divers lacked a bail-out bottle. These incidents are examples of stupidity and no corrective strategies will prevent them. Even if the compressor has an attendant a checked bail-out bottle is essential because air hoses can become snagged, rupture or kink.

Air compressors need regular maintenance. In one incident reported poor compressor maintenance could have resulted in multiple deaths. Poor filtering (due to a lack of maintenance) allowed silica dust to enter the air cylinders during filling. This silica obstructed the air cylinder's pillar valve during use. All the air cylinders filled from this compressor were noted to have silica in them. In addition, none of the air cylinders had been pressure tested or visually inspected before this incident. Regulations governing compressor maintenance are worthless unless a regulatory body (if it exists) performs spot checks. Checking that a hired air cylinder has been recently tested would give a good indication of the shop's equipment maintenance.

TABLE 10

10 COMPRESSOR INCIDENTS

Problems (5 types)

1 Ran out of petrol.
2 No attendant.
3 Contaminated air supply to scuba tanks.
4 Diver using surface supply commenced the dive without turning the compressor on.
5 Compressor air hose kinked or ruptured.

Misuse

a No attendant.

Major contributing factors

a Lack of maintenance.
b Failure to check.

TABLE 9

22 CYLINDER INCIDENTS

Problems (12 different types)

1 Fracture detected in new cylinder.
2 Cylinder not secured properly in backpack or BCD.
3 Cylinder slipping out of BCD.
4 Pillar valve leak.
5 Buoyancy problem because of a change from steel to aluminium cylinder.
6 Buoyancy problem because of aluminium cylinder.
7 O ring rupture.
8 Covering tape left over pillar valve.
9 Tank straps loose, BCD dislodged.
10 Change to smaller cylinder size caused a quicker depletion of air supply leading to an out-of-air situation.
11 Air supply turned off while diver still climbing exit ladder.
12 Incorrect attachment of the regulator to the pillar valve.

Major contributing factors

a Lack servicing/inspection.
b Failure to check.
c Inexperience.
d Anxiety.
e Inattention.
f Haste.
g Poor judgement/decision.

The loss of a fin in an emergency situation may be fatal. In an analysis of diving fatalities, one study reported a 13% incidence of a missing fin or fins. The loss of a fin was thought to be associated with active leg movement during panic or while swimming against a strong current or using a fin too large for the diver's foot.[1] These problems were also highlighted in the incidents received, however, in several incidents breakage of a fin strap occurred which was not associated with strenuous exercise or panic (Table 11). A pre-dive check must include a check of the integrity and tightness of the fin straps.

It is not surprising that some of the incidents involving dive computers (Table 12) resulted in morbidity. Standardisation of the layout of the face, and of the units used, would prevent confusion in reading the displayed data.

To prevent sudden power failures, all computers

TABLE 11

21 FIN INCIDENTS

Problems (3 types)

1 Lost during dive.
  - a incorrect for boot size, too large.
  - b loose strap.
  - c strap broke.

2 Forgot to put fins on before dive.

3 Fins forgotten.

Misuse

a Incorrect size of fin for boot size.

Major contributing factors

a Failure to check.

b Error judgement.

TABLE 12

11 COMPUTER INCIDENTS

Problems (4 types)

1 Not activated before the dive.

2 Battery became flat during the dive.

3 Diver unable to understand layout.

4 Diver unable to understand numerical data.

Major contributing factors

a Poor design.

b Lack of understanding.

should be equipped with either a low battery alarm or a mechanism by which the diver can test battery power before a dive. Computers should be used to assist dive planning and should not be the sole method of dive management. All divers using computers should dive with an additional timing device, depth gauge and a set of tables to calculate decompression requirements (if needed) even after surfacing when the computer failed. However, misreading dive tables also featured in the morbidity incidents reported to DIMS.

TABLE 13

9 DIVE TABLE INCIDENTS

Problem

9 cases Misreading.

Major contributing factors

a Lack of understanding.

b Poor design/layout.
  - a Poor training.
  - b Inexperience.

The increasing popularity of dive computers has resulted in less attention to dive planning and consultation with a set of diving decompression tables. However, diving decompression tables are difficult to understand and frequently errors are made during calculation of dive profiles and decompression requirements. This was clearly evident in the incidents reported here (Table 13). Basic education about inert gas uptake and elimination, necessary to the understanding of safe decompression and dive table theory, and the use of a dive computer to guide the dive plan are both important aspects of diver training. The rechecking of a computer dive plan with a set of recognised dive tables will only enhance the safety of the diver.

Analogue depth gauge inaccuracy is of concern (Table 14). Even when a depth gauge is first purchased, the accuracy of the gauge is not known. Once purchased, there is no current requirement for any recalibration. It is clear that recalibration of these gauges is required.

TABLE 14

9 DEPTH GAUGE INCIDENTS

Problems (4 types)

1 Inaccurate.

2 Maximum indicator stuck in analogue gauge.

3 Maximum depth indicator not zeroed before dive.

4 Depth indicator not zeroed at commencement of dive.

Major contributing factors

a Lack recalibration /servicing.

b Failure to check.

Surface signalling devices (Table 15) are important to prevent the loss of a diver on the surface. These devices must be able to be seen in rough seas and poor visibility conditions. Safety sausages (an elongated sausage shaped coloured plastic tube which is extended by filling with air) are usually visible and easily maintained in an upright position in calm conditions, but from the reports received they are often invisible and failed to maintain their upright position in adverse conditions. These devices need to be made from a sturdy material and tested in all conditions before being sold. All divers should finish the dive with enough air remaining in their air cylinders to manage adverse surface conditions and to fill a safety sausage. Air management is a training and educational issue.

Any whistling device used must be powerful enough to attract the attention of all on the surface and be audible over the noise of a boat's engine. This would minimise the chances of a whistle signal being neglected by the boatman.

TABLE 15

8 SURFACE SIGNALLING DEVICE INCIDENTS

Problems (4 types)

1 Unable to inflate safety sausage because diver out of air.
2 Signalling device (whistle) not responded to.
3 Safety sausage not seen because of poor visibility, or rough conditions.
4 Safety sausage failed to remain in the upright position during use in bad weather conditions.

Major contributing factors

a Poor design/manufacturing material.
b Inattention.

TABLE 16

5 EXIT LADDER INCIDENTS

Problems

5 cases Sea conditions made it difficult to use ladder.

Major contributing factors

a Not familiar with diving conditions.
b Lack of dive planning.
c Weather conditions.

TABLE 17

4 LIGHT SOURCE (TORCH) INCIDENTS

Problems

2 cases Torch snagged on other equipment or between rocks.
1 case Flooded during use.
1 case Batteries became flat during use, unable to check battery charge before use.

Major contributing factors

a Poor design.
b Lack of pre-sale testing.

The reported problems with exit ladders (Table 16) at the end of the dive indicated that planning the exit was not part of these dive plans. Water entry and exit are important parts of dive planning. A bouncing exit ladder in rough sea conditions is an important but fortunately rare cause of diver harm.

Limited visibility diving requires the use of a primary and secondary diving torch (Table 17). The water and pressure resistance of any diving torch needs to be tested before sale. The addition of a battery power indicator would prevent power failure during a dive. If a piece of equipment is considered essential, it is reasonable that at least one level of redundancy (e.g. duplicate equipment such as a contents gauge, dive timer, depth gauge and torch) are needed.

TABLE 18

10 WET SUIT INCIDENTS

Problems (5 types)

1 Tightness causing difficulty with breathing.
2 New suit altered buoyancy, diver failed to adjust weights.
3 Inadequate thermal protection.
4 An old Lycra suit providing inadequate protection from coral/jellyfish stings.
5 Hood causing claustrophobic reaction.

Major contributing factors

a Lack of training.
b Inexperience.
c Failure to check.
d Anxiety.

An alteration in buoyancy (Table 18) occurs when a diver changes his/her wet suit, uses a smaller tank or adds a piece of equipment. This is a training and education issue. Wearing a poorly fitting wet suit (either too large or small) is either due to ignorance, inexperience or stupidity.

TABLE 19

2 J VALVE INCIDENTS

Problem

2 cases J valve in “on” position at commencement of dive.

Major contributing factors

a Lack of understanding.
b Inexperience.
c Failure to check.

Contributing factors

FAILURE TO CHECK

Failure to check was the most frequently reported error. Checking protocols for each piece of equipment should be emphasised during training. Divers then can, or should be encouraged to, use these protocols as a template to develop their own pre-dive check list which will be easy for them to remember and hence perform. A previous study

TABLE 20

2 SNORKEL INCIDENTS

Problems

1 case Flap valve absent.
1 case Unable to keep snorkel dry because of non functioning flap valve.

Major contributing factors

a Failure to check.
b Failure to understand equipment.

TABLE 21

5 MISCELLANEOUS INCIDENTS

Problem

1 case Surface floating line snagged around diver.

Major contributing factors

a Inattention.

Problem

1 case Shot line snagged around diver.

Major contributing factors

a Inattention.

Problem

1 case Scooter motor back-wash activated the purge valve on diver's octopus regulator causing an unnoticed depletion of the diver's air supply.

Major contributing factors

a Inattention.
b Failure to check.
c Failure to understand equipment.

Problem

1 case Weight belt snagged on knife during emergency ditching.

Major contributing factors

a Inattention.
b Inexperience.
c Error in judgement.

Problem

1 case Video camera altered diver's buoyancy to positively buoyant.

Major contributing factors

a Inexperience.
b Error in judgement.
c Poor dive planning.

demonstrated that divers, even when the number of errors were known with a set of equipment, failed to identify all of them.[25] Failure to check was frequently associated with haste, inattention, a lack of post-dive maintenance and a lack of, or poor, servicing.

The incidents reported highlighted that the following are not often checked:

1 the condition of the fin and mask straps;
2 that the weights are securely fastened on the weight belt ;
3 that the weight belt is the correct size without too much tongue overhang;
4 that the tank is securely fastened in the BCD or backpack;
5 that no piece of equipment will impede the safe jettisoning of a weight belt in an emergency;
6 that any piece of equipment which has been recently serviced is functioning correctly before using it diving;
7 that the emergency BCD dump valve is functioning;
8 that the BCD inflator is correctly attached;
9 the high and low pressure air hoses for leaks or areas of weakness;
10 the octopus regulator is secured in an accessible position;
11 that an independent redundant air cylinder and regulator is full and turned on and has enough air to enable the diver to ascend safely without missing any required decompression stops;
12 the condition of the mouth pieces (on both the regulator and BCD inflator) and these are securely fastened; and
13 there are no dangling pieces of equipment that may get snagged during the dive.

A pre-dive check should address these issues. A pre-dive checklist suggested from the first 1,000 DIMS incidents will be the subject of a future paper.

Anxiety was also a major contributing factor in many of the incidents. This has implications for diving medical fitness. An anxiety trait may predispose a trainee to panic. Some published data indicate that 39% of diving deaths were associated with panic.[26]

A lack of understanding of how a piece of equipment functions, inexperience and insufficient training are educational and training issues. Divers must be made to realise that neither an open water nor advanced diver qualification means they are qualified for all diving situations.

Inattention was usually associated with a failure to check during the dive, however, at depth it may be due to nitrogen narcosis or carbon dioxide retention due to a poorly functioning regulator.

DESIGN CHANGES NEEDED

Some of the incidents reported highlight poor equipment design. Co-location of the inflate and deflate mechanisms on the BCD's inflator hose is ergonomically poor. Inflate and deflate mechanisms need to be separated. Other BCD design changes proposed include:

1 a larger, more accessible emergency dump valve in all BCDs,
2 a cut off mechanism to the power inflator and
3 standardisation of positioning of controls and valves on BCDs.

Other equipment design changes proposed include:

1 a low battery alarm in all dive computers;
2 standardisation of the dive computer face layout;
3 an audible low pressure alarm in contents gauges and tank pillar valves.

Sturdier manufacturing materials are needed in the surface sausage signalling devices. Light sources need to pressure tested before being sold. It is also reasonable to argue that all battery powered equipment should have either a low battery alarm or a monitor that indicates battery status.

MISUSE OF EQUIPMENT

Equipment misuse has been cited as a contributing factor in some recreational diving fatalities.[1,2]

BCDs are used to adjust a diver's buoyancy during a dive. Over-inflation to help raise a heavy object (i.e. anchor) is an incorrect use of a BCD. These incidents invariably are associated with accidental dropping of the object causing a rapid and uncontrolled, Polaris type, ascent with subsequent morbidity. The lifting of a heavy object should involve planning and perhaps 2 divers. If anchor retrieval is required at the conclusion of the dive then it should be part of the dive planning.

Safe diving practice dictates the use of an alternative air source for the out of air situation.[22,23] This usually involves the addition of another 2nd stage, octopus, regulator to the diver's 1st stage so that one diver's air supply can be shared with the diver who is out of air. Using the octopus regulator in this manner allows a controlled ascent once one diver is out of air.[19]

To use this regulator to continue the dive when one diver is out of air is a misuse of the octopus regulator and is not safe diving practice.

Diving with a non-functional octopus regulator is an unsafe practice. This can result in what might have been a well managed out of air problem becoming a panic situation.

Occupational diving regulations specify that a compressor attendant is necessary for hookah diving. The attendant is necessary to ensure that exhaust fumes are not sucked into the compressor's air inlet and that the compressor does not run out of fuel and to deal with problems causing compressor failure or resulting from a dragging anchor. Diving without using a surface attendant has been implicated in many "hookah" diving deaths.[27] It is also an example of stupidity.

Fins are necessary for locomotion underwater. To choose a pair, that is too large has safety implications. The loss of fins has been implicated in some diving deaths.[1]

Conclusions

A meticulous pre-dive check, the use of back-up equipment, additions and alterations to equipment design and manufacturing materials, regular servicing, post dive maintenance, recalibration of all gauges and adherence to strict standard diving safety practice will minimise the effects of all these equipment problems.

Corrective strategies

The strategies proposed to reduce the occurrence and minimise the effects of these equipment problems are shown in Table 22 (pages 193-195).

References

1 Edmonds C and Walker D. Scuba diving fatalities in Australia and New Zealand. Part 3 The Equipment factor. *SPUMS J* 1991; 21: 2-4
2 Edmonds C and Damron R. Hawaiian scuba deaths. *SPUMS J* 1992; 22 (3): 135-138
3 Bennett PB. Equipment and diving accidents. In *Diving Accident Management. 41st Undersea and Hyperbaric Medical Workshop*. Bennett PB and Moon RE. Eds. Bethesda, Maryland: Undersea and Hyperbaric Medical Society, 1990; 128
4 Acott CJ. Equipment malfunction in 1,000 diving incidents. *SPUMS J* 1999; 29 (3):122-126
5 Alnutt MF. Human factors in accidents. *Brit J Anaes* 1987; 59: 856-864
6 Norman DA. Categorisation of action slips. *Psychol Rev* 1981; 88 (1):1-15
7 Reason JT. *Human Error*. New York: Cambridge University Press, 1990
8 Runciman WB, Sellen A, Webb RK, Williamson JAW, Currie M, Morgan C and Russell WJ. Errors, incidents and accidents in anaesthesia practice. *Anaes Intens Care* 1993; 21: 506-519
9 Flannagan JC. The critical incident technique. *Psychol Bull* 1954; 51: 327-358

TABLE 22

SUGGESTED STRATEGIES TO MINIMISE OUTCOME ASSOCIATED WITH EQUIPMENT PROBLEMS

Equipment problems	Corrective strategies
Buoyancy Control Device	
Inflation mechanism failure.	Pre-dive check, Servicing, Maintenance.
The inflation mechanism was not connected.	Pre-dive check.
Spontaneous activation of the inflation mechanism	Redesign, Educate, Servicing.
Not knowing how to use oral inflator.	Educate.
Confusion between the deflate and inflate buttons.	Redesign.
The BCD leaked.	Pre-dive check.
The diver did not know how to deflate the BCD.	Educate.
The dump valve malfunctioned.	Pre-dive check, Redesign.
The BCD was uncomfortable to wear.	Pre-dive check, Educate.
When fully inflated the BCD restricted the diver's respiration.	Pre-dive check.
The BCD provided inadequate buoyancy.	Educate, Pre-dive check.
The BCD too large.	Pre-dive check, Educate.
Regulator	
Pre-dive checks and stage problems.	Redesign, Extra air, Good buddy diving, Pre-dive check.
Servicing and stage problems.	Pre-dive check, Servicing, Maintenance, Good buddy diving.
Mouthpiece problems.	Pre-dive check, Maintenance.
Incorrect connection.	Pre-dive check, Educate.
Contents gauge	
Inaccurate.	Recalibrate, Pre-dive check, Alarm, Good buddy diving Redundancy, Dive plan, Check during dive.
Unable to read.	Redesign, Pre-dive check.
Lack of understanding of the units used.	Pre-dive check, Educate.
Lack of understanding of a fluctuating needle.	Educate.
Weight belt	
Dislodged during dive.	Pre-dive check, Educate.
Dropped at exit.	Educate.
Forgotten.	Pre-dive check.
Snagged on other equipment.	Educate, Pre-dive check.
Weights fell out of BCD pocket.	Pre-dive check, Educate.
Position prevented emergency jettisoning.	Pre-dive check, Educate.
Alternative air source	
Inadequate air supply.	Pre-dive check, Educate.
Not turned on.	Pre-dive check.
Empty.	Pre-dive check.
Octopus second stage not working.	Pre-dive check, Servicing.
Difficulty in breathing from octopus.	Educate, Pre-dive check, Servicing.
Difficulty during emergency ascent.	Redesign.
Leaking.	Pre-dive check.
Mask	
Mask squeeze.	Educate.
Flooding.	Educate.
Dislodgment.	Pre-dive check.
Mask strap broke.	Pre-dive check.
Unable to clear.	Educate.

TABLE 22 (CONTINUED)

Equipment problems	Corrective strategies
Cylinder	
Fracture in new cylinder.	Servicing.
Not secured adequately in backpack.	Pre-dive check.
Tape left on pillar valve.	Pre-dive check, Educate.
Change to smaller cylinder caused problems.	Educate, Dive plan, Pre-dive check.
Fins	
Fin strap broke.	Pre-dive check.
Forgotten.	Pre-dive check.
Loose – incorrect size.	Educate, Pre-dive check.
Computer	
Not activated before dive.	Redesign, Redundancy.
Unable to understand faceplate layout.	Educate, Redesign.
Battery flat.	Alarm needed, Redundancy.
Compressor	
No attendant.	Safe diving practice.
Ran out of fuel.	Pre-dive check, Safe diving practice.
Contaminated air supply.	Servicing, Safe diving practice.
No bail out bottle used.	Safe diving practice, Educate, Extra air.
Hose kinked or ruptured.	Extra air.
Wet suit	
Too tight.	Educate.
Inadequate thermal protection.	Educate.
Inadequate protection.	Educate.
Hood causing claustrophobia.	Educate.
Depth gauge	
Inaccurate.	Recalibrate, Redundancy, Good buddy diving.
Maximum depth indicator stuck.	Pre-dive check, Recalibrate, Redundancy, Servicing.
Maximum depth indicator not zeroed before dive.	Pre-dive check, Recalibrate, Redundancy, Servicing.
Dive tables	
Misreading.	Educate.
Surface signalling device	
Unable to inflate device.	Pre-dive check.
Device not responded to.	Safe diving practice.
Not visualised in rough conditions.	Dive plan, Redesign, Change manufacture.
Did not stay upright in adverse conditions.	Change manufacture.
Exit ladder	
Sea conditions making it difficult to use.	Dive plan, Redesign.
Light source	
Flooded.	Test by manufacturer, Pre-dive check.
Battery flat during use.	Alarm needed.
J valve	
Turned on before dive.	Pre-dive check, Educate

TABLE 22 (CONTINUED)

Equipment problems	Corrective strategies
Snorkel	
Unable to keep snorkel dry.	Pre-dive check
Emptying flap valve not working.	Pre-dive check.
Scooter	
Depleted air supply.	Check during dive.
Surface line	
Snagged around diver.	Dive plan, Educate.
Knife	
Snagged weight belt.	Educate.
Video camera	
Changed diver's buoyancy.	Educate.
Shot line	
Snagged around diver.	Dive plan, Educate.

10 Nagel DC. Human errors in aviation operations. In *Human Factors in Aviation*. Wiener EL and Nagel DC. Eds. New York: Academic Press, 1988

11 *CAIR (Confidential Aviation Incident Reporting) Brochure and report form*. Bureau of Air Safety Investigation. Canberra: Australia, 1988

12 Williamson AM and Feyer A. Behavioural epidemiology as a tool for accident research. *J Occup Accid* 1990; 12: 207-222

13 Webb RK, Currie M, Morgan CA, Williamson JA, Mackay P, Russell WJ and Runciman WB. The Australian incident monitoring study: an analysis of 2,000 incident reports. *Anaesth Intens Care* 1993; 21: 520-528

14 Cooper JB, Newbower RS, Long CD and McPeel B. Preventable anaesthesia mishaps: a study of human factors. *Anesthiol* 1978; 49: 399-406

15 Williamson JA, Webb RK and Pryor GL. Anaesthesia safety and the 'Critical Incident' technique. *Aust Clin Review* 1985; 17:57-61.

16 Acott CJ, Sutherland A and Williamson JA. Anonymous reporting of diving incidents: a pilot study. *SPUMS J* 1989; 19 (1): 18-21

17 Acott CJ. Scuba diving incident reporting, the first 125 reports. *SPUMS J* 1992; 22 (4): 218-221

18 Acott CJ. Diving incident monitoring, an update. *SPUMS J* 1994; 24 (1): 42-49.

19 Acott CJ. Incident reporting: out of air and diving safety. In *Proceedings of the XXth Annual Meeting of the European Underwater and Baromedical Society on Diving and Hyperbaric Medicine.* Cimsit M, Aktas S and Aydin S. Eds. Istanbul, Turkey: Hyperbaric Medicine and Research Centre (HITAM), 1994; 32-41

20 Webb RK, Russell WJ, Klepper ID and Runciman WB. Equipment failure: an analysis of 2,000 incidents. *Anaesth Intens Care* 1993; 21: 673-677

21 Acott CJ. An evaluation of buoyancy jacket safety in 1,000 diving Incidents. *SPUMS J* 1996; 26 (2): 89-94

22 BSAC. *Safety and Rescue for Divers*. London: Stanley Paul, 1987.

23 *PADI Open Water Manual*. Santa Ana. California: PADI, 1990

24 Edmonds C, Lowry C and Pennefather J. *Diving and Subaquatic Medicine. 3rd edition.* Oxford: Butterworth Heinemann, 1992; 88

25 Acott CJ. A pre-dive check: an evaluation of a safety procedure in recreational diving. *SPUMS J* 1995; 25 (2): 76-77

26 Edmonds C, Lowry C and Pennefather J. *Diving and Subaquatic Medicine. 3rd edition.* Oxford: Butterworth Heinemann, 1992; 84

27 Walker D. *Report on Australian Diving Deaths 1972-1993.* Melbourne: JL Publications, 1998

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THE WORLD AS IT IS

A DIVING DOCTOR'S EXPERIENCE WITH DCS AND PFO

Peter Glanvill

Key Words

Cardiovascular, case report, decompression illness, medical conditions and problems, recreational diving, treatment.

Introduction

A couple of items in the June 2001 Journal have prompted to me to write with some observations and comments which I trust will at least be of interest if not worthy of further debate.[1,2]

First my credentials. I am a GP in the UK and have a long interest in diving medicine which I inherited from my father (a former GP) who took up diving in 1957. I qualified in diving aged 14 (1965) and have dived each year since. I became a qualified member of the British Cave Diving Group in the early 1980s. I am a HSE approved examiner for professional divers and a medical referee for the UK Sport Diving Medical Advisory committee.

This paper started as a too long *Letter to the Editor* and has been influenced by comments by Dr Bob Wong, co-author of *Modes of presentation of foramen ovale in ten divers*, one of the papers referred to above. Some of Dr Wong's comments appear after this paper, but some, the appropriate DCIEM table stops, have been included in italics after the decompression times in the text.

Case report

I have never been a deep diver (40 m maximum and that only once) and decompression is something imposed on me by circumstance rather that choice.

The situation changed dramatically between 1985 and 1986 and I feel the following narrative from a medically trained observer might be of interest. It has taught me the value of keeping a detailed diving log.

By 1985 20 years incident free diving, using the BSAC/RNPL tables and sometimes close to their limits, had made me somewhat blase. I had always dived with small capacity tanks and I attribute what occurred partly to the longer dive times I could achieve with a 12 litre cylinder! In early May 1985 I dived to 28 m for 23 minutes doing a 4 minute stop at 5 m (*DCIEM tables require 3 minutes at 6 m and 9 minutes at 3 m*). 30 minutess to an hour after the dive I had intense itching over my right biceps preceded by 20 minutes of migrainous fortification symptoms in both eyes. The itching disappeared over 6 hours. There was no rash. I developed a cold the next day and decided this had probably precipitated a mild skin bend.

During the next month I did two more dives, one to 21 m for 40 minutes (*DCIEM tables require 5 minutes at 3 m*) and another to 32 metres for only a few minutes, due to my buddy panicking with narcosis. The headache on that dive I attributed to carbon dioxide retention on descent from fighting the current. It went before surfacing.

Three days after a brief dive to 31 m, with a long period at the end in 6 m, I dived to 23 metres and ascended after 38 minutes, a no-stop dive in the BSAC/RNPL tables (*DCIEM tables require 11 minutes at 3 m*). Unfortunately for the first time in my life I did an uncontrolled ascent from 10 m (dry suit over inflation). Within 10 minutes of surfacing I noticed what can only be described as a flush of chest discomfort followed by a wave of numbness ascending from my feet to the mid chest. At 20 minutes I had paraesthesiae in both legs but could walk and was relieved to find I could empty my bladder. We were within 15 miles of a decompression chamber and in the absence of a phone my wife took me there arriving no more than 1.5 hours after surfacing. The symptoms had regressed completely by then but I opted for a full USN table 6 treatment.

I continued to dive cautiously that season. Nineteen dives later, now in 1986, and, ironically, with another diving physician, after a 30 minute dive to 20 m I again developed an itch over my right biceps, an ache in my shoulders, nausea and, within 40 minutes a florid skin rash. I admit denial, as I concluded the rash was not a skin bend (cutaneous DCS is quite common in the UK) but dry suit pinch. However numbness in the right big toe and over the right knee by the next morning resulted in my taking another trip to the recompression facility. By then it was 18 hours after surfacing. Despite recompression using a helium/oxygen mixture on a Comex table the symptoms were unchanged in the chamber and persisted for another 24 hours before disappearing.

Demoralised at being "bends prone" I nevertheless continued to dive but never below 12 m until I volunteered 3 or so years later to have double contrast echocardiography performed by Dr Peter Wilmshurst. I was shown to have a large PFO.

There is no doubt in my mind that the PFO contributed to my episodes of decompression sickness. My feeling was relief when I found I had a PFO. Before this I was bends prone and really did not know what I could do about it. Realising that control of bubble development by following conservative tables, using nitrox mixes and controlling my ascent could avert further problems put me back in control of my diving.

After a friendly colleague lent me a copy of the Canadian (DCIEM) tables I continued to dive, albeit defensively, by avoiding dives near no-stop limits, ascending very slowly, doing routine shallow stops and most recently using nitrox. I have no ambitions to dive deep just to continue to admire and photograph the underwater world.

Since then I have completed over 500 dives in a variety of locations with no symptoms after diving. Before my first episode of DCS I had never been deeper than 32 m and then on only a handful of occasions mostly due to lack of opportunity and the unwillingness to consider decompression. Since my episodes of DCS I have done some deeper dives but again on a very limited number of occasions and these have been excursions to about 35 m and once to 40 m. All these dives ended well inside no-stop times with the main body of the dive being in the 10 m zone and, being from the shore, ascent rates were extremely slow. For many years I have spent something like 3 or 4 minutes on average surfacing from my bottom depth of 22 m (most diving in my part of the world is at that depth) with probably something like a minute spent on the last 6 metres or less. This gives an ascent rate of about 5 to 7 m a minute.

I must say that I never consciously measured my ascent rate but usually with a surface marker buoy it is possible to control it quite well. Certainly I feel the precipitating factor in my first treated episode of DCS was the rapid ascent from 10 m to the surface due to an overinflated dry suit. The second treated episode in May 1986 had no obvious precipitating factor with the dive time being 30 minutes at 20 m and a slowish ascent. The dive was curtailed when my buddy (another SPUMS member !) found his watch had malfunctioned and confused my gauge reading with dive time!

Discussion

I think diving practices have a lot to do with the presentation of diving related diseases. Having had the opportunity to dive in the Caribbean, Turkey and the Red Sea I can compare the experience with UK diving. The outstanding difference is the control divers can exert over ascent rate and dive profile outside the UK. Much diving to any significant depth in Britain is done from boats into blue water (not that it is ever that colour here!) wearing dry suits. Dives always end with a direct ascent to the surface. Ascent rates have improved (slowed) over the years but control of speed can be tricky particularly if divers are inexperienced. In many other countries dive profiles allow a slow ascent along a reef and this I think must be a significant factor.

As far as I am aware little research has been done into the incidence of PFOs in a specific diver population. I have unpublished data relating to a questionnaire answered by 75 of the Cave Diving Group (which is about the percentage of current active members in the UK). Seven have had treatment for DCS and another 26 have had symptoms (half of which were skin or CNS) for which they had had no treatment. 10 members have had double contrast echocardiography. Of those 10 there were 5 positives, one treated for DCS, 4 not treated but suspected to have had it in the past and another 5, who had never had symptoms, who were negative.

My next observation relates to the migrainous aura I experienced. I had several episodes unrelated directly to dives in 1986 and they disappeared until last year when I experienced another cluster which seems to have ceased. A MRI scan was entirely normal and anecdotally this would appear to be a common phenomenon which goes largely unreported. Four of the six in our dive boat last week (Sat 23 or Sun 24 June 2001) admitted to such symptoms and none had consulted a physician!

Which leads me to a comment on the study on subclinical decompression sickness on recreational divers. I agree that the numbers are too small to draw any conclusions. My admission that I have had DCS myself, has allowed individuals to "confess" to more than subclinical symptoms for which they have never been treated because they were transient. The most extreme have involved temporary paralysis. I find this quite worrying and perhaps we need to get the message over that transient symptoms probably do need treatment. I refer back to my findings from the Cave Divers Group study.

It is interesting that the 4% figure quoted for many "inside the tables" decompression incidents is so similar to the figure quoted for the presence of significant PFOs in the general population!

Finally I find myself in something of an ethical dilemma when advising other individuals with PFOs. One of the problems we have as medical advisers is that we do not know how much to trust our patients insight into the potential severity of the problem and so we tend to issue blanket bans.

References

1 Wong R and Wright D. Modes of presentation of patent foramen ovale in ten divers. *SPUMS J* 2001; 31 (2): 62-69

2 Donatsch C. Subclinical decompression illness in recreational scuba divers. *SPUMS J* 2001; 31 (2): 69-74

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Comment on Dr Glanvill's letter by Dr Bob Wong, co-author of *Modes of presentation of foramen ovale in ten divers*, one of the papers referred to in Dr Glanvill's personal history.

I would like to congratulate Dr Glanvill for putting his own case history into print. He had dived without any incidents for 20 years before finding out that he had a large patent foramen ovale (PFO) . This is consistent with some patients we have seen in Fremantle. It is interesting that since he changed his diving technique, he has been incident free.

On ascent after dives (decompression), bubble formation occurs. This is particularly so after deep dives and with repetitive dives and /or fast ascents. Brubakk has shown in experimental studies that the lung is an excellent filter for gas bubbles, and gas will only pass through if the venous gas load is considerable, increasing the pulmonary arterial pressure by 100-150%. If however, there is a PFO, a pressure increase of only 30% will allow bubbles to pass through.[1]

In my opinion 35 to 40 m is *not* a shallow dive. Pilmanis showed in the 1980s that a 2 minute stop at 3 m (10 ft) after a 25 minute dive (no-stop in USN tables) to 30 m (100 ft) produced a dramatic drop, by more than five fold in the first 15 minutes, in bubble numbers when compared with a direct ascent to the surface.[2] He suggested that short safety stops could be beneficial in reducing the occurrence of "silent bubbles" in divers. It has been shown in goat experiments that decompression can be shortened if the 9m and 6m stops were prolonged and the 3 m omitted.[3] Furthermore, Neuman et al have shown that in humans bubble scores can be dramatically decreased by a deeper decompression stop.[4] I feel that a slow rate of ascent together with a deeper decompression stop would reduce the number of silent bubbles.

Cutaneous decompression sickness (DCS) is an uncommon presentation in Western Australia. However, Wilmshurst has "published data which shows that right to left shunts, usually patent foramen ovale, are associated with certain types of decompression sickness, particularly some types of neurological, cutaneous and cardiorespiratory decompression sickness". Of 60 divers with cutaneous DCS studied by his group, 47 (78%) had a shunt.[5]

The DCIEM Air Decompression Tables only allow shorter no-stop times than the BSAC/RNPL tables.

It is interesting that since he has dived to DCIEM Tables, and by avoiding going near no-stop limits and ascending "very slowly" and doing routine stops, he had clocked over 500 dives without an incident. His slow ascent rate will have minimised the number of bubbles generated.[6]

I agree with Dr Glanvill that "transient" symptoms do need treatment, especially the temporary paralysis. A trial of pressure (USN Table 6) does no harm and could "cure" the symptoms of the diver.

The problems of detecting PFO in divers include that sometimes they have no symptoms, or that the symptoms are so minor they tend to dismiss them. Also symptoms may be transient and ignored. Cerebral symptoms could even have been attributed to the "flu" by divers and doctors alike. It is not easy to obtain statistics on divers with PFO, due perhaps to the fact that most medical practitioners would advise such divers not to dive.

References

1 Brubakk AO. Transport of bubbles through a PFO. *Aviat Space Environ Med 2000 Mar ASMA Meeting Abstracts #376*; 71 (3): 353

2 Pilmanis A. Ascent and silent bubbles. In *Proceedings of Biomechanics of Safe Ascents Workshop*. Lang MA and Egstrom G. Eds. Cosa Mesa, California: American Academy of Underwater Sciences 1989; 65-71

3 Hills BA. Limited supersaturation versus phase equilibration in predicting the occurrence of decompression sickness. *Clin Sci* 1970; 28 (Feb): 251-267

4 Neuman TS, Hall DA and Linaweaver PG Jr. Gas phase separation during decompression in man: ultrasonic monitoring. *Undersea Biomed Res* 1976; 3 (2):121-130

5 Wilmshurst P. The relation between decompression sickness and patent foramen ovale. *Aviat Space Environ Med 2000 Mar ASMA Meeting Abstracts #375*; 71 (3): 352

6 Wong RM. Doppler studies on the dive schedules of the pearl divers of Broome. *SPUMS J* 1996; 26 (1) *Pearl Diving Supplement*: 36-42

SPUMS NOTICES

SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY

DIPLOMA OF DIVING AND HYPERBARIC MEDICINE

Requirements for candidates

In order for the Diploma of Diving and Hyperbaric Medicine to be awarded by the society, the candidate must comply with the following conditions:

1 The candidate must be a financial member of the Society.

2 The candidate must supply evidence of satisfactory completion of examined courses in both Basic and Advanced Course in Diving and Hyperbaric Medicine at an approved institution.

3 The candidate must have completed the equivalent (as determined by the Education Officer) of at least six months full time training in an approved Hyperbaric Medicine Unit.

4 The candidate must submit a written research proposal in a standard format for approval by the Education Officer before commencing their research project.

5 The candidate must produce, to the satisfaction of the Education Officer, a written report on the approved research project, in the form of a scientific paper suitable for publication.

Additional information

The candidate must contact the Education Officer to advise of their intended candidacy, seek approval of their courses in Diving and Hyperbaric Medicine and training time in the intended Hyperbaric Medicine Unit, discuss the proposed subject matter of their research proposed, and obtain instructions before submitting any written material or commencing a research project.

All research reports must clearly test a hypothesis. Preference will be given to reports of original basic or clinical research. Case series reports may be acceptable if thoroughly documented, subject to quantitative analysis, and the subject is extensively researched and discussed in detail. Reports of a single case are insufficient. Review articles may be acceptable if the world literature is thoroughly analysed and discussed, and the subject has not recently been similarly reviewed. Previously published material will not be considered.

It is expected that all research will be conducted in accordance with the "Joint NH&MRC/AVCC statement and guidelines on research practice" (available at http://www.health.gov.au/nhmrc/research/nhmrcavc.htm). All research involving humans or animals must be accompanied by documentary evidence of approval by an appropriate research ethics committee. It is expected that research project and the written report will be primarily the work of the candidate.

The Education Officer reserves the right to modify any of these requirements from time to time.

The Education Officer's address is Dr David Doolette, Department of Anaesthesia and Intensive Care, The University of Adelaide, Adelaide, South Australia 5005. Telephone + 61-(0)8-8303-6382. Fax +61-(0)8-8303-3909. E-mail <David.Doolette@adelaide.edu.au>.

Key Words
Qualifications.

MINUTES OF THE ANNUAL GENERAL MEETING 2001 held at Madang Resort Hotel Papua New Guinea on 2001/6/1

Meeting opened at 1800.

Apologies

Drs Douglas Walker and David Doolette.

1 Minutes of the previous meeting.

Moved that the minutes, which have been posted on the notice board, are a true record, proposed Dr John Knight, seconded Dr Guy Williams. Carried

2 Matters arising from the minutes.

None.

3 President's Report 2001 (Dr Robyn Walker).

I would first like to acknowledge the efforts of Guy Williams and Allways Travel for again making this years Annual Scientific Meeting a success. James Francis has excelled with his succinct and informative presentations and I thank him for his contributions. I envisage however, he may not return for a repeat performance unless the meeting is held in a cooler climate.

The past year has been eventful to say the least. Highlights for the Society include the Journal's acceptance by EMBASE, the Excerpta Medica database for indexing. This is an important achievement as many authors are reluctant to publish in an non-indexed journal and it goes a long way to ensuring the continued submission of high quality articles for publication. John Knight and Michael Bennett are to be congratulated for their efforts in achieving this recognition of the Journal by the scientific community.

Michael Bennett has indicated he will step down from the position as Chairman of the Australian and New Zealand Hyperbaric Medicine Group in September and will therefore relinquish his position on the SPUMS Executive Committee. I thank him for his contributions over his term and look forward to welcoming his successor.

The SPUMS diploma has been awarded to 5 candidates (Drs Lalith Ekanayake, Pauline Whyte, David Vote, Mike Bennett and David Williams) since May 2000 with a significant number of others with projects underway. The changes made at last year's Annual General Meeting with respect to the Education Officer and the diploma are working well. However a number of further refinements will be made in the future to ensure a streamlined process.

In September 2000 Dr Peter Dupont resigned as Treasurer of the Society after having held the position for approximately 15 months. It is noted that the audited receipts for the financial years 1998 and 1999 remained outstanding at that time despite the concerted efforts of the other committee members. Due to irregularities in the accounts when received from Dr Dupont, a full review and audit of the accounts was required. Dr Dupont acknowledged he had "borrowed" some money from the SPUMS accounts and made retribution of this money in late 2000. He at that time believed he had repaid the Society in full. After receiving the reports for the years 1998, 1999 and 2000 from our auditor (Mr David Porter) on 25 May 2001 there is a further $1,257.07 owing to the Society. It is my intention to contact Dr Dupont on my return to Australia and request immediate payment of this amount. It is the Committee's expectation that this amount will be repaid in full.

On the advice of our auditor two signatories (either President, Treasurer or Secretary) will now be required for all payments to avoid a repeat of this situation.

Despite this the Society remains in a sound financial state with assets at the end of 2000 of $109,000.00. However, we may envisage increasing Journal costs in coming years with the impending retirement of John Knight as Editor. There are no other foreseen major expenses expected by the Committee. It is therefore recommended the annual membership fees remain at $121.00 for full members and $60.50 for associates. These prices include GST for the Australian membership and a mailing surcharge for the overseas membership.

I would like to thank the efforts of all Committee members over the last 12 months and look forward to a smoother 12 months ahead. We have co-opted Dr Barbara Trytko who has volunteered to take over the role of Treasurer for the next 12 months until the next scheduled election of Office Bearers. Steve Goble, who was appointed as our administrator last year, has provided excellent assistance in managing the membership, our website and projectionist duties at this meeting.

The 2002 ASM will be held at Iririki Island Resort, Vanuatu with dates (barring airline scheduling changes) of 17-24 May. There will be two themes for the meeting with diving/travelling in remote localities being the first and the morbidity and mortality associated with diving equipment being the second. I look forward to seeing you in Vanuatu next year.

Moved from the floor at the end of the President's report by Dr Mike Bennett.

During these unfortunate events it has been your actions which have saved the Society from what could have been a complete disaster and I, as a Committee member, knew some of the details but certainly not all of them. I think it is difficult for people outside the Committee to understand exactly the problems you have had to wade through to solve them and I wish to commend your efforts in public.

Carried by acclamation.

4 Secretary's report (Dr Cathy Meehan).

I would also like to thank our SPUMS Administrator Steve Goble for the smooth running of the administration of SPUMS over the last couple of years. Having Steve around has really made things a lot easier for the Society and the members and also for the committee members. I think that everyone will agree that having Steve at the Annual Scientific Meeting, has really helped with all the audio-visual and the technical parts of the conference. Steve has also taken it into some extra training so that he will be able to manage the SPUMS website. We will be formatting it in a way that is much more user friendly and we hope in the next 12 months to put a lot more information on the website so that it can be accessed by everybody.

At present there are 906 financial members. There are still 179 members from last year that have not yet renewed but Steve is chasing them up. During 2000 we had 103 new members join and so far this year, we have 41 new members join so the Society is not losing members.

5 Treasurer's report (Dr Robyn Walker).

This has been covered by the President's report. The Committee feels that the audited accounts are a true reflection of the state of our Society. The Auditor's report, the balance sheet, bank balances, income and expenditure statement and SPUMS approval of the accounts follow.

Moved that the audited accounts be accepted. Proposed Dr Guy Williams, seconded Dr John Knight. Carried.

6 Subscription fees for the coming year.

It is the Committee's recommendation that they remain the same as this year at $121 for full members and $60.50 for associate members. Proposed by Dr Bob Green, seconded by Dr Barbara Trytko. Carried

7 Committee positions

Two positions on the committee, due to resignations, to be filled. Elections are not due until the next AGM. The Committee has co-opted Dr David Doolette as Education Officer and Dr Barbara Trytko as Treasurer.

8 Appointment of the Auditor.

The President stated that she had a very close relationship with the auditor this year and, as he has intimate knowledge of the Society's financial affairs ,she recommends that he continue to audit our accounts. Moved that Mr David Porter be reappointed auditor, proposed Dr Mike Davis, seconded Dr Barbara Trytko. Carried.

9 Business of which notice has been given.

There was none.

Meeting closed at 1818.

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AUDIT REPORT TO THE MEMBERS OF THE SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY

I have conducted various tests and checks as I believe are necessary considering the size and nature of the Society and having so examined the books and records of The South Pacific Underwater Medicine Society for the year ended 31 December 2000 report that the accompanying Income and Expenditure and Balance Sheet have been properly drawn up from the records of the Society and gives a true and fair view of the financial activities for the year then ended.

Dated 2001/5/25
Level 3, Suite 304
20 Bungan Road, Mona Vale, New South Wales 2103

David S Porter
Chartered Accountant

THE SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY BALANCE SHEET AS AT 31 DECEMBER 2000

	2000	1999
MEMBERS' FUNDS		
Balance at 1 December 2000	85,664	112,957
Surplus/(Deficit) for year	23,544	(27,293)
	$ 109,208	$ 85,664
represented by:		
CURRENT ASSETS		
ANZ Bank 1998 ASM Account	7,402	612
ANZ Access Cheque Account	35,632	3,119
ANZ VZ PLUS	61,585	77,976
Sundry loan	4,141	3,957
GST recoverable	448	-
NET ASSETS	$ 109,208	$ 85,664

These are the accounts referred to in the report of D S Porter, Chartered Accountant, Mona Vale 2103.

Dated 2001/5/25

THE SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY
STATEMENT OF INCOME AND EXPENDITURE FOR THE YEAR ENDED 31 DECEMBER 2000

	2000	**1999**
INCOME		
Subscriptions and Registrations	129,132	138,338
Interest	3,795	3,362
Advertising and Journal sales	491	90
ASM 2001	23,105	-
Sundry Income	-	3
	156,568	141,793
EXPENSES		
ASM costs	37,855	44,116
Bank adjustment	2,183	1,271
Secretarial	11,066	11,468
Stationery and Printing	435	3,220
Journal	34,196	28,432
Postage and Facsimile	1,789	5,896
Conferences and Telephone	6,386	10,450
Computer Equipment	5,677	25,553
Miscellaneous/Subscriptions	1,439	1,818
Bank Charges	4,387	2,610
Audit	1,219	-
ASM deposit	-	4,058
Editor's honorarium	15,857	15,602
Audio-Video Equipment	-	11,305
ASM 2001 costs	7,100	-
Insurance	3,435	3,287
	133,024	169,086
SURPLUS/(DEFICIT) FOR THE YEAR	$ 23,544	$ (27,293)

These are the accounts referred to in the report of D S Porter, Chartered Accountant, Mona Vale, NSW 2103. Dated 2001/5/25.

THE SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY MOVEMENTS ON BANK BALANCES FOR THE YEAR ENDED 31 DECEMBER 2000

		2000	**1999**
OPENING BALANCES			
ANZ bank	1998 ASM account	612	11,984
	Access Cheque account	3,119	25,973
	VZ PLUS	77,976	75,000
	81,707	112,957	
add, **RECEIPTS**	156,568	141,793	
	238,275	254,750	
less, **PAYMENTS**	133,656	173,043	
CLOSING BALANCES			
ANZ bank	1998 ASM account	7,402	612
	Access Cheque account	35,632	3,119
	VZ PLUS	61,585	77,976
		$ 104,619	$ 81,707

NOTE

Receipts and Payments above may include Balance Sheet items which are not included in the Income and Expenditure statement.

SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY
COMMITTEE REPORT
FOR THE YEAR ENDED 31 DECEMBER 2000

The Committee of the Society states that:-

The accounts annexed hereto present fairly the result of the operations of the Society for the financial year ended 31 December 2000 and the state of affairs of the Society as at the end of the financial year ended on 31 December 2000.

The committee has reasonable grounds to believe that the Society will be able to pay its debts as and when they fall due.

There is no body corporate that is a subsidiary of the Society.

The Society is not trustee of any Trust.

SIGNED for and on behalf of the Committee in accordance with a resolution of the Committee made on the 29th day of May 2001.

Robyn Walker, President
Catherine Meehan, Secretary

MINUTES OF THE SPUMS EXECUTIVE COMMITTEE MEETING
MADANG RESORT HOTEL, PAPUA NEW GUINEA

held on 28 May 2001

Opened 1345

Present

Drs R Walker (President), G Williams (Immediate Past-President), C Meehan (Secretary), J Knight (Editor), C Acott, S Mitchell (Committee Members), M Bennett (ANZHMG Representative), S Goble (Administrator).

Apologies

D Doolette (Education Officer), D Walker (Committee Member).

1 Minutes of the previous meeting (Sept 2000)

Moved that the minutes be accepted as a true record. Proposed Dr Knight, seconded Dr Acott, carried.

2 Matters arising from the minutes

2.1 Job description for the Convenor, with the suggested amendments, has been circulated to all the Committee Members. Any member who has not seen the final version should inform the Secretary.

2.2 Update by Administrator, Mr S Goble. The website has been reformatted for easier navigation. SPUMS membership is healthy. There were no outstanding administrative problems.

2.3 The SPUMS medical has been placed on the website. It can be downloaded.

2.4 Insurance for SPUMS equipment. An itemised list of the SPUMS equipment held by Committee Members should be sent to the Administrator. Any items not covered by the Member's own home insurance policy should be identified, so that arrangements can be made to cover them. They may be able to be covered under the ANZCA policy.

2.5 A written update by the Education Officer, Dr D Doolette, was presented.

2.6 Update on the indexing of the South Pacific Underwater Medicine Society Journal given by Dr J Knight.

2.7 SPUMS involvement with an UHMS meeting proposed in Sydney, 2003 or 2004 was discussed.

2.8 Update on statement to be published outlining the minimum age for diving and clarifying SPUMS recommendations. No final decision was made regarding this.

2.9 Dr M Davis will be requested to update us on the NZ Chapter.

2.10 Update from ANZHMG given by Dr Bennett. A formal thanks was given to Dr Bennett for his valuable involvement on the SPUMS committee, as the Chairperson of the ANZHMG. Dr Bennett will stand down from this position at the next HTNA Meeting in September.

2.11 Dr J Knight again informed the committee that he will retire from his position as Editor at the 2002 Annual Scientific Meeting. A successor is needed. Discussions have been entered into with Dr M Davis.

2.12 Next face-to-face meeting will be held in Sydney in November. Although it has been the practice of recent years to hold the committee meeting on the Sunday at completion of the HTNA meeting, the difficulty with travel arrangements has lead to a change of venue for this year.

2.13 The SPUMS oxygen kit will need to be brought back to Australia and may need to be modified.

3 Annual Scientific Meetings

3.1 1999 ASM, Layang Layang.
Final figures for profit and loss were provided.

3.2 2000 ASM, Castaway Island, Fiji.
Final figures for profit and loss were provided.

3.3 2001 ASM, Madang, PNG.
Any profit made will be donated to the local hospital.

3.4 2002 ASM. Iririki Island, Vanuatu has been recommended. The dates have been set for 17-24 May 2002. Dr R Walker is the convener. The topic suggested was Travel Medicine.

3.5 Future ASM.

4 Treasurer's Report

Dr R Walker has temporarily taken over the Treasurer's duties and has fully assessed the financial statements with the accountant. It appears that there may still be some outstanding monies and this will be further investigated. The Committee thanked Dr Robyn Walker for all her hard work in producing a financial report. There are new protocols to be followed in the future handling of the finances. A new treasurer will be co-opted at the AGM. Membership fees for 2002 were discussed.

5 Correspondence

5.1 Letter Dr M Davis

6. Other Business

6.1. There will be a CPI increase to wages.

Closed 1500

2002 ANNUAL SCIENTIFIC MEETING OF SPUMS

to be held at

Iririki Island Resort, Port Vila
Vanuatu

Dates
Friday May 17th to Friday May 24th
(barring airline scheduling changes)

Themes
Diving and travelling in remote localities
Morbidity and mortality associated with diving equipment

The Guest speaker is
Dr Trish Batchelor
National Medical Director
of the **The Travel Doctor**
previously
Travellers' Medical and Vaccination Centre

Members wishing to present papers should contact
CMDR Robyn Walker
Deputy Fleet Medical Officer, Maritime Headquarters
1 Wylde St, Potts Point, New South Wales 2011, Australia
Phone + 61-02-9359-4563. Fax + 61-02-9359-4554
E-mail <Robyn.Walker@defence.gov.au>

The Official Travel Agent is
Allways Dive Expeditions
168 High Street
Ashburton, Victoria 3147, Australia
Tel + 61-(0)3-9885-8863
Toll Free 1800-338-239
Fax + 61-(0)3-9885-1164
E-mail <allwaysdive@atlasmail.com>

Needed

An Editor for the SPUMS Journal.

The term of Dr John Knight as Editor of the South Pacific Underwater Medicine Society Journal expires at the 2002 Annual General Meeting.

He has informed the Committee that he will not be available for reappointment. However he is willing to produce the June 2002 issue of the Journal.

The Journal exists to provide education in underwater and hyperbaric medicine to the membership, which is about one third non-medical associate members. The Journal is the only way we have to make the Annual Scientific Meeting available to the 90% of the membership which cannot attend the meeting.

The Editor is responsible for the production, printing and distribution of the South Pacific Underwater Medicine Society Journal. A part of the production of the Journal is providing an annual update of the cumulative index, published with the December issue each year. Maintaining the index, which is now available on CD with Adobe .pdf documents of all the issue of the Journal from 1971 to December 2000.

The Editor of the South Pacific Underwater Medicine Society Journal is an appointed position and there is an honorarium.

Selected applicants will be invited to submit a proposal to the SPUMS Executive Committee outlining how they intend to deliver the Journal. Remuneration will be dependent upon the level of individual involvement and the level of professional services utilised in the production of the Journal. Recommended reading is The Australian Editing Handbook ($ 44.00).

The Editor has a part to play in running the Society as he (or she) has a place on the Executive Committee. The appointment is for three years.

Members interested in taking the position of Editor should apply in writing to
Dr Cathy Meehan, Secretary of SPUMS
C/o ANZ College of Anaesthetists
630 St Kilda Road
Melbourne, Victoria 3004
Australia
or by e-mail <cmeehan@ozemail.com.au>)
for details of the duties of the Editor. They should nominate their requirements for accepting the position and the date at which they would be able to commence duties.

NOW AVAILABLE

The South Pacific Underwater Medicine Society has produced a CD, readable by at least Windows and Macintosh computers, containing every issue of the Society's Newsletter and Journals as Adobe .pdf documents, from the first issue in May 1971 until and including December 2000. All that is needed to read and print these documents is Adobe Acrobat Reader (version 3 or later) which can be downloaded free from the Adobe web site.

None genuine without this label.

The CD also contains the index for the South Pacific Underwater Medicine Society Journal. This runs from 1971 (Volume 1) to December 2000 (Volume 30 No. 4).

The index is supplied as a downloadable tab-separated document which can be entered into the reader's database. It is supplied in RTF (rich text format) and as Windows 97 DOC and TXT for Windows. Macintosh formats are RTF and Word for Mac 5.1.

The CD is available for $Aust 25 (including GST or overseas mailing charge) from either

The Editor of the South Pacific Underwater Medicine Society Journal or
The Administrator of SPUMS

The address of both is
C/o ANZ College of Anaesthetists
630 St Kilda Road
Melbourne, Victoria 3004
Australia

APOLOGY

The South Pacific Underwater Medicine Society Journal apologies to Dr Carl Edmonds for printing Tables 1 and 2 in Dr Robert Wong's paper ***Abalone diving in Western Australia: diving practices***, pages 131-135 in the September 2001 issue, without any acknowledgment that they were taken from Dr Edmond's book ***The Abalone Diver***.

NOTICE TO AUTHORS

With the recent introduction of new copyright laws and the development of *Mexitext*, a medical electronic database, which is available on line by subscription, there is a need to have formal standard conditions for publication which cover printed and web accessible electronic publication.

In future all authors will have to agree to these conditions, in writing, before their papers can be accepted by the South Pacific Underwater Medicine Society Journal. The conditions cover copyright and royalties and include the statement that the author "will always be acknowledged as the copyright owner of the article".

Although this means more paperwork for the Editor the new agreement has advantages for our authors, giving certainty about their copyright position.

DIVING MEDICAL CENTRE

Scuba diving medical examiner's courses

A course for doctors on diving medicine, sufficient to meet the Queensland Government requirements for recreational scuba diver assessment (AS4005.1), will be held by the Diving Medical Centre

on the Gold Coast
over the Easter Weekend 2002

Previous courses have been endorsed by the RACGP (QA&CE) for 3 Cat A CME Points per hour (total 69)

Phone Brisbane (07)-3376-1056 for further details

Information and application forms for courses can be obtained from
Dr Bob Thomas
Diving Medical Centre
132 Yallambee Road
Jindalee, Queensland 4047
Telephone (07) 3376 1056
Fax (07) 3376 4171

WORLD CONGRESS OF DROWNING, 2002

To be held in Amsterdam
on 26, 27 and 28 June 2002

Breath-hold, scuba and hose diving

Recreational scuba diving is recognised as a safe sporting activity. There are relatively few accidents compared with other sports although, when an accident does occur in the water, it happens in a very unforgiving environment. What might be an insignificant incident at the surface can start a sequence of events that quickly escalates to become life threatening. The environment in which this happens is also the probable reason why up to some 60 per cent of in-water diving fatalities meet their deaths by drowning. Drowning is the *mode* of their deaths, but <u>not</u> the cause. In examining the *causes* of drowning in divers, one must look at the way in which people dive. To reduce the risk of drowning in divers one must address not only their in-water procedures but also basic issues such as fitness, training and equipment.

For this reason the diving community has been invited to participate in the **World Congress of Drowning** to be held in Amsterdam on 26, 27 and 28 June 2002. This conference was initiated by *The Society to Rescue Persons from Drowning* which was founded in the Netherlands in 1767.

Partners in this venture include the International Federation of Red Cross and Red Crescent, ILS (International Life Saving) and DAN.

The aims of the Congress are

to make recommendations on the prevention, rescue and treatment of drowning victims;
to stimulate and facilitate initiatives to further promote the prevention of drowning;
to reduce the number of drowning victims;
to improve the survival rate and outcome of drowning victims.

"**Breath-hold, scuba and hose diving**" (Chairman: David Elliott, UK) is thus just one of around 10 task forces convened to review particular aspects of this vast topic.

Other task forces and Chairpersons include

Epidemiology	Christine Branche, CDC, Atlanta.
Rescue	Chris Brewster, International Life Saving Federation, USA.
Resuscitation	Paul Pepe, Emergency Medicine, University of Texas.
Hospital treatment	Jean Louis Vincent, Erasmus Hospital, Brussels.
Immersion hypothermia	Beat Walpoth, University Hospital, Insel, Switzerland
Brain	David Warner, Duke University Medical Center, USA.

Each task force has an international group of experts in the appropriate specialities.

The diving task force covers the hazards associated with all types of diving. This includes recreational diving of every variety. It also covers subsistence fishermen-divers in the third world, most of whom have inadequate equipment and no proper training and who have an unknown rate of in-water incidents. The other large group is military and working divers who follow procedures that for them should make the risk of drowning negligible.

A number of drowning fatalities in divers occurs among divers who may have made an avoidable error or who may have been subjected to one. After reviewing such accidents the task force has prepared has prepared draft recommendations and reviewed those submitted by others. The following topics are among the questions that they consider deserve discussion at the World Congress.

Should diver certification last a lifetime, or is there a need for re-certification after a few years?

What changes can be recommended in the training of divers and diving instructors that might enhance diving safety?

Should a once-only medical declaration that was made before training potentially last for a lifetime?

Is there a minimum age for diving as one of a buddy-pair?

Should there be a greater emphasis at all levels of recreational diver training on the causation of known in-water fatalities?

Visit the web site (www.drowning.nl) for more details about the Congress, its task forces and the arrangements. Some 60 task force members from 20 nations have prepared formal presentations and reviewed the many recommendations for the Congress. Each task force has a summary of its proposed agenda, each will have a plenary session for all and then a number of sessions on selected diving topics.

Look through the recommendations in the diving section. Because they come from a wide range of sources, some appear worthwhile but others may not be universally acceptable. These will be discussed and, where appropriate, their implementation will be reviewed at the Congress in Amsterdam, 2002.

You can also write for more information to the
World Congress of Diving 2002 Secretariat
c/o Consumer Safety Institute
PO Box 75169, 1070 AD Amsterdam, The Netherlands.
or e-mail <Secretariat@drowning.nl>

Key Words

Breathhold diving, drowning, meeting, occupational diving, recreational diving.

DIVING AND HYPERBARIC MEDICINE INTRODUCTORY COURSE

The Alfred Hospital
Melbourne
April 8th to April 19th 2002

Applications are invited for a two week, full time course aimed at doctors interested in the fields of therapeutic diving and hyperbaric medicine. This includes referring clinicians who wish to gain more knowledge about the field as well as doctors who are involved or may become involved in the operation and supervision of hyperbaric medicine facilities.

The course is jointly presented by
The Australian and New Zealand College of Anaesthetists Special Interest Group in Diving and Hyperbaric Medicine
and
The Australian and New Zealand Hyperbaric Medicine Group

The course has been offered at Prince of Wales Hospital, Sydney in 2000 and 2001. The course faculty includes speakers from most of Australia's major hyperbaric units. Significant practical work is included and attendees are strongly encouraged to experience pressurisation in The Alfred's state of the art rectangular, walk-in chambers. A comprehensive set of course notes will be provided.

Topics to be covered include

Physics and physiology underlying Diving and Hyperbaric Medicine
Decompression illness, gas embolism, gas toxicity
Hyperbaric oxygen mechanisms
Hyperbaric chamber operations and safety
Ventilation and intensive care management under pressure
Application of HBO in "approved indications" such as:
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The Alfred Hyperbaric Service
Phone (03) 9276 2269Fax (03) 9276 3052
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ROYAL ADELAIDE HOSPITAL HYPERBARIC MEDICINE COURSE

Medical Officers Course

July 2002			
Basic	8/7/02	to	12/7/02
Advanced	15/7/02	to	19/7/02
October/November 2002			
Basic	21/10/02	to	25/10/02
Advanced	28/10/02	to	1/11/02

Cost

Basic Diving Medicine Course	**$825.00**
Advanced	**$825.00**

Diving Medical Technicians Course

Cost of three unit course **$Aust 1,375.00**

February 2002			
Unit I	4/2/02	to	8/2/02
Unit II	11/2/02	to	15/2/02
Unit III	19/2/01	to	23/2/01
July 2002			
Unit I	24/6/02	to	28/6/02
Unit II	1/7/02	to	5/7/02
Unit III	8/7/02	to	12/7/02
October 2002			
Unit I	7/10/02	to	11/10/02
Unit II	14/10/02	to	18/10/02
Unit III	21/10/02	to	25/10/02

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Februrary 2002	11/2/02	to	15/2/02
July 2001	1/7/02	to	5/7/02
October 2001	14/10/02	to	18/10/02

Cost **$Aust 550**

All prices include GST

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Royal Adelaide Hospital, North Terrace
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	Overseas	+61-8-8232-4207

BOOK REVIEWS

RECREATIONAL NITROX DIVING

Robert N Rossier.
ISBN No. 0-941332-83-7. 82 pages. Soft cover.
Best Publishing Company, P.O.Box 30100, Flagstaff, Arizona 86003-0100, U.S.A.
Price from the publishers $US 10.50. Postage and packing extra. Credit card orders may be placed by phone on +1-520-527-1055 or faxed to +1-520-526-0370. E-mail <divebooks@bestpub.com>.

When nitrox was introduced to recreational diving in the mid-eighties, reaction varied from derision to open hostility. Fortunately education gradually replaced hysteria and, as the diving public learned more about nitrox, it soon began to understand that it was far less sinister than its detractors had claimed. Legitimacy came with acceptance by the recreational training agencies, all of whom now offer their own nitrox courses.

Recreational Nitrox Diving, one of the Best Publishing Company's Diversification Series, is a book that is aimed at the general diving public. The depth and scope of information is similar to that presented in the basic, nitrox texts provided by the major recreational training agencies. It is an accurate, simple, yet well presented, summary of the topic, designed to cater for the budget end of the market.

The material is expressed in clear language, and would be easily understood by anyone who wishes to understand the concepts of nitrox. Despite its simplicity, the book discusses the appropriate topics in sufficient detail.

Robert Rossier has achieved an appropriate balance between the advantages of nitrox and the added risks associated with its use.

Some proponents of nitrox are guilty of promising too much to its users. It does not eliminate the risk of decompression sickness, especially if the user dives in a provocative manner, or is unusually susceptible. *Recreational Nitrox Diving* clearly states that risks still exist, and correctly urges caution.

The author also makes it clear that the book is not a substitute for formal training in nitrox.

The most critical decision that a nitrox user must make is the maximum oxygen partial pressure ($PP0_2$) to be used in order to minimise risk of CNS oxygen toxicity. Most training agencies advocate a maximum $PP0_2$ of 1.4 atmospheres (bar). *Recreational Nitrox Diving* provides a thorough discussion of the various "industry limits" and recommends 1.3 bar as a maximum safe level, with 1.4 to 1.5 bar to only be used with caution. This more cautious limit is in line with US Navy recommendations.

The issue of oxygen cleaning is not discussed in any detail. The need for cleaning is confirmed but the procedures for cleaning are not mentioned. Nor are the appropriate oxygen compatible lubricants and 0 rings specifically named.

It is generally accepted that if equipment is exposed to oxygen levels of less than 40%, it does not need to be oxygen cleaned, but some would claim that ANY compressed gas (including air) containing oxygen should be oxygen cleaned and serviced. Rossier has settled on the 40% figure, which is in line with what most agencies advocate.

This book falls slightly short of being adequate as a textbook for nitrox training, even though it covers all of the topics required.

I was concerned at its lack of an index, though this was offset somewhat by cross referencing within the text. A useful glossary of terms is provided.

As with most books written in the USA, depths are written in feet, yet surprisingly, pressures are expressed in atmospheres.

I have no hesitation in recommending *Recreational nitrox Diving* to anyone who seeks a concise overview of nitrox. Divers trained in nitrox would find little value in the book, as they would already have been provided with a textbook, which covers all that this book does.

Stan Bugg

Key Words
Book review, mixed gas, nitrox, recreational diving.

THE TECHNICAL GUIDE TO GAS BLENDING

Nicos Raftis.
ISBN 0-941332-84-5. 161 pages. Soft cover.
Best Publishing Company, P.O.Box 30100, Flagstaff, Arizona 86003-0100, U.S.A.
Price from the publishers $US 12.50. Postage and packing extra. Credit card orders may be placed by phone on +1-520-527-1055 or faxed to +1-520-526-0370. E-mail <divebooks@bestpub.com>.

This book, one of the Best Publishing Company's Diversification Series, was nothing like what I expected from the title. I expected it to be a detailed, step by step, account of the procedures involved in gas blending, but it assumes that the reader is already conversant with such processes, and it moves into far more complex areas of the topic.

Nicos Raftis has covered the setting up of a blending station, and has provided detailed analysis of the logistics of running a blending operation for profit, discussing such aspects as plant room layout, time management, maintenance and use of air banks. Choices of various hoses, valves and fittings are analysed, with advantages and disadvantages of each type discussed. The business side of blending is emphasised, with an analysis of costing of actual blending and of on-going maintenance.

Such topics would be of great interest to any dive professional involved in gas blending. Costing is expressed in US dollars, and appropriate conversion would need to be done to equate findings with the reader's situation.

Other topics include methods of nitrox production, system cleanliness, physics of blending, gas analysis and trimix blending.

The author has also sprinkled the text with hints and tricks of the trade to overcome the difference between ideal gas laws and what actually happens when blending is performed.

The book is clearly expressed, and professionally presented. The text is enhanced by graphs, diagrams and tables. I found some of the graphs a little confusing, and had to read the text several times to understand them , but I have to confess that I am no mathematician. It is possible that more knowledgeable readers would find them to be very basic.

This is a very informative book which covers aspects of gas blending that I had not considered before. I learned a lot from reviewing it.

Despite its obvious quality as a book, I cannot see *A Technical Guide to Gas Blending* appealing to anything other than a niche market within the wider diving community. However, it would be a valuable and informative resource for anyone involved in mixed gas production and would be of interest to any diver who was interested in the processes involved in producing nitrox and trimix.

Stan Bugg

Key Words
Book review, mixed gas, nitrox, recreational diving.

Stan Bugg is co-author, with John Lippmann, of the Diving First Aid Manual. He is an instructor for scuba, technical and cave diving and a qualified gas blender.

IN THE WAKE OF GALLEONS

Robert F Marx

ISBN 0-941332-95-0. Hard cover. 418 pages. 174 Black and white illustrations.
Best Publishing Company, P.O.Box 30100, Flagstaff, Arizona 86003-0100, U.S.A.
Price from the publishers $US 21.95. Postage and packing extra. Credit card orders may be placed by phone on +1-520-527-1055 or faxed to +1-520-526-0370. E-mail <divebooks@bestpub.com>.

Robert F Marx is a treasure hunter who has dabbled enough in underwater archaeology to be able to call himself an archaeologist. That may be a harsh assessment but this book makes it quite clear that, most of the time, when there is was a choice between abandoning the search for treasure and re-establishing the grids needed to map a wreck accurately, treasure hunting was the first choice. However he was one of the earlier searchers of the Spanish records of shipwreck and lading of lost vessels and he used this research to find wrecks that yielded considerable gold and silver and artifacts. His recovery methods were often crowbars and hammers but how else does one excavate a wreck covered in coral without using explosives? With sandy bottoms he used less damaging tools, including a device put round the propeller of the diving vessel which directed the flow from the propeller down onto the sand and washed it away.

As mentioned in the review by Richard Moon of Marx's earlier book, *Deep, Deeper, Deepest*, Marx is an entertaining writer who tells a good story. *In the Wake of Galleons* is about finding treasure, with a few mentions of the underwater excavation of Port Royal, the port in Jamaica which disappeared during an earthquake. This was where Marx was mostly archaeologist so was logically left out of the treasure hunting tale.

Marx is a man of many interests having sailed across the Atlantic in the Nina II, a reproduction of Columbus' ship in 1962 as well as having spent a night floating in the lagoon while a boatload of armed treasure hunters searched the island and made off with all that he had found.

His tales of disaster and success are enthralling. Disaster often came from the weather but sometimes it was due to stupidity in taking unnecessary risks when diving. Or, in the final deep diving chapter, stupidity in not listening to the pilot of a submersible telling him how to surface the vessel in an emergency. That lack of attention nearly led to the death of the crew when the new, inexperience pilot collapsed unconscious. In a dramatic description Marx describes his efforts, which were eventually successful to start the ascent. Unfortunately another piece of unnecessary risk taking has been to start the dive in heavy seas, which worsened during the dive, and coming up to the surface as the stern of the mother ship crashed down off a wave and landed on the submersible's escape hatch jamming it and preventing it opening.

The book is made up of 19 chapters, each of which stands alone. The links between the chapters are very thin and so the chronology of Marx's life is almost invisible. But that hardly matters, however it would have been interesting to be able to follow Marx through his career rather than be limited to the excellent snapshots of his treasure hunting. Talking of snapshots, Best Publishing Company's graphic designer and printers have let the book down as far too many illustrations are of poor quality. Of course this may be due to the poor quality of the originals but in that case the illustrations should have either been omitted or modified in Photoshop, a program which can achieve "miracles" when used to improve scans.

I strongly recommend this book to those who interested in diving and risk taking and the finding of treasure. Cautious divers will agree that Robert F Marx kept his guardian angel working hard over many years.

John Knight

Key Words

Book review, diving operations, general, history, recreational diving, salvage, submarine.

THE AUSTRALIAN EDITING HANDBOOK

Elizabeth Flann and Beryl Hill.
ISBN 1 86335 040 3. 2001.
Common Ground Publishing.
<www.BooksOnWriting.com>
RPP $Aust 44.00.

Why review an editing manual in a medical journal?

Many doctors write with a view to publication and usually they start off knowing nothing of how to set out their paper, at least that is what I did over thirty years ago. Of course the most important thing about writing anything is to get the message across undistorted. Showing the manuscript to someone else is a first step to checking that the message comes across. But unless one is writing for a restricted audience, say of cardiologists, it is worth showing the manuscript to someone without a medical background to make sure that it is intelligible to the majority of doctors. This is especially necessary if the paper is destined for, say, the SPUMS Journal which has a readership of approximately 30% non-medical people.

In some Journals there appear footnotes saying "Received on date 1 Accepted on date 2" and the publication date is often months later. Not all the delay is due to laggardly peer reviewers. Much of it is caused because the paper has to be sent back to the author for rewriting to fit in with the peer reviewers suggestions, which often comment adversely on less than lucid writing. It has been my experience that many people have difficulty in coming to terms with rewriting their heart-throb, and put the Editor's letter and the returned manuscript in the too hard basket. In the interests of getting the Journal out fairly close to time I have often undertaken the rewriting. I have however always sent a copy of the revised paper to the author for his or her approval. If they do not reply within a fortnight I usually assume that they have no serious objections to my work.

It is in everyone's interest for authors wishing to be published in a journal to study that journal thoroughly to see if it has a "house style" in its English, some do and the paper there will be edited into the house style. References are a problem. There are many different standard layouts. In medical publishing the Vancouver style, now over 20 years old, and used by the Lancet, the British Medical Journal, the South Pacific Underwater Medicine Society Journal and many others, requires superscript numbers, in numerical sequence and the references at the end of the paper are in numerical order. Other methods, putting reference numbers in brackets but in no specific order (it does happen!) and putting (Jones et al. 1990 a) in sentences make reading of the text much more difficult and do not make finding the references any easier than the Vancouver system. It pays to read the instructions to authors before sending off the references as most Journals refuse to accept papers with the references in the wrong style.

The Australian Editing Handbook opens with three pages of publishing terms. Did you know that the columns of the SPUMS Journal are justified? Then it leads its readers through 15 pages of *Introduction to the publishing process* then 10 pages of *Where to start*. This is about editing but it applies to authors too, who need to be organised to produce good work. Reading *The editor's role* and *Things to mark up* in 1979, unfortunately long before the first edition, would have saved me many hours of wondering how to convey my meaning to typists and printers.

This short review does not do justice to the fund of knowledge packed between its covers. Certainly it is designed for editors, but authors can benefit by knowing the ground rules and writing in easily understood, unambiguous and clearly expressed English.

One very good reason for an author to read this book is to discover the meanings of all the various signs and symbols used in editing on paper. It is very frustrating to be sent back a text covered in squiggles which convey very little and have to redo the text to conform to the changes requested. After all authors are sent their manuscripts to proof read and make the necessary corrections. It is useful to be able to use the publishing trade's "lingua franca"
. Just changes in the manuscript can lead to unnecessary work by the publisher if these changes alter the formatting or the house style.

John Knight

Key Words

Book review, general interest.

SPUMS ANNUAL SCIENTIFIC MEETING 2000

LIVING ON COMPRESSED AIR. A CASE STUDY

Michael Logan

Key Words

Air, case report, general interest, medical conditions and problems, ventilators.

Introduction

We have been discussing fitness to dive. This patient, though in no way fit to dive, lives because of compressed air. I would like to tell you the story of a boy, born in 1972. I will call him AB. He has been on a ventilator for seventeen years and I have been involved with his care since his admission to hospital in 1984 when he was 12 years old.

Case report

AB developed Congenital Myasthenia Gravis as a baby and recovered fully. Unfortunately he developed a polyneuritis at the age of ten. This progressively destroyed his spinal cord to C2 and virtually destroyed his optic nerves. He can only move his head side to side on the pillow. His intelligence is unimpaired.

AB was admitted to the Base Hospital in February 1984 , virtually blind and with sensory and motor loss below C2. He has lived in the hospital for 17 years on constant ventilator support, a wonderful tribute to constant 24 hour nursing care.

Every day he has needed to be ventilated, given food and drink, his bladder and bowels emptied, his skin and his hygiene cared for and his medical care carried out. Of course there are problems from time to time.

VENTILATION

We started with 6 mm uncuffed tracheostomy tube and, by trial and error, found the right settings for the ventilator. We have used many ventilators both pneumatic and electric. These are run off wall outlets. When he is in a wheel chair we originally used a Campbell pneumatic ventilator with the gas cylinder mounted under the chair. Now he has an electric ventilator operated by battery or 240 volt AC.

FOOD AND DRINK

Initially AB was tube fed, then a gastrostomy feeding tube was used. This was removed when he was able to swallow without difficulty. His diet varies with his appetite and desires so it is unpredictable

BLADDER AND BOWELS

At first we used Penrose tubing but this led to retention and hydronephrosis (Figure 1). An indwelling catheter caused a stricture. His bowels move with regular suppositories.

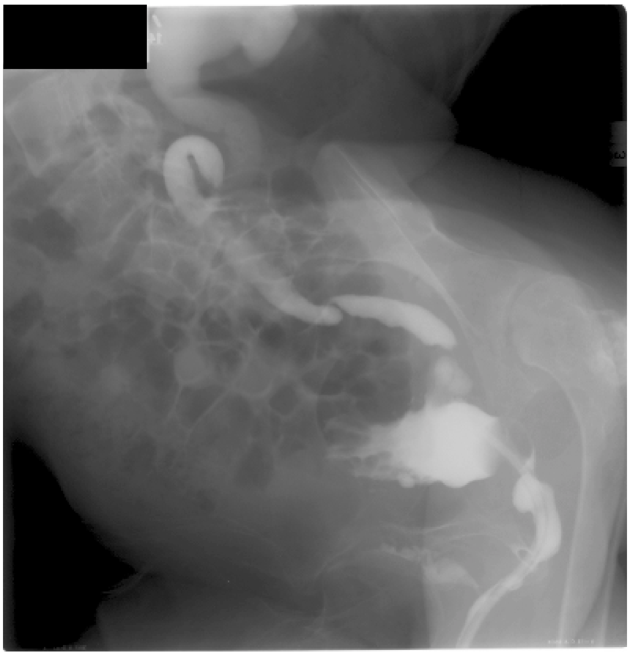


Figure 1. Pyelogram showing hydronephrosis at top, dilated ureter and gas in intestine.

SKIN CARE

For 17 years he has had daily bathing and rubbing of pressure spots when being turned every two hours. In spite of these precautions he has had one bad pressure sore which required a musculo-cutaneous rotation flap.

His stoma and catheter have been recurrently infected. Treatment has been mostly topical and granulations have been treated with copper sulphate.

MEDICAL CARE

Infections have been treated as necessary. His ventilation supported adequately.

He has learnt to time his speech to fit the expiratory stage of the ventilator. We have provided psychological support and made sure that he obtained an education.

COMPLICATIONS

AB has had occasional complications with ventilation, infections and pressure areas as mentioned above.

Because he has lost the power to move, his bones have become osteoporotic and very fragile. Fractures cause him no pain. Figures 2 and 3 show fractures in femur and humerus which occurred while lifting him into and out of his bath.

Some fibres of his right phrenic nerve have been spared so that he can make a small inspiratory effort and is able to breathe spontaneously for about ten minutes with great difficulty but then he is exhausted. This spontaneous inspiratory effort has caused his right lung to increase in size at the expense of his left lung and has caused his spine to develop severe scoliosis as is demonstrated by serial X-rays (Figures 4-6).

AUTONOMIC RESPONSES

These have been unpredictable. Six or seven episodes of bradycardia and hypotension occurred approximately ten years after admission and on one occasion, during an anaesthetic for removal of tracheal stoma polyps, he had a cardiac arrest. He has recovered from these episodes without harm and has had none for the last five years.

MENTAL STRESSES

He has been in his present condition since he was nine years old. He has had to pass through puberty and adolescence, with its problems, blind and helpless. For some years in his teens he was a most difficult patient with vicious spiteful remarks to his carers that was his only outlet for his anger and frustration. This caused a fairly rapid turnover of carers but a solid core have stuck by him through it all.

He has now passed that phase and has "grown up" and is now a most cheerful and interesting young man.

When I asked him recently how he managed day by day he surprised me with his reply that "He had lost the sense of time" so that he never felt that the day, week or month was going slowly and that "he enjoyed his own company" and that "he always had a lot of thing to rehash and sort out" and "he was never bored". (I am impressed that this psyche defence mechanism has made his life so apparently enjoyable when it appears from outside that it would seem to be so easy to be depressed and morbid.)

GROWING UP IN HOSPITAL

His teenage years were difficult. He insisted on total immersion baptism when he found religion. Having a

Figure 2. Fracture of lower end of femur showing muscular wasting and osteoporotic bone.

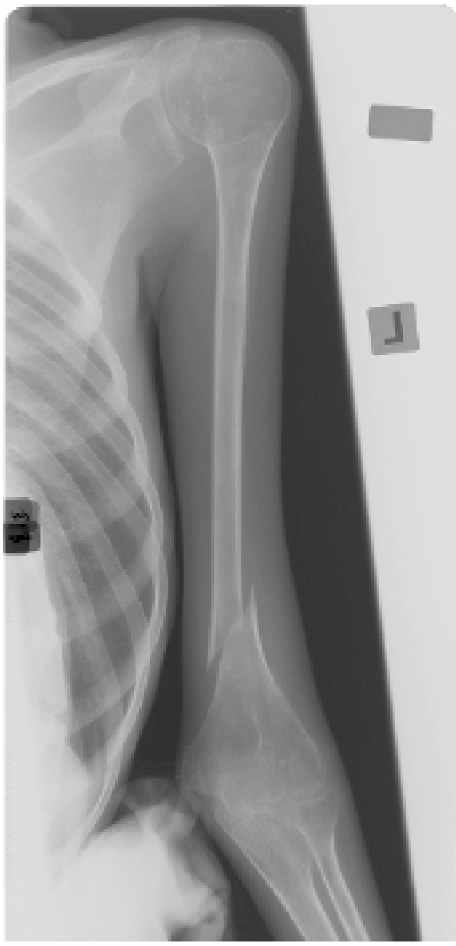


Figure 3. Fracture of lower end of left humerus showing osteoporotic bones.

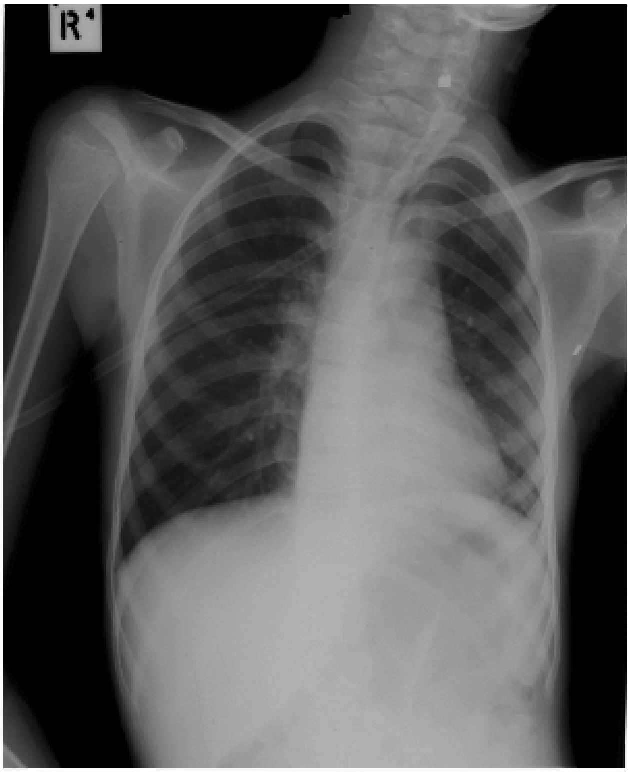


Figure 4. An early X-ray of AB’s chest. The endotracheal tube can be detected running down the neck across the mediastinum and into the right lung field.

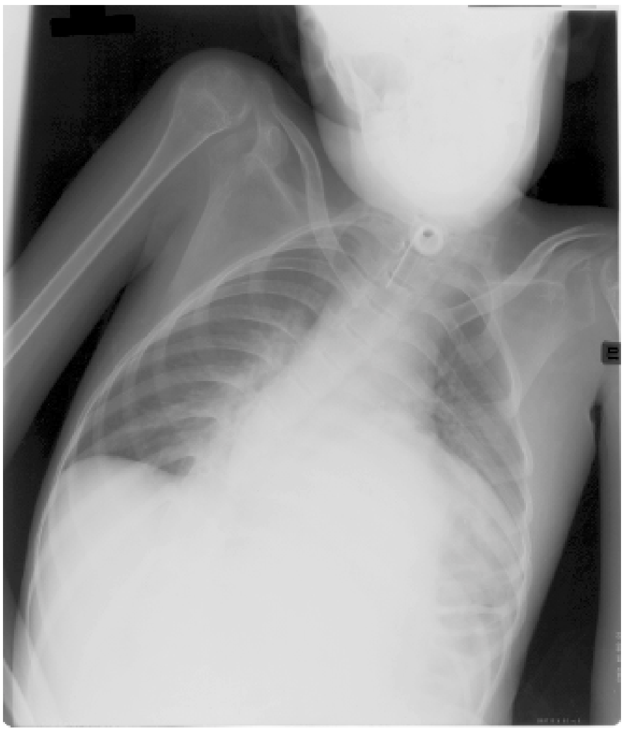


Figure 5. Later X-ray showing shortening of the ribcage and the presence of a tracheostomy tube.

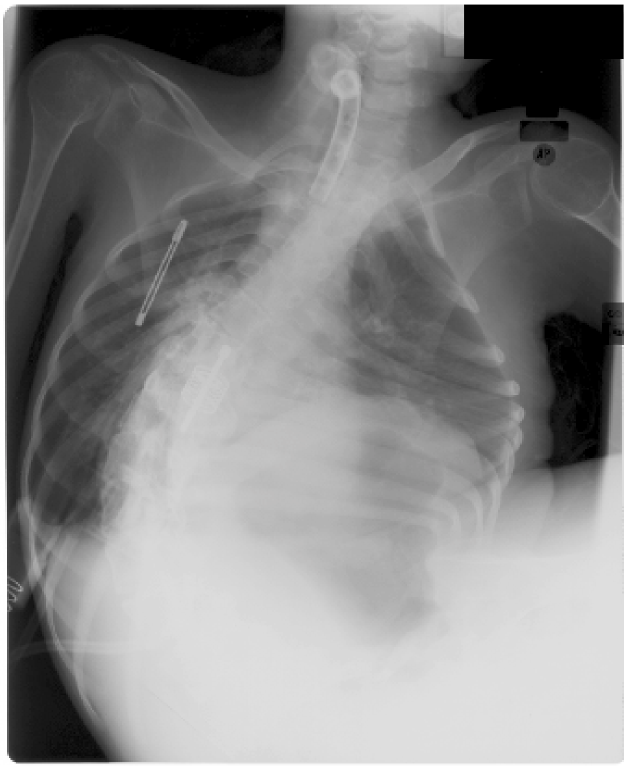


Figure 6. Later X-ray showing tracheostomy tube and extreme scoliosis.

computer opened a new world, even though someone else has to work the keyboard and read the screen to him.

ACTIVITIES

His days are filled with using his computer, “reading” (listening to) books, visits from and conversations with friends and making plans for the future.

THE FUTURE

His desire is to escape from the hospital and have a “home” with some independence. In February 2001 AB moved from the Base Hospital into a house with two other severely handicapped people. He is now (June 2001) much happier. All is well at his new home. Last week he had to have a suprapubic drain put into his bladder because of continuing catheter problems but everything else is going well.

Conclusions

AB’s survival is a tribute to the excellent care and devotion lavished on him by the nurses who have cared for him. They have been with him 24 hours a day for 17 years. I salute them all for their dedication above and beyond the call of duty.

When scuba diving we submit ourselves to depending on compressed gas. In return we enter a marvellous world of colour and movement.

In the 18 years that I have been a member of the South Pacific Underwater Medicine Society the thrust of the Society has been safety in sports diving.

I encourage the members to continue to try to make exposure to compressed air as safe as possible. Individually we should be careful to prevent injury to ourselves and others.

Dr Michael Logan, FANZCA, is now a retired anaesthetist. His address is 13 Dalton Street, Dubbo, New South Wales 2830, Australia. Phone +61-(0)2-6882-2362. Fax +61-(0)2-6884-7497.
E-mail <MikeLog@bigpond.com>.

SPUMS ANNUAL SCIENTIFIC MEETING 2001

THE HISTORY AND DEVELOPMENT OF THE SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY JOURNAL

John Knight

Key Words
General, history, underwater medicine.

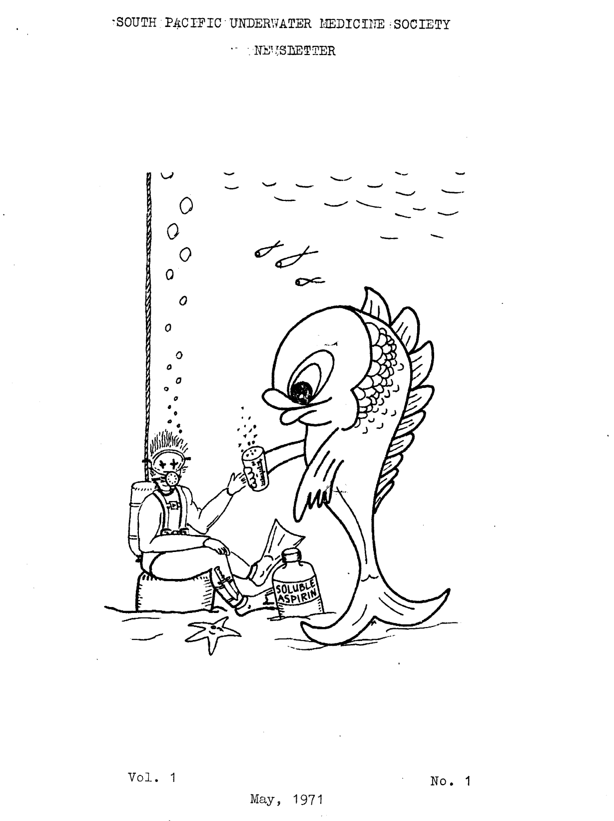
Introduction

This paper presents the history of the South Pacific Underwater Medicine Society Journal from 1971 to 2001, covering not so much the content of the publication as the processes by which the Journals have been produced and the behind-the-scenes work of those involved in the production of the 31 volumes published so far. A great deal of work is involved in transforming papers written by doctors from their original form to a final format, understandable by non-medical associate members. This is then printed in the Journal and posted to members around the world. The major reason for presenting this paper is to find someone to replace me as Editor at the 2002 Annual General Meeting (AGM) when I will not
be available for appointment.

For the past six years SPUMS has paid the Editor a honorarium and in return has required the Editor's attendance at the Annual Scientific Meeting (ASM). The Editor negotiates annually with Committee the amount of the honorarium.

The early years

The South Pacific Underwater Medicine Society (SPUMS) was founded on Monday, March 3rd 1971, in the Wardroom at HMAS PENGUIN. The foundation members were Carl Edmonds, the first President of SPUMS, Bob Thomas, who succeeded Carl as Editor of the Newsletter in 1973, Douglas Walker who was Editor from 1974 to 1990, Ian Unsworth and Cedric Deal. The first issue of the "South Pacific Underwater Medicine Society Newsletter" appeared in May 1971, so within three months of the foundation of the Society educational material was on its way to the members. This emphasis on membership education through the Journal has continued without a break. The first Newsletter was produced using a Roneo machine, probably the one at the Royal Australian Navy Diving School at HMAS PENGUIN. The cartoon on the cover started a tradition which carried on for seventeen years until untimely death of the Resident Cartoonist, Peter Harrigan. Each cartoon dealt with some aspect of underwater medicine, physiology or safety.



As early as 1972 the Society was concentrating on medical standards for divers, an issue that still appears at every scientific meeting of the Society. The newsletter was again Roneoed. This meant that the Editor only had to choose what to put in, write quite a lot of it, and then have a typist cut the stencils. As the Acronym became better known the name was changed to "SPUMS Newsletter" on Volume 2 No 4.

By March 1974 (Volume 4 No 1) the Newsletter had developed into a booklet of 16 A4 pages, printed on both sides. This issue contained the first photograph to appear in a SPUMS publication, the first of my papers to appear in the Journal and the Sub-Committee Report on the Diploma of Diving and Hyperbaric Medicine.

Pure economics drove Volume 4 No 2 back to the previous single page format but with a slide-on binder. It contained a 6 page article on Medical Standards, written by Carl Edmonds, which eventually led to the medicals in current Australian Standards. This form of binding continued until 1979. However the contents were printed typescript rather than being Roneoed.

With the July-September issue in 1976 the Newsletter transformed in the Journal/Newsletter.

The middle years

In 1979, when the Journal/Newlетter was regularly appearing well behind schedule, I took over the job of assembling the Journal for publication and assumed the title of Assistant Editor.

Preparing articles for printing had changed from 1952 and 1953 when, as a medical student, I was involved in producing the St Bartholomew's Hospital Journal. In those days the typewritten texts were sent to the printer who set the type andreturned galley proofs for correcting. By 1979 short runs of printing, like the Journal, was all done from photographic plates, which were made by photographing camera-ready copy.

Camera-ready copy must be as near perfect as possible. It is the intended pages, including their numbers, without errors. For folded publications like the Journal the printer sets up, on double sized paper, the pairs of pages which will appear on the folded sheet. This is not as easy as it sounds as pages 1 and 60 are printed side by side, and on the back of that sheet are pages 2 and 59. This sequence works its way to the middle sheet. It is a job that I always left to the printer, who usually made up a set of smaller folded pages and numbered them to make sure that he got the large sheets in the right order.

To achieve camera-ready copy in pre-computer days someone had to type all the texts selected by the Editor,

SPUMS

SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY

NEWSLETTER

Vol. 4, No. 1, MARCH 1974

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SPUMS JOURNAL

South Pacific Underwater Medicine Society

OCTOBER TO DECEMBER 1979

OFFICE BEARERS

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continued on page 28

Registered for posting as a publication (Category B). Printed by: Universal Copy Service 140 William Street, Melbourne 3000

Douglas Walker, onto A4 paper with wide margins. Each article started on a new piece of paper. When all pieces were typed the fun or, more properly, the cutting and pasting, started, getting text and illustrations to fit the space available. It needed all of the dining table, scissors and non-wrinkling paste. The most useful gadget was an Adgauge, a large transparent set-square engraved with a multitude of parallel lines. Besides being essential for getting the lines of type positioned exactly horizontally on the A3 sheets it was useful for working out how much an illustration had to be reduced to suit the column width. The sheets had to have their margins trimmed so that the text was about 12 cm wide. Two of these pieces fitted nicely across width of a numbered A3 page, giving two columns of text. Each column was longer than could be typed onto an A 4 page so more cutting and pasting was needed to fill the page properly.

At this stage proof reading had to be done. This was time consuming as every typo (typographical error) had to detecteded and then be corrected by getting the typist to retype the entire line on a new piece of paper which was then cut out and pasted over the faulty line. The typing was contracted out. A steady hand was needed for the scissors and for positioning!

With all that done the A3 sheets were then taken to the printer who reduced the A3 pages to A4 size when making the photographic printing plates.

By 1979 SPUMS had developed its logo so I used that to rename the Journal/Newsletter the SPUMS Journal for my first issue, Volume 9 No 3. This was a left side stapled, 2 columns to the page production printed on both sides. Since then all Journals have been folded, except for the 1981 supplement, which reported the joint SPUMS and Republic of Singapore Navy Meeting in Singapore in I980. This ran to 80 pages, which was too thick for that format.

Technology has made cutting and pasting and the correction of text much easier, as it can all be done on a computer without any scissors or paste. With the right programs and a little experience computers are just wonderful !

Modern times

In 1987 the Assistant Editor bought a Macintosh SE, his second computer and the first with an built-in hard drive, with the then enormous capacity of 20 MB. This allowed the use of the then new program “PageMaker”, which electronically cut and pasted electronic documents. This advanced technology cut the time for assembling the Journal to send to the printer from about 30 hours with cutting and pasting to about 20 hours for the first, learning curve affected, effort with PageMaker.

Volume 17 No 2 was the first SPUMS Journal to be desk top published (produced by a computer on the Editor’s desk). As the editorial printer was a dot matrix machine I had to take the Journal, in PageMaker format (it fitted on the new larger 800 kbyte floppy discs with space to spare) to a Macintosh bureau with a laser printer to print out what I was to take to the printer.

In those days, before the appearance of MacLink and its translators, the typist needed to have a compatible computer to produce the text. So she (all our typists, except occasionally the Assistant Editor or later the Editor, have been female) was given the old, hard-diskless Mac 512 (the size of its built in RAM). This was not such a problem as modern computer users might think, as in those far off days the Microsoft Word program fitted onto one of the 400 kbyte floppy discs of the time and still left room for the text to be saved onto that disc! An external disc drive allowed for another 400 kbytes, giving plenty of space to save all the text for an issue.

Although physical cutting and pasting of text had been abolished diagrams and photographs still had to be pasted onto the final PageMaker pages before they went to the printer.

One trouble with using a computer to assemble a publication is that an editor is tempted to alter things on the screen and medical editors are seldom fast or accurate touch typists, so the final product often developed typos. Whatever method of producing text one uses everything must be proof read three or four times before printing and even then things can go wrong.

Before using PageMaker, making alterations to the layout was very time consuming and often frustrating. With PageMaker alterations are pretty easy but again consume time. However it is fun and occasionally second thoughts are actually better!

Over the years programs have appeared to enable text written on a Windows machine to be translated for other operating systems. So the Society has not had to provide the typist with a Mac for some years.

During these years a start was made on indexing all the past Journals and allocating key words to each paper. This was a long drawn out process, mostly done by highly educated typists who referred any problems to me for decisions. It was only once the main index had been completed that the Editor started producing an annual index sent out with the December Journal. The main index, electronically updated every year, now covers the entire span from 1971 to 2000.

The present

In August 1996 the Society purchased for the Editor a PowerMac, a scanner and Photoshop, an image manipulating program. The days of pasting were finally over as illustrations could be scanned and adjusted electronically and when acceptable put into PageMaker. This machine is still in use 5 years later which is almost a record for commercial computer longevity.

In 1999 Adobe Acrobat was added to the Journal's armamentarium and various documents were made available to the SPUMS Web Page.

In 2001 the Journal goes to the printer on disc, an Iomega Zip drive of 100 MB as the Journal can be up to 9 MB, ready for printing out so that the A4 pages are arranged in the right order so that when printed on A 3 paper and folded the page numbers will run consecutively. Unfortunately I still have to take the disc personally to the printer as sending the Journal as a PageMaker file over the internet would take hours. Actually hand delivery also makes sure that the file does not get corrupted on the way. and allows me to remind the printer's computer person to remember to set the printer at 75 lines per inch and 600 dpi to get the best results for making the plates.

In late 2000 the Journal was accepted by Elsevier Science, which based in The Netherlands, for indexing in EMBASE, their medical database, from January 1st 2001. EMBASE can be accessed over the internet at <www.embase.com>.

Later 2000 the Journal joined the Copyright Agency Ltd, the Australian National Library and RMIT University, in Melbourne, in the Meditext Project, along with many other medical journals. RMIT Publishing will produce an electronic, searchable, downloadable database, accessed through the internet. It will include all papers, as separated indexed items, from all the Medical Journals arriving in the National Library. Journals are usually supplied because all items published in Australia must be supplied to the National Library. This database will electronically record all downloadings and this will allow royalties to be collected on the journals' behalf. The arrangement with the publishers is that most of the royalties will be used to keep the journals afloat but, after a threshold half the royalties must be paid to the author within 60 days. Unfortunately this means that there is more paperwork to complete before a paper can be published in the Journal.

There have also been some changes to copyright laws which make it necessary for a contract to be entered into between the Journal and authors so that their rights to copyright royalties can be preserved.

A project completed in 2001 was to have all the issues of the Journal, in its various incarnations, available on disc as Adobe .pdf, which stands for portable document format, documents which can be read by any computer using Acrobat Reader. The CD ROM disc also has on it the 1971-2000 index as a tab-separated document, and this can be downloaded into your data management program. Write in for your copy and browse the back numbers.

As Assistant Editor and Editor, I have been a Jack of All Trades, selecting what is to go in the Journal, writing items, chasing up authors, getting the tape recordings of the ASM typed up, as not all authors provide the text and illustrations of their papers, correcting the typescripts of these rescued papers and converting papers from medical jargon into intelligible English, among many other things. Translation is often necessary because about a third of the SPUMS membership is made up of Associate Members, who like to understand what they are reading.

To help everyone to understand the abbreviations used by various authors the Editor has to make sure that they are all spelt out in full the first time they are used with the acronym appearing in brackets after the full name. This is written in the instructions to authors inside the back cover of every Journal but few authors actually follow all the instructions.

When the text has been corrected and rewritten it is printed off and sent, with printouts of the illustrations, back to the author for review. Sometimes I send the text as an e-mail attachment in Adobe .pdf which can be read by any computer using Adobe Acrobat Reader. As always there are unexpected complications, for instance David Elliott found that his not very new printer was unable to print the .pdf file out for him to correct!

Most authors send the corrected text back in a reasonable time frame with their corrections added in longhand. It is then that I wish I had become a pharmacist, with vast training in deciphering medical hand writing! Some authors return the text, so eventually I presume that they are happy to have it printed as it is.

E-mail has made this simple life rather more complicated. It is now so easy to attach a document to an e-mail that authors send me the whole of the text with their changes embedded in it. This actually does not save me time as I then have to reformat the whole thing to SPUMS J house style all over again! I like getting Mike Bennett's corrections as he types them in CAPITALS into the electronic text so that I can find them and use them easily.

Once the printed text and illustrations have been approved by the author and corrected it only has to be reprinted and sent to the Proof Reader, either John Couper-Smartt in Adelaide or David Davies in Perth, whose job is to find the typos, grammatical errors, missing punctuation marks, missing words etc. that the author and I have failed to notice. Like me, they both find spotting mistakes on paper easier than on a computer screen.

At this stage the article is ready for desk top publishing (DTP). This is the process whereby anyone can sit down at a computer and, using clever programs like PageMaker, can turn out beautiful pages full of text and appropriate illustrations. As each "story" has to be placed by a human, things do not always turn out perfectly at first try. Then it is a struggle with the arrangement of the text or with a computer which will not do what I want so that the

HOW THE JOURNAL IS PRODUCED

INPUT TO THE JOURNAL

Unsolicited input
Papers
Letters
sent to the Editor

Committee generated input
Committee minutes
AGM minutes
Annual reports
Financial statements

Member generated input
Diploma theses
Diving Doctor's Diary
The World as it is
AGM papers

EDITOR
(Definition One)
supervises or directs the preparation of a newspaper, magazine etc.

EDITOR **SOLICITS**
Papers
Books for review
Permission to reprint
Course dates etc.

EDITOR **NEEDS**
Peer reviewers
Book reviewers
Proof readers

EDITOR **MAY EMPLOY**
Editors
(Definition Two) to collect, prepare and arrange materials for publication
(Definition Three) to revise and correct
Desk top publisher
Indexer

EDITOR
or team
produces
Quarterly Journal and
Annual update of Index.

PRINT READY JOURNAL
sent to printer

PRINTER
sends printed Journals to Mailing House

MAILING HOUSE
posts Journals to members

EDITOR
or nominee
maintains
Journal Archives and electronic Index

final result looks good and is easy to read. When all is in place in PageMaker the result is printed off and proof read again. It is amazing how many corrections have to be made. In the June 2001 Journal there were only 20 out of 60 pages which did not need attention after the first proof reading, this in spite of Editor, Author and Proof Reader having done their jobs. When those had been dealt with, during proof reading next day, four pages were still found which needed changing. In three this was to kill off either a widow or an orphan, the single line of a paragraph at the bottom or top of a page. The fourth contained a paragraph which was not in italics when it should have been.

I wonder how many of our readers spotted that every page, except the covers, of the June 2001 Journal was headed September 2001? Neither the printernor I did before printing. It was noticed only after the Journals had been posted! Mr Murphy is everywhere.

The future

The Editor has overall responsibility for producing the South Pacific Underwater Medicine Society Journal. I covered all the jobs myself, except for typing, even transcribing tapes when no one else could understand a Singaporean English accent (It helped that I knew the speaker).

I will not be available for appointment as Editor at the 2002 AGM. Over the last 8 years I have only been able to spend so much time with the Journal because I have retired from medical practice.

The Editor must be a full member as he or she has a place on the Committee.

Besides producing the Journal the Editor is also the custodian of all the previous Journals. History is important and archives must be kept and be available. On my shelves are three copies of every issue of the Journal, of the Constitution and of the SPUMS Diving Medical, almost certainly the only complete collection of SPUMS publications. The Journals (1971-2000) and the 1971 to 2000 index are now on CD ROM, so the next Editor has the choice of keeping records as paper or as a CD.

The Macquarie Dictionary gives many meaning for “edit”. The first three, slightly abridged, are

1 to supervise or direct the preparation of a newspaper, magazine etc.

2. to collect, prepare and arrange materials for publication.

3 to revise and correct.

So the Journal Editor can be a supervisor or director while others collect, prepare and arrange materials for publication and revise and correct. There are many self-employed people, known as freelance editors, who carry out these functions. They have the skills to transform colloquial conversation into readable English and to carry out all the routine work of preparing a Journal, including the production of text and illustrations. There are also freelance indexers and people who produce magazines or journals on computer from text supplied by editors, with the output being printed by a printing house, using programs like PageMaker and Quark Express.

Page 219 shows, very much in outline, how the Journal is produced. The Editor sits at the centre of a web with various items coming to him or her. These incoming items are redirected to others with the relevant skills, leading eventually to the production of an electronic version to make the hard copy for the printing plates. Already there is the technology available to make printing plates without hard copy first. Then it is over to the printer and to the mailing house which sends the Journals to the members.

Desk top publishing of a magazine like the SPUMS Journal is not difficult for someone,with a few computer skills, to learn. There is lot to be said for a medical person to do the final assembly of the Journal as I often have to remove a few words, without changing the meaning, to fit a sentence on a page properly. Usually this can be achieved by changing inter-paragraph spacing but the results are not always visually pleasing. A good layout helps readers follow the text and whoever succeeds me will, I hope, always remember that the Journal is educational and should be both interesting and easy to read.

The new Editor will want to change things and there are many things that probably need altering. After all I have moulded the SPUMS Journal and then the South Pacific Underwater Medicine Society Journal for nearly 21 years and it is now the literary equivalent of a tram, decorated in just three type faces, Times, Zapf Chancery and, for the title on the front cover, Book Antiqua Bold Italic, running in predestined grooves, and usually arriving on, or close to, time.

Dr John Knight FANZCA, Dip DHM, who joined SPUMS in 1972, has been a Committee member, Secretary and President of SPUMS as well as Assistant Editor and, since 1990, Editor of the SPUMS Journal. He has been either elected or co-opted to the Committee continuously since 1975. His address is Editor SPUMS Journal, C/o Australian and New Zealand College of Anaesthetists, 630 St Kilda Road, Melbourne, Victoria 3004, Australia. Telephone +61- (0)3-9819-4898. Fax +61-(0)3-9819-5298. E-mail <spumsj@labyrinth.com.au>.

The above is an expanded version of a presentation at the 2001 Annual Scientific Meeting entitled SPUMS Journal Editorial.

PULMONARY FITNESS TO DIVE

James Francis

Key Words

Asthma, diving medicals, fitness to dive, medical conditions, pulmonary barotrauma.

Abstract

Determining pulmonary fitness to dive is not a scientific process. While it may be possible to make an informed judgment on the likely effect of diving on pre-existing disease, predicting the risk of diving diseases caused by pre-existing disease is not yet possible with confidence. This is because our understanding of the pathogenesis of the major diving diseases, decompression illness (DCI) and pulmonary barotrauma (PBT), is incomplete. The situation is made more difficult because even measurement of the principle function of the lung and circulation, aerobic capacity, is poorly standardised outside physiology laboratories and there is no agreed aerobic standard for diving. The determination of pulmonary fitness to dive therefore relies upon the physician being able to make a reasonable assessment of the physical fitness of the candidate and be aware of what is known about the causes of PBT and DCI. From this baseline a judgment can be made. The conditions that should preclude diving include: those with intrinsic or poorly controlled asthma or asthmatics with a reduced peak flow; recent spontaneous pneumothorax; bullous disease detected on chest X-ray and significant lung parenchymal or pleural scarring.

Introduction

Determining fitness to dive, like much of medicine, is not a precise science. While we can make a fairly educated judgment on the likely effect of diving on some pre-existing conditions, we are a long way from being able to do the reverse with any degree of confidence. Not only is our knowledge of the pathophysiology of the diving disorders incomplete, but our understanding of the risk factors for important diving-related disease, such as pulmonary barotrauma and decompression illness, is still at a primitive stage.

The are a number of reasons for this. The most important, in my view, is inadequate epidemiology. It is only in the last ten years or so that serious attempts have been made to collect diving accident data systematically. This is not a criticism of past generations of diving physicians. The reason for our lack of epidemiological data is that, until about ten years ago, there was a lack of the widely available, user-friendly software and hardware that are necessary to design and run sophisticated databases. Dissecting diving accidents into fields for databases is a time-consuming process. A good database will include fields for: personal characteristics of the diver, past medical and diving history, the dive profile(s) prior to the causative dive, unusual features of the dive such as cold water, lost weight belt or out of air, the onset and progression of each of the manifestations, any delay to treatment, the first aid and subsequent management the casualty received and the outcome. This is a staggering amount of information to try to process. The Royal Navy's Institute of Naval Medicine (INM) database, for example, has over 100 fields for each case and now contains many thousands of cases. Despite this effort, we are still some way from identifying the natural syndromes of disease, let alone their risk factors.

A substantial problem with collecting data in this way is that there are no denominators with which to compare the numerators – how many uneventful dives to 30 m are there? How many uninjured divers have lung parenchymal scarring? It will be for the likes of Dick Vann and his colleagues at the Diver Alert Network (DAN) with their prospective studies, using down-loads from recreational divers' computers, to answer some of our basic questions.

Another fundamental problem is that inadequate resources have been devoted to basic physiological research in the field of diving medicine. This is a problem that has been getting more severe since the ending of the Cold War and the advances that have been made in the capabilities of remotely operated vehicles underwater. No longer are the navies of the world or the oil companies willing to sponsor such studies. Having said that, I am delighted to say that the US Navy will shortly be making available substantial amounts of money for precisely such work in a program that will last for multiple years. This money will not be ring-fenced for US Navy scientists or even American universities, but the Office of Naval Research will consider funding proposals from other countries. So, in a few years, I hope we will be less able to use the fig leaf of lack of funds to excuse our lack of knowledge.

I have chosen to introduce my talk in this way to make the point that what follows is not science. What I intend to do is review the conditions that we are trying to prevent and discuss some of the strategies we employ to try to achieve this.

Lung function testing in diving

We can look at lung function testing with the view to checking that a diver can achieve adequate ventilation during exercise. We wish to avoid pulmonary barotrauma and testing for this risk is mostly based on theoretical grounds of obstruction as there is little hard data about why divers develop pulmonary barotrauma. Then there are physiological changes combined with behavioural patterns which can cause PBT.

Exercise Testing

The most important function of the heart and lungs in a diver, just as with anybody else, is to provide body tissues with an adequate supply of oxygen and remove their metabolic waste, mainly carbon dioxide. Failure to achieve this will result in the diver becoming incapacitated in the water and may lead on to the ultimate failure of the heart and lungs, drowning.

Although this sounds like a fairly specific requirement it is not. The demands made on the cardiopulmonary system will depend on what the diver does during the dive. There is a world of difference in the cardiopulmonary function required by a US Navy SEAL or RN Special Boat Service diver conducting a five mile covert swim in 4°C water compared with a timid tourist hovering just under the surface, taking in the delights of the Great Barrier Reef. Even within sports diving there is a considerable spectrum of activity from the hairy-chested tech diver exploring the RMS Lusitania at 90 m to the novice diver learning buoyancy control in a swimming pool. Furthermore, there is a wide age range in recreational divers. A standard that might be reasonable for a twenty year old to achieve is likely to be unreasonable for a fifty or sixty year old. Given this great disparity of demand on the cardiopulmonary system is it reasonable or even possible to determine a "fitness standard" for divers?

One way of looking at the problem is to assess the VO_2 required to swim at certain speeds.[1] Table 1 shows swimming speed and the VO_2 required to achieve these speeds.

TABLE 1

SWIMMING SPEED AND VO_2

Speed (knots)	VO_2 (l/min)
0.6	1.0
1.0	1.7
1.2	2.4

It can be seen that swimming at 1.2 knots requires a considerable VO_2 which equates to a V_E of about 80 l/minute at the surface. However, with increasing depth the air breathed will become more dense with a consequent increase in the work of breathing and the VO_2 required. Thus, even stipulating a swimming speed standard is imprecise because the demand it will make on the cardiopulmonary system will depend on the diver's depth and other factors such as what the diver is wearing. However, a more basic question is how fast does a diver need to be able to swim? This gets us back to the issue of what kind of diving does the individual intend to do. Setting a standard based on an arbitrary swimming speed, therefore, has severe limitations in terms of practicality with respect to where the standard is set. A bigger problem, however, is how should an index of that standard, the VO_2, be measured?

The UK Health and Safety Executive, which regulates the medical standards for UK commercial divers recognised this problem and decided to specify no formal fitness standard in the regulations issued in 1998.[2] Instead, these state:

"A commercial diver must be able to meet the physical requirements of the task to be performed. That includes the ability to rescue a stricken diver and effect a rapid recovery. An assessment of exercise capacity must be carried out at both the preliminary examination and each subsequent annual assessment."

The guidance goes on to suggest that a step, swimming or cycle ergometer test may be appropriate means of determining adequate fitness. The guidance gets close to specifying Bove's suggested standard of 13 Mets,[3] but backs off and notes in the appendix that:

"without being too prescriptive, it is important that some form of standardised exercise test is performed."

The UK Sport Diving Medical Committee, which determines fitness standards for most UK sports divers, states:

"The value of screening exercise tests in apparently normal populations has now been largely discredited because of the appreciable false positive and false negative results in such groups. Furthermore we have no control over the quality of equipment or type of standardisation on which the Exercise ECGs on our members would be performed. This only compounds the possibility of false reporting of the test."

Our own society, SPUMS, also takes a pragmatic view:

"Consideration must be given to the candidate having adequate reserves of physical fitness to cope with unexpected demands inflicted by adverse weather or sea conditions, surfacing away from a boat, having to aid a distressed buddy, or other emergencies."

In conclusion, while responsible bodies recognise that an adequate level of exercise tolerance is necessary for all divers, the practical difficulties in setting a standard and reproducibly measuring the fitness of diver candidates makes this a qualitative rather than a quantitative assessment.

Causes of pulmonary barotrauma

We all know it is important that there is free communication between the pulmonary air spaces and the mouth, particularly during ascent. An airway with an obstruction that prevents air distal to it escaping from the lung has the potential to cause barotrauma. As the volume of trapped gas expands, it eventually causes the parenchyma to expand beyond its elastic limit and break. Let us look at what can cause such an obstruction.

PERMANENT AIRWAY OBSTRUCTION

If an airway is permanently obstructed the tissues distal to it are unlikely to suffer barotrauma. This is because these tissues, if they contain gas, will behave like the bowel during a dive, with its volume decreasing during descent and returning more-or-less to their original volume during ascent. More often than not, the air in lung tissue distal to a permanent obstruction will be absorbed and so again, barotrauma will not be a problem.

LABILE AIRWAY OBSTRUCTION

Here we do have a potential problem, particularly if the obstruction occurs at depth. What could cause such an obstruction?

Bronchospasm may be provoked by exercise, cold air, dry air or by the stress of an emergency, such as being out of air. Another potential cause is nebulised saline which may be injected into the airways by a faulty regulator.

Tumours. The remarkable case described by Liebow et al. has alerted us to the possibility of a ball-valve action by a calcified mass.[4] However, careful reading of this case, a submariner undergoing escape training, leaves some questions unanswered. For example, the calcified mass was in the left lung and yet there was evidence of barotrauma affecting both lungs. Thus the relevance of the calcified mass is open to question. Unsworth reported a very rare case of pulmonary barotrauma occurring in a compression chamber following a session of hyperbaric oxygen therapy.[5] The patient was found to have a neoplastic mass in the right middle lobe and, given the rarity of PBT in compression chambers, the possible role of the mass in generating the injury cannot be ignored.

Mucus. An argument against asthmatics diving is that tenacious mucus could obstruct an airway. Here we enter a Catch 22 situation because, to my knowledge, no case has been reported in which mucus plugging was shown to be the cause of pulmonary barotrauma. There is a reason for this, of course, and that is that for many years asthmatics were supposed to be banned from diving. However, things are changing and in the UK some asthmatics are allowed to dive, as I shall discuss later. Patrick Farrell is in the process of completing a study of diving asthmatics and this should be complete in about six months. It will be interesting to see if they are at increased risk of PBT. One point that should be borne in mind is that asthmatics have made many millions of flights in commercial aircraft. These commonly run at a cabin altitude of 8,000 ft or 196 mmHg below 1 ATA, a rather greater excursion than the 70 mmHg or so that is needed to rupture a normal lung. If mucus plugging was a serious risk factor, I would expect there to have been many more examples of PBT in airline passengers than have been reported.

PARTIAL AIRWAY OBSTRUCTION

Air can escape from normal lung at a rate that even the fastest of ascents can be conducted safely. In submarine escape training, for example, ascent rates of over 3 m per second can be reached wearing the Beaufort Submarine Escape and Immersion Equipment. This requires that the airways communicate with the mouth such that over the last 10 m the volume of the lung can be exhaled in about three seconds. For comparison, a healthy person can exhale about 75% of vital capacity in a second. In a forced expiratory manoeuvre the rate at which air can be exhaled decreases with time as the small airways close. During the last 10 metres of a submarine escape, air will be expanding rapidly within the lung and thus the airways will not close and so this high rate of exhalation can be maintained. A problem may occur if even a small part of the lung, such as a bullus, can not empty at the required rate. In a rapid ascent, particularly near the surface, it may reach its elastic limit and rupture. The problem is that small bullae are common, impossible to detect clinically and may be invisible or easily overlooked on a p-a chest X-ray. There must be many thousands of people with bullae who dive without difficulty. Thus, the extent to which this is a genuine hazard is in some question.

SMALL OR STIFF LUNGS

Lungs break or tear when they reach their limit of elasticity. When breathing in, the elasticity of the lungs decreases as total lung capacity (TLC) is approached. The lungs are vulnerable to over inflation because they become stiff and eventually break. In a study of barotrauma in submarine escape trainees Benton et al. found that it is not trainees with evidence of obstruction on spirometry, lower than predicted forced expiratory volume in 1 second (FEV_1) or FEV_1/FVC (forced vital capacity) ratio, who were over represented amongst those with barotrauma, but those with evidence of restriction (smaller than predicted FVC).[6] This is supported by the original work of Colebatch et al. who showed that reduced compliance is a risk factor for PBT.[7,8]

LUNG PARENCHYMAL SCARRING

In the only study of its kind that I am aware of, Calder looked for scarring in the lungs of deceased divers with pulmonary barotrauma.[9] He found that victims of PBT frequently had lung parenchymal scarring but, interestingly, the site of lung rupture was usually remote from the scarring. David Denison and I concluded that parenchymal scarring may provoke lung rupture by effectively shortening the elastic fibres that radiate from the hilum to the pleura. If fibrosis renders a section non-elastic, when stretched the remaining elastin will reach its elastic limit sooner and may rupture. This would render the elastic fibres in series with an area of fibrosis vulnerable to pulmonary over-inflation and thus it is they, rather than the scar that will break.[10]

PLEURAL ADHESIONS

It was Malhotra and Wright who first observed that pulmonary adhesions are a risk factor for pulmonary barotrauma.[11] In their classic study of fresh cadavers they showed that lungs ruptured where the visceral and parietal pleura were connected by adhesions. Interestingly, in the world of aviation, air crew who have had spontaneous pneumothoraces can be made fit to fly by undergoing pleurectomy. This will render the lung more-or-less completely adherent to the chest wall. This substantially reduces the risk of a recurrent pneumothorax. The hazard of pleural adhesions may be that they focus the stress of pulmonary over-inflation at the site of the adhesion. If this has a small surface area, the force acting on the lung may be sufficient to cause it to tear.

Behavioural and physical factors

For completeness, it is perhaps worth just mentioning some behavioural and physical factors that may predispose a diver to pulmonary barotrauma. The most obvious is voluntary breath-holding during ascent. This is often associated with panic after a mishap and is most common in inexperienced divers. It is usually addressed by training. It is perhaps worth mentioning the possible role of involuntary breath-holding. It is striking that in a substantial proportion of cases of pulmonary barotrauma in submarine escape trainees, no cause is found. When close to the surface, the rate of change of pressure is about 250 mmHg per second. A person with their lung volume close to TLC would only have to hold their breath for about a third of a second to generate an overpressure that may be sufficient to cause lung rupture. This could happen if they coughed, hiccuped or sneezed.

Head-out immersion in water results in a shift of about a litre of blood from the periphery into the chest. A diver, who is submerged vertically in the water, and has a regulator in his or her mouth is in a similar situation. One effect of this shift in blood volume is that full capacitance vessels splint the lung and reduce its compliance. It may therefore be that an inescapable consequence of diving is to make the lungs more vulnerable to pulmonary barotrauma than if similar pressure changes were experienced out of water. Other factors are involved, but this may be one reason why pulmonary barotrauma is rare in aviators and those who undergo pressure excursions in compression chambers.

As has already been discussed, the compliance of the lung is at its lowest at TLC. Thus the lung is more vulnerable to a reduction in ambient pressure at TLC than when it contains less gas. It is perhaps surprising that divers ever skip breathe. Unlike normal breathing in which the sequence is breathe in, breathe out, hold; skip breathers breathe in, hold, and then breathe out. It is a practice in which the lung is deliberately held fully inflated, and at its most vulnerable to barotrauma, for as long as possible. There may be some advantage with respect to gas usage or a psychological comfort of having lungs filled with air, but from a physiological perspective it makes no sense. Even modest loss of buoyancy control while skip breathing renders the diver vulnerable to pulmonary barotrauma.

Pulmonary fitness to dive

Having explored what the lung is for and why it may fail underwater, can we come up with some pulmonary standards for divers? We have already concluded that this is not possible in a quantifiable way with respect to assessing physical fitness. What about other aspects of lung structure and function?

ASTHMA

In the UK, a more relaxed attitude is developing towards asthma and diving. Rather than a blanket prohibition, which was always porous to dedicated divers, the following position has been adopted. Those with allergic asthma who are well maintained on inhaled steroids or chromoglycate, and only need to use a bronchodilator occasionally, may dive. They are advised to take a peak flow measurement twice a day in the diving season and if the result is within 10% of their usual best, they may dive. If not, they should wait until the result has been within 10% of their usual best for 48 hours. A Beta$_2$ agonist can be taken prior to diving as a preventative measure but not to relieve symptoms. Those whose asthma is provoked by exercise, stress or cold air are not considered fit to dive. This strikes me as a balanced approach.

LUNG FUNCTION TESTS

What is the role of lung function tests in determining fitness to dive? Speaking as somebody who has put literally hundreds of prospective and practicing divers through the lung function laboratory, and making only a tiny percentage of them unfit to dive on the basis of their lung function tests, I am forced to concede that the role is limited. There are two reasons for this. If a standard is to be imposed:

a It has to be measured in a standard way.

b It has to be relevant.

As we have seen with respect to exercise testing, standardising tests is difficult. It relies on each testing station having similar equipment and using it in a similar way. The same is true of lung function tests. As soon as anything more complicated than a peak flow meter is required standardisation will become an issue. The introduction of provocation testing would add another layer of difficulty. Testing bronchoreactivity to exercise, cold, saline or a general stimulant such as methacholine could only be standardised if it were done at a very limited number of centres and this would introduce serious transport and other cost implications for diving candidates.

The foregoing assumes that we know which tests to perform. For many years the Royal Navy has imposed a spirometric standard on its divers and submarine escape trainees based upon indices of obstruction. This was introduced after a cluster of deaths in the submarine escape training tower in the early 1970s. At that time it was believed that airways obstruction was the most important cause of pulmonary barotrauma. However, as we have seen, this may not be the case and the standard may be irrelevant to preventing barotrauma. My opinion is that until we have a better understanding of how and why the lung ruptures in barotrauma, it is premature to introduce lung function standards that are intended to prevent this.

THORACIC SURGERY

It is inevitable that people with lung parenchymal scarring will have reduced the compliance of the lung at the site of injury and this will make the normal lung proximally and distally to the lesion(s) vulnerable to over stretching. The problem we have is in quantifying how much more vulnerable the lung is. Where there has been mediastinal chest surgery and the pleura have remained intact, there is no theoretical reason for preventing diving; although, the reason for the surgery should be determined and a full recovery confirmed. If a pleural cavity has been opened and there is sufficient parenchymal or pleural scarring to be detected on X-ray or CT, it is my opinion that the individual is unfit to dive. Similar arguments apply to accidental traumatic chest injury.

BULLOUS DISEASE

Small bullae are common and asymptomatic and are likely to remain undetected at a routine medical examination. It is therefore irrational to ban all people with bullae from diving. A chest X-ray will only be requested where there is an indication based on family, social or past medical history or if an abnormality is detected on examination. It is my opinion that if bullae are found on such an X-ray, this is sufficient to render the individual unfit to dive.

SPONTANEOUS PNEUMOTHORAX

A past history of spontaneous pneumothorax is important. This occurs most commonly in young adults (up to age 40), is much more common in males than females (6:1) and is associated with smoking.[12] Almost all are unilateral (only 2% are bilateral) and affect both sides with equal frequency. About 50% recur, most commonly on the same side. However, after two years recurrence is very uncommon. After age 40 pneumothorax is increasingly associated with underlying disease. Given this, it is reasonable to ensure that there is no underlying disease and that there has been at least two years since the pneumothorax. Under such circumstances, I feel that individuals are fit to dive.

Making a decision on fitness to dive

In making a decision on fitness to dive the physician has a responsibility to the diver and the diver's buddy. The process involves striking a balance between risk and benefit. In sports diving, the benefits are exercise and pleasure and diving is but one of many ways in which the individual concerned can gain these benefits. The benefit, therefore, is not great and so nor should be the risk associated with diving. I have found that where there is an above average risk associated with an individual diving, if the risks are explained, the individual will make an appropriate decision as to whether or not they are fit to dive. In professional diving, the benefits associated with diving are great and physician is constrained by a regulatory framework and a duty to the employer. Determining fitness to dive is therefore considerably more demanding. Nonetheless, I have found it useful to involve the diver in the decision making process and it has been mercifully rare that I have resorted to imposing a decision on a recalcitrant diver.

Conclusions

In an ideal world, determining pulmonary fitness to dive would involve a candidate undergoing a series of laboratory tests to determine aerobic capacity and the ventilatory function of the lungs. The results would then be compared with an absolute standard and a determination made. However, this is not an ideal world. There is no agreed series of tests and no standard against which to judge the results. Thus the determination of pulmonary fitness to dive is not a scientific process, it is a judgment that is reached by weighing up an incomplete knowledge of the hazard posed by existing pathology against a subjective assessment of the benefits of diving. Despite the inadequacy of this approach, some generalisations can be reached. Those with intrinsic or poorly controlled asthma or asthmatics with a reduced peak flow should not dive. Other conditions that should preclude diving include: recent spontaneous pneumothorax; bullous disease detected on chest x-ray; significant lung parenchymal or pleural scarring.

References

1 Neuman TS. Pulmonary fitness for diving. In *The Lung at Depth*. Lundgren CEG and Miller JN. Eds. New York: Marcel Dekker Inc. 1999; 73-90

2 UK Health and Safety Executive. *MA1, the Medical Examination and Assessment of Divers*. Glasgow: Health and Safety Executive, 1998

3 Bove AA. In *Fitness to Dive. 34th Undersea and Hyperbaric Medical Society Workshop.* Linaweaver PG and Vorosmarti J. Eds. Bethesda, Maryland: UHMS, 1987; 26-41

4 Liebow AA, Stark JE, Vogel J and Schaeffer KE. Intrapulmonary air trapping in submarine escape training casualties. *US Armed Forces Med J* 1959; 10: 265-289

5 Unsworth IP. Pulmonary barotrauma in a hyperbaric chamber. *Anaesthesia* 1973; 28: 675-678

6 Benton PJ, Pethybridge RJ and Francis TJR. A review of spirometry and UK submarine escape training tank incidents (1975 -1997) using objective diagnostic criteria. *Undersea Hyper Med* 1999; 26 (4): 213-217

7 Colebatch HJH, Smith MM and Ng CKY. Increased elastic recoil as a determinant of pulmonary barotrauma in divers. *Respir Physiol* 1976; 26: 55-64

8 Colebatch HJH and Ng CKY. Decreased pulmonary distensibility and pulmonary barotrauma in divers. *Respir Physiol* 1991; 86: 293-303

9 Calder IM. Autopsy and experimental observations on factors leading to barotrauma in man. *Undersea Biomed Res* 1985; 12 (2):165-182

10 Francis TJR and Denison DM. Pulmonary barotrauma. In *The Lung at Depth*. Lundgren CEG and Miller JN. Eds. New York: Marcel Dekker Inc. 1999; 295-374

11 Malhotra MS and Wright HC. The effects of a raised intrapulmonary pressure on the lungs of fresh unchilled cadavers. *J Pathol Bacteriol* 1961; 82: 198-202

12 Light RW. Pneumothorax. In *Textbook of respiratory medicine. 2nd Edition*. Murray JF and Nadel JA. Eds. Philadelphia: Saunders 1994; 2193-2210

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ASTHMA AND DIVING SCREENING PROTOCOLS

Cathy Meehan

Key Words

Asthma, diving medicals, fitness to dive.

Background

Ten to fifteen percent of children have some history of recurrent wheezing. It is estimated that 5 to 8% of adults are diagnosed as asthmatics. Asthma is an air trapping disease and the diving environment contains several potent triggers to asthma, such as exercise, inhalation of cold, dry air and also the possible inhalation of non-physiologically isotonic water which can be hypotonic fresh water or hypotonic salt water. There is no hard evidence that asthmatics are at greater risk of pulmonary barotrauma or death during diving. We know that some recreational divers who have asthma dive. They are often failed by the first diving doctor they consult but passed by the second because they suppress their asthma history.

Should asthmatics dive?

There is a divergence of opinion in the guidelines issued by authorities in different countries regarding fitness to dive. The UK recommendations for recreational divers can be briefly summarised as allergic or well controlled asthmatics may dive.[1] In America, as far as I am aware, there is no current agreed standard though active asthma is regarded as a contra-indication and provocation testing is regarded as a useful tool. In Australia there are various opinions. Carl Edmonds believes that asthmatics should not dive.[2] The Thoracic Society of Australia and New Zealand have published guidelines and there are Australian Standards for Recreational and Occupational Diving.[3-5]

Both Australian Standards state that any evidence of obstructive airways disease, such as current asthma, chronic bronchitis, allergic bronchospasm, shall automatically disqualify. In case of doubt, specialist medical opinion should be sought.

The Thoracic Society of ANZ states that the student should fail if there is a history of asthma or use of bronchodilators within the last 5 years.[3] If there have been no symptoms for 5 years and there is evidence of bronchial hyper-responsiveness after provocation testing they fail. A 20% fall in FEV_1 is usually needed to fail. Edmonds et al. consider that a greater than 10% reduction in FEV_1 after both histamine and hypertonic saline is a fail.[2] I recently surveyed some diving specialists in Australia through the ANZ HMG chat line. I want to thank everyone who replied very much. I found that there was a range of opinions from a slight variation of the Thoracic Society Guidelines to entering into a formal contract of risk assessment and informed consent with the student who wanted to dive regardless of occasional mild symptoms.

It is well known that prospective divers, who are very keen to dive, often go off and just not put their history of asthma on the form. Screening procedures are available from various centres, the waiting periods are from one day up to 10 days. Some centres require visits to more than one location to get the screening done. Hypertonic saline challenge was done by all the centres I checked on and some added exercise challenge but not all of them.

So who has the final say? Is it the diving doctor or the diver's physician? The dive instructor or the training agency? They both like to have a say sometimes. Or is it the informed diver or the student diver?

Bronchial challenge testing

Bronchial challenge tests have been shown to be useful in the identification of persons who would be at risk from acute airway narrowing during the activities associated with diving. Traditionally pharmacological agents, such as histamine or methacholine, have been used. But hypertonic saline seems more appropriate when assessing divers. Strenuous exercise, when an increased rate of respiration causes water loss which may also act as a hypertonic stimulus, can induce asthma.

What is the most appropriate challenge test for would be divers? What is the degree of responsiveness that can be accepted? How does this actually relate to the diver risk? And can the screening procedure be simplified so that the student diver can continue with the training without major disruption to their timetable?

In 1995 Dr Graham Simpson, a respiratory specialist in Cairns, and I did a study of the incidence of bronchial hyper-responsiveness in a group of experienced recreational scuba divers.[6] Our objectives were to study the incidence of hyper-responsiveness in experienced scuba divers, some of whom had obtained their diving qualifications before rigid medical criteria applied to diving candidates. Each diver was given a pharmacological challenger, histamine, and was also challenged with hypertonic saline. The subjects were all volunteer divers recruited from a local dive club and a local dive school and they all signed an "informed consent" form. The protocol was approved by the hospital Ethics Review Committee.

Hypertonic saline challenge was performed by me and was followed by documenting any response to a bronchodilator. The histamine challenge was performed by Dr Simpson in his rooms and at least 72 hours separated the two challenges. The results were totally confidential and each individual diver was given an opportunity to discuss his or her results and any possible implications with regard to their continued diving. Confidentiality was particularly important because some of the divers were actually occupational as well as recreational divers.

For the hypertonic challenge, I used a small hand held ultrasonic nebuliser and complied with the standards and protocol used by Royal Adelaide Hospital Respiratory Unit. The protocol is measuring the FEV_1 at increasing times after inhalation of hypertonic saline using a minimum of 15 ml of hypertonic saline. Histamine provocation tests were done using the rapid hand operated technique with a Diviblis hand-held nebuliser. There were 50 divers who had a total of 70,000 dives between them. The average age was 37. Fifty two percent of the volunteers were occupational divers and 48% were recreational. Seventy six percent were male and 24% female. Forty six percent were smokers and 54% non-smokers. Most of the occupational divers were smoker.

These divers had very few problems associated with their 70,000 dives. Four, all occupational divers, had suffered salt water aspiration. Three had a history of decompression illness. One had experienced shortness of breath and wheeze. One gave a history of muscle strain underwater. And one had actually become wheezy after diving.

Six of the 50 divers gave a past history of asthma and 5 of these had experienced symptoms within the last 5 years. Four had actually suffered symptoms within a month and of these, 3 were on regular medication and one was on intermittent therapy. Four of the 6 with a history of asthma had smoked in the past and one had abnormal baseline function test.

Divers with a history of asthma

Of the divers who gave a history of asthma some were on quite a lot of medication and had quite regular symptoms and the others had very intermittent symptoms and one had not had symptoms since childhood.

Results of bronchial challenge testing

Table 1, reprinted from our 1995 paper, summarises the falls in FEV_1 after hypertonic saline or histamine.[6] We took the highest fall after both tests. Fifteen (30%) of the divers had a fall of greater than 10%, which is Carl Edmonds' standard. Six (6) of the divers had a fall of greater than 15% while only two (4%) had a fall of greater than 20%, which is the Thoracic Society's recommended level.

TABLE 1

RESPONSES OF 50 EXPERIENCED DIVERS TO BRONCHIAL PROVOCATION TESTING WITH HISTAMINE (47) AND SALINE (50)

Fall in FEV_1	Histamine	Saline	Responding to either
Less than 10%	32	32	27 (54%)
10% to 14%	10	13	15 (30%)
15% to 19%	3	4	6 (12%)
20% or greater	2	1	2 (4%)
Totals	**47**	**50**	**50 (100%)**

Of the 50 divers, 11 had abnormal, baseline, respiratory function testing. Four more had a history of wheeze within the last 5 years and eight others had a fall in FEV1 of 10% or greater after challenge with histamine or hypertonic saline. Using the strictest criteria 23 (46%) of these experienced divers would have been excluded from diving. Using the most lenient criteria 2 (4%) would have been excluded for failing due to 20% drop after provocation testing. We concluded that further evaluation of criteria for assessment of pulmonary medical fitness to dive was necessary and that a 10% fall was far too stringent. Other conclusions were that the clinical history was a good indicator of increased potential risk and that abnormal lung function appeared to increase the potential risk.

In our survey divers with a history of asthma who were well maintained on medication had a reduced response to provocation testing and passed the provocation test. What are the implications that this has on asthma and diving.

I have performed a retrospective analysis of the bronchial provocation testing that I had done when assessing fitness to dive in diving students with a history of asthma or wheeze. They all passed a diving medical in all other aspects of health. There were 50 challenges with histamine before 1994. After that I used hypertonic saline and I have done over 100 hypertonic saline challenge tests. In the last few years, I have been adding an exercise challenge. Unfortunately, because the others were filed separately, I was only able to go through the 23 that have been done this year.

The 50 histamine challenges of prospective divers who had a history of asthma were done quite a long time ago and 17 (34%) failed at a 10% reduction. In the end only 11 (22%) of the students failed. Only nine (18%) dropped by 20% but two others started to wheeze and so were failed. In the joint study 15 divers (30%) failed at a 10% reduction, about the same proportion as with the trainee divers.

Twenty three people had both a hypertonic saline challenge and an exercise challenge this year. In Fiji in 2000 David Elliott suggested that I could break new ground by testing for both to see how well they compared. My protocol is to exercise the students using the British Army step test for 6 minutes. It is done in an air conditioned office, which has dry and cool air. One minute after finishing the exercise FEV_1 was tested and then was repeated after 5 minutes. After the 5 minutes the hypertonic saline challenge was started. The end result is probably a combination of both tests. This was done purely to enable the test to be carried out on the one day.

After exercise the FEV_1 was unchanged after 5 minutes in 22 (96%) of the subjects. Only one (4%) of the 23 had dropped by more than 16%. But at the end of the hypertonic saline challenge 8 (35%) of the students had a significant drop and were excluded from diving.

The overall outcomes were that similar percentage of student divers and experienced divers had a 10% fall in FEV_1 after provocation testing. Seventeen (34%) of the students had hyper-responsiveness after histamine but only nine (18%) after hypertonic saline. Of those who had hypertonic saline after exercise 8 (35%) had a positive response but the numbers are small so I am not sure if that is significant. It would be useful to compare the response after exercise challenge to the response after hypertonic saline if these can be carried out on separate days. Simon Mitchell tells me that he does this but if they have a positive response to exercise he does not do a hypertonic saline challenge on the second day. And so his results cannot be compared with mine.

There needs to be a standardised protocol for exercise challenge testing. Do we need to look at air temperature, the humidity and what is the appropriate activity? We need an internationally recognised consensus of the medical opinions of what criteria determined respiratory fitness to dive.

References

1 Francis TJR. Pulmonary fitness to dive. *SPUMS J 2001*; 31 (4): 221-226
2 Edmonds C, Lowry C and Pennefather J. *Diving and Subaquatic Medicine. 3rd Edition.* Oxford: Butterworth-Heinemann, 1992; 461-476
3 Jenkins C, Anderson SD, Wong R and Veale A. Compressed air diving and respiratory disease. *Med J Aust* 1993; 158: 275-279
4 *Training and certification of recreational divers. Part 1: Minimum entry-level scuba diving. AS 4005.1 - 1992* Sydney: Standards Australia, 1992
5 *Occupational diving operations. Part 1: Standard operational practice. AS/NZS 2299. 1:1999.* Sydney: Standards Australia, 1999

6 Simpson G and Meehan C. Prevalence of bronchial hyper responsiveness in a group of experienced scuba divers. *SPUMS J* 1995; 25 (4): 249-253

The above is an edited version of the transcript of the recording of Dr Meehan's paper presented in Madang.

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LUNG FUNCTION TESTING TO DETECT ASTHMA IN RECREATIONAL DIVERS

Paul S Thomas

Key Words

Asthma, exercise, histamine, hypertonic saline, lung function testing, methacholine.

Introduction

Current Australian recommendations suggest that those with active asthma should not dive, nor should those with previous symptoms of asthma and current bronchial hyper-reactivity.[1,2] These recommendations are not universal and a number of countries suggest that individuals with well-controlled asthma may dive. Recently the British Sub-Aqua Club (BSAC) and other organisations have introduced guidelines which allow those with mild and well-controlled asthma to dive, with the intention of monitoring this policy in terms of safety.[3] Undoubtedly, some divers from these countries will be visiting Australasia and will be diving. In addition, many Australian recreational divers have asthma.[4] This paper will briefly discuss some of the issues surrounding asthma and diving, and will summarise the methods of diagnosing current asthma. The issues that give rise to concern have been described in previous issues of this journal and elsewhere are several-fold and can be summarised in terms of:[5-8]

1 the hypothetical increased risk of barotrauma;
2 the risk of salt-water aspiration or nebulisation and subsequent bronchospasm;
3 exercise-induced asthma;
4 poorly controlled asthma leading to difficulties either while submerged, or while swimming at the surface.

The risk of pulmonary barotrauma is considered to be increased in asthma as there is the potential for small airways to be either constricted by smooth muscle over-activity or by mucous plugs. This could occur while at increased barometric pressure and so fail to allow this portion of the lung to equilibrate on ascent, leading to overpressure and pulmonary rupture, with subsequent pneumothorax or pneumomediastinum. The available data in man are very much lacking, despite this making sound physiological sense. Colebatch et al. showed that in those submariners who developed pneumothoraces on ascent, the problem was associated with abnormal elastic properties of the lung, rather than an obstructive pattern in their lung function, although those with frank airway obstruction had been screened out of this group.[9] James Francis reported at the 2001 SPUMS Scientific Meeting, that the data from the Royal Navy would suggest that a restrictive pattern was associated with pneumothoraces, rather than any evidence of obstruction.[10] Also reported at the same meeting were data from our own research in those with a heavy smoking history who underwent hyperbaric oxygen therapy. While the degree of airway obstruction was mild, there was clear evidence of air-trapping at baseline which did not increase after hyperbaric therapy, and the residual volume did not change. The likelihood of air-trapping in association with airway obstruction and hyperbaric conditions remains to be proved.

Salt water aspiration is probably not uncommon in any diving population and regulators may allow a mist of sea-water to be nebulised into the airway. This hypertonic solution could cause airway narrowing in a susceptible individual, particularly those with unstable asthma. It would therefore seem logical that those with a significant response to a challenge of hypertonic saline should at least be aware of the increased risks of diving, if not advised not to dive at all. Again, the data suggesting that this is the correct advice are minimal.

Exercise-induced asthma is associated with airway cooling and drying. Cold dry air is a bronchoprovocant for some asthmatic individuals, and can be associated with exercise-induced asthma. The logical advice again is that if there is evidence of bronchoconstriction during or after strenuous exercise, then diving should be avoided, particularly as the compressed air will be cold and have a low humidity, thus making bronchoconstriction likely. In addition, if a vigorous swim against a strong current is required to return to the surface or to the boat is required, this too may provoke exercise-induced asthma.

An additional, but largely unsubstantiated risk which is oft quoted is that the use of bronchodilators could lead to increased systemic gas emboli.[11] These experiments were performed in dogs which were given aminophylline, and the normal filtering of bubbles by the lung as blood passed through the pulmonary circulation was considered to be reduced. These results have not been demonstrated in man. Thus, in theory, the use of bronchodilators in asthma could be disadvantageous if shown to increase the passage of bubbles into the systemic circulation.

Despite all of these quite cogent reasons why asthma and diving would appear to be a fatal mixture, the data surrounding diving deaths and asthma do not implicate this disease in any large excess of misadventures, despite the fact that in several surveys the prevalence of asthma would appear to be same in divers as in the general population.[3-5,12] Asthmatic subjects are not banned from swimming in the ocean, where one would expect them to inhale hypertonic saline, nor from the swimming pool where they inhale small, but potentially irritating quantities of chlorine gas, and, they are in fact often encouraged to take up this form of exercise. Thus, diving may or may not be a problem for those with asthma, but the current guidelines in Australia make it important to identify those with active disease or airway hyper-responsiveness and to encourage them not to dive.

Diagnosis of Asthma

Various bodies have attempted to define asthma over many years, and with each successive effort the description becomes more convoluted and complex. Objective clinical definitions are easier to use, and generally suggest:

1 a decrease below the predicted value of the forced expiratory volume in the first second (FEV_1) or peak expiratory flow (PEF) with a >20% increase after bronchodilator (200 micrograms salbutamol via a spacer device);
2 20% spontaneous variation in the FEV_1 or PEF during the day, usually the lower value being in the early morning;
3 airway hyper-responsiveness.

A diagnosis of airway hyper-responsiveness is associated with asthma, but can also occur in other syndromes, e.g. after noxious gas inhalation, after viral respiratory tract infection, and in a very small number of people who are otherwise normal. The majority with hyper-responsiveness have asthma. It is important to recognise that the three methods of diagnosing asthma will often be normal if the subject takes regular inhaled glucocorticosteroids, or an adrenergic $beta_2$ agonist prior to the tests.

Which challenge test?

Challenge tests use the principle of the dose response curve to make an arbitrary division between those with and those without hyper-responsiveness. There do not appear to be discrete populations at each end of the dose response range which makes the process of defining hyper-responsiveness arbitrary. Each point is a dose or concentration which is twice that of the last dose or concentration (a "doubling dilution"). A common method is to interpolate between these points to generate the curves as depicted in Figure 1 and then to take a predetermined point, e.g. a 15 or 20% fall in FEV_1, and to calculate the provocative dose or concentration (PD_{20} or PC_{20}) of drug or stimulus required to cause this response. Cut-off points have been derived from population data to divide the results into normal or hyper-responsive. Hyper-responsiveness appears to be related to airway inflammation, and secondary to this inflammation, mediators are released which may make the airway smooth muscle more excitable or '"twitchy" and thus more likely to constrict when presented with a stimulus.

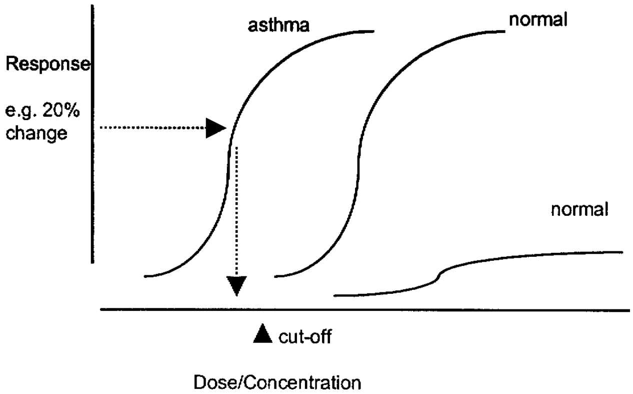

Figure 1. Concentration response curve for airway challenge tests. When an increasing concentration of a bronchoconstrictor is inhaled, there is a progressive fall in FEV_1. The provocative concentration causing a 20% fall in FEV_1 is interpolated from the data (PC_{20} or PD_{20}). Using population data, an arbitrary cut-off point where a 20% fall in FEV_1 occurs can distinguish between hyper-responsive or asthmatic subjects (left) and normal subjects (to the right of the cut-off point).

In European countries and in North America, the most popular tests for hyper-responsiveness are the methacholine and histamine challenges. Each has a direct action upon the airway smooth muscle by activating the muscarinic or histamine receptors respectively to cause bronchoconstriction. Broadly speaking, these tests are similar, although few large-scale comparative studies have been performed in the same individuals. When compared with other challenge tests, these two tests have a higher sensitivity and may therefore have less specificity. In Australia, both methacholine and histamine require a licence from the Therapeutic Goods Administration (Therapeutic Goods Act, Section 19, Subsection 5), and are expensive. Hypertonic saline is recognised to be less sensitive than either of the above methods, but has gained in popularity by virtue of not requiring a licence and by being inexpensive. The mode of action of this test is thought to be by increasing airway osmolarity and hence activation of mast cells, but some subjects will also react to isotonic saline. All three of these tests have a repeatability which is approximately two doubling dilutions. The results for methacholine and for histamine are usually expressed as the provocative concentration/dose to cause a 20% fall in FEV_1, while hypertonic saline tests are usually considered positive if a 15% fall is achieved.[13]

Exercise testing is often performed in adults in respiratory laboratories, but tends to fulfil the function of trying to distinguish between cardiac and pulmonary causes of breathlessness in older adults. It is designed also to detect exercise-induced asthma, but the details of maximal oxygen uptake (VO_2max) and ECG monitoring are not usually appropriate for young, fit adults. Recommended exercise varies from"6-8 mins of strenuous exercise" to very prescriptive guidelines. Guidelines include target heart rate (210-age), or refer to a predicted power output based on age, sex, weight and height, or a predicted VO_{2max}. The European Respiratory Society and the American Thoracic Society each make suggestions as to how these tests should be carried out for the detection of exercise-induced asthma.[13,14] In brief, these organisations recommend either a treadmill or bicycle ergometer to produce exercise at near-maximal targets for 4-6 minutes. Targets are suggested to be 80-90% of predicted target heart rate (210-age), or 40-60% of maximal minute ventilation (estimated as FEV_1 x 35). The end point for the bicycle ergometer test can be measured in terms of power, when target rate in watts = (53.76 x FEV_1)-11.07. Exercise-induced asthma is precipitated by cold, dry air, and it is important that the subject uses a nose-clip and inhales air which is less than 25° C, and less than 50% humidity. Medical compressed air is suitable for this purpose, but air-conditioned premises will often satisfy these requirements. The end-point is taken as being a 10% fall in FEV_1, although some epidemiological studies use 15%. A fall of 10% is considered significant as most normal subjects bronchodilate on exercise and therefore a fall is thought to represent a greater decrement than is measured by simple FEV_1. The reproducibility appears to be about 12-25% if the test is repeated within one month.[15] BSAC suggests a step test, but this method is not favoured by most respiratory societies.[3]

Comparative Studies

Few studies have considered large numbers of individuals and compared any two tests of bronchial hyper-reactivity, but many small studies exist comparing the response of a small number of asthmatic responses to one challenge test versus another challenge test. In a study of 108 random subjects, 25 had a positive response to methacholine versus 11 for histamine, and of an additonal 95 subjects selected for the symptom of wheeze, the values were 67 and 45 respectively,[16] while others have shown rather poor correlation in smaller studies.[17] Nonetheless, while most research suggests that methacholine is probably more sensitive than histamine as a challenge test, the two tests yield comparable results. In a study of clinically-diagnosed asthmatic subjects, all had achieved a PD_{20} with methacholine, while 84% of these subjects achieved a PD_{20} with hypertonic saline which confirmed an earlier study.[18,19] If wheeze is taken as an indicator of asthma, the sensitivity and specificity of hypertonic saline in the paediatric community was only 47% and 92% respectively, and exercise challenge was 46% and 88%.[20] In a small group of asthmatic subjects, there was little correlation between either hypertonic saline and methacholine or histamine challenges.[17,21] Likewise, a negative result for a methacholine, histamine or hypertonic saline challenge does not preclude exercise-induced asthma.[15,22]

Conclusion

Thus, the challenge tests are not interchangeable, and for the purposes of selecting diving-induced asthma, it would seem appropriate to use an exercise challenge if this is a reported provocant. Hypertonic saline can be used as a general screening tool, as exposure to these exercise or saline is likely to be encountered in diving, and hypertonic saline is less likely to demonstrate a false positive response, compared to methacholine or histamine. Methacholine or histamine challenges remain the preferred provocants for determining clinical asthma. It should be remembered, however, that an asthmatic subject who is currently taking inhaled bronchodilators or glucocorticosteroids is likely to be unreactive to these challenges and therefore may have a normal response. The use of exercise and hypertonic saline challenges does not require a licence and the equipment for the latter is relatively inexpensive. Few studies have been published in terms of the challenges performed for the purposes of diving medical examinations,[23] and none have reviewed those passed as having normal responsiveness and who have gone on to dive. It remains to be seen whether the rather more stringent restrictions on diving and asthma in Australasia remain unchanged in the face of relatively more permissive attitudes elsewhere.

References

1 Australian Standards. *Australian Standard 4005.1 Training and certification of recreational divers Part 1: Minimum entry level scuba diving*. Sydney, 1992 <http://www.standards.com.au>

2 Jenkins C, Anderson SD, Wong R and Veale A. Compressed air diving and respiratory disease. *Med J Aust* 1993; 158: 275-279

3 *British Sub-Aqua Club website*. <http://www.bsac.co.uk>

4 Cresp R, Grove C, Lalor E, Valinsky L and Langton P. Health status of recreational scuba divers in Western Australia. *SPUMS J* 2000; 30 (4): 226-231

5 Neuman TS, Bove AA, O'Connor RD and Kelsen SG. Asthma and diving (review). *Annals of Allergy* 1994; 73: 344-350

6 Bove A. Observations on asthma in the recreational diving population. *SPUMS J* 1995; 25 (4): 222-225

7 Veale A. A respiratory physician's approach to asthma and diving. *SPUMS J* 1995; 25 (4): 225-230
8 Chapman-Smith P. Asthmatic fitness to dive. *SPUMS J* 1995; 25 (4): 230-233
9 Colebatch HJH, Smith MM and Ng CKY. Increased elastic recoil as a determinant of pulmonary barotrauma in divers. *Respiration Physiol* 1976; 26: 55-64
10 Francis TJR. Pulmonary fitness to dive. *SPUMS J* 2001; 31 (4): 221-226
11 Butler BD and Hills BA. The lung as a filter for microbubbles. *J Appl Physiol: Respir Envir Exercise Physiol* 1979; 47: 537-543
12 *Divers Alert Network (DAN) website*. <http://www.diversalertnetwork.org/medical/articles>
13 European Respiratory Society. Airway responsiveness. Standardized challenge testing with pharmacological, physical and sensitizing stimuli in adults. *Eur Respir J* 1993; 6: 53-83
14 American Thoracic Society. Guidelines for methacholine and exercise challenge testing-1999. *Am J Respir Crit Care Med* 1999; 161: 309-329
15 Haby MM, Anderson SD, Peat JK, Mellis CM, Toelle BG and Woolcock AJ. An exercise challenge protocol for epidemiological studies of asthma in children: comparison with histamine challenge. *Eur Respir J* 1994; 7: 43-49
16 Higgins BG, Britton JR, Chinn S, Jones TD, Vathenen AS, Burney PG and Tattersfield AE. Comparison of histamine and methacholine for use in bronchial challenge tests in community studies. *Thorax* 1988; 43: 605-610
17 Makker HK and Holgate ST. Relation of the hypertonic saline responsiveness of the airways to exercise induced asthma symptom severity and to histamine or methacholine reactivity. *Thorax* 1993; 48 (2):142-147
18 Smith CM and Anderson SD. Inhalational challenge using hypertonic saline in asthmatic subjects: a comparison with responses to hyperpnoea, methacholine and water. *Eur Respir J* 1990; 3: 144-151
19 Araki H and Sly PD. Inhalation of hypertonic saline as a bronchial challenge in children with mild asthma and normal children. *J Allergy Clin Immunol* 1989; 84: 99-107
20 Riedler J, Reade T, Dalton M, Holst D and Robertson C. Hypertonic saline challenge in an epidemiological survey of asthma in children. *Am J Respir Crit Care Med* 1994; 150: 1632-1639
21 Belcher NG, Lee TH and Rees PJ. Airway responses to hypertonic saline, exercise and histamine challenges in bronchial asthma. *Eur Respir J* 1989; 2: 44-8
22 Kivity S, Greif J, Reisner B, Fireman E and Topilsky M. Bronchial inhalation challenge with ultrasonically nebulised saline: comparison to exercise-induced asthma. *Ann Allergy* 1986; 57: 355-358
23 Anderson SD, Brannan J, Treillion L and Young IH. Lung function and bronchial provocation tests for intending divers with a history of asthma. *SPUMS J* 1995; 25 (4):233-248

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DISCUSSION following Meehan and Thomas papers

Mike Bennett, Chairman

I am sitting in the hyperbaric unit with a diving candidate, who gives a history of wheeze and took some Ventolin (salbutamol) 6 or 7 years ago but he thinks he has been OK since then, in front of me. I ring up wanting to do some provocation testing to see whether this person can safely be allowed to do a dive training course. What do you say to me?

Paul Thomas

As a respiratory physician I would say to you that I am happy to organise a provocation test but I do not actually certify divers. That responsibility lies with you.

I think saline is adequate. However I am not very fond of it because it is not very sensitive for the sort of work that I do. My experience with it is that there are some people, who quite clearly have asthma, who do not respond. That may be because some of them have been on treatment. Also one does not really get a very clear response in a large number of patients. In a lot of cases I was not sure whether they had asthma. Probably for divers with a history of wheezing it is probably a quite adequate test. I do not think it is sensible to exclude people because they have a positive methacholine test but no other symptoms.

Debbie Yates, Respiratory physician, Sydney

I probably would use saline simply on the basis that it is not a terribly good test and I think that people with asthma who dive are not at a great risk and therefore if you do a bad test, you will actually let more of them who perhaps should be allowed to dive, dive anyway.

James Francis

Well said. We are starting this discussion from the position that asthma is a risk factor for barotrauma. However there is no good evidence to support that belief.

We have got ourselves into is sort of Catch-22. Many years ago, people thought about the mechanisms of pulmonary barotrauma. They thought airways obstruction was the thing to avoid. They thought that since asthma can obstruct airways it would be best to stop these people diving.

Which is what happened. So no data have been collected on the effect of asthma on diving and the risk of pulmonary barotrauma. Since there is no evidence that asthmatics are fit to dive they are kept out of the water! We know that asthmatic people die in the water. They quite commonly drown, but we do not know about the risk of pulmonary barotrauma in these people. Cathy Meehan's data tell me that all these tests are irrelevant. That is my conclusion.

There was a very good workshop, which David Elliott held before the UHMS meeting in Palm Beach in 1995, in which the entire day was spent discussing asthma and diving. After all the luminaries had given their talks we reached the conclusion that there really is no evidence for asthma being an important risk factor and that what we ought to do is to try to roll back the restrictions that we apply to people diving with reversible airways disease. Perhaps to the point, eventually, where we let them all dive.

The UK approach to asthma and recreational divers, is now to allow well controlled asthmatics to dive and watch carefully to see if they develop pulmonary barotrauma with greater frequency than those who have no apparent manifestations of asthma. These asthmatics are advised to test their peak expiratory flow twice a day and that their peak flow should be within 10% of their best for 48 hours before they go diving. They should not dive if they have required medication for an acute exacerbation in that 48 hours. However this change in the UK is only for sports divers. Asthmatics are still banned from military and commercial diving. If these asthmatics become over represented in the barotrauma statistics it will become apparent that we have gone one step too far and the restrictions will be stiffened again. But at the moment there is no apparent increase in pulmonary barotrauma amongst those asthmatics who are well controlled and are allowed to dive. If this situation persists, the next step will be to assess those who are not quite so well controlled, let them dive and see what happens. I am convinced that this is the correct approach rather than to dream up arbitrary lung function standards that may be completely irrelevant.

Simon Mitchell, Brisbane

Is there any evidence that the diving population in England have more problems with asthmatics than we do in Australia, given that your standards are much more liberal than ours.

James Francis

No. Pulmonary barotrauma in sports divers in the UK is very rare. Even in those who we have allowed to dive with well controlled asthma.

Paul Thomas

That point is borne out by the fact that when one does surveys of Australian divers asthma is just as common as in the ordinary community.[1] A large number of people actually do have asthma and continue to dive with it.

Simon Mitchell

If I interpret Cathy Meehan's data correctly, using Carl's criteria, 46% of them would have been made unfit. The whole group had done 70,000 incident free dives except for 3 cases of DCI, a DCI rate of 0.4 per 10,000 dives. The group of divers who should not have been diving probably did about 35,000 dives. Even if all 3 cases of DCI were in this group the DCI rate would be 0.8 per 10,000 dives.

James Francis

As you have just shown, asthmatics do not appear, on the basis of Cathy's data which included a big group of dives, to be any different from the general population. Actually asthmatics or non-asthmatics is irrelevant because Fred Bove calculated a DCI rate, using reasonable methodology, certainly the best that has been available, in the general diving population of 1 to 2.5 cases per 10,000 dives. So even if all three cases were in the asthmatic group, that is exactly what one would expect in the general population.

Debbie Yates

I think it would be helpful to liaise with the Thoracic Society to develop a unified approach. The Thoracic Society guidelines are less conservative than some of the others. There is a mechanism for publishing joint position papers which would probably have a fairly good effect. It would be one way to set about changing the standards, which I think are probably unreasonable. I say this because in clinical practice, it is much better that people should be on appropriate medication, including inhaled steroids, and dive safely than to hide it, which is what diving asthmatics do.

As there are no good data a prospective study of asthmatics diving, on a multi-centre basis, would not be very expensive and would be worthwhile doing. It would have to be done on a collaborative basis with divers. One might want to use provocation tests in order to properly make a diagnosis of asthma. Such an investigation needs to be done because the data so far are not clear and it does need to have an evidence base to it.

James Francis

That is a good idea but there may be ethical difficulties with a trial like that, given that you have got such very stringent regulations at the moment. Perhaps repeating Cathy's study of current divers lung function with many more divers might get the rules relaxed a bit. Test hundreds or even thousands of divers and the numbers of dives that they have done. If there is a large population of people who would fail provocation tests and they have done many thousands of uneventful dives, that I think is pretty good evidence for amending the current restrictions.

Cathy Meehan

The Australian standard is based on the SPUMS position and the SPUMS position is based on the Australian Thoracic Society position so they are really similar. The

SPUMS dive medical does say that current acute asthma or hyper-responsiveness is an exclusion and then refer on for specialist medical opinion, including provocation testing, which then goes on to the Thoracic Society guidelines.

Debbie Yates

I was suggesting was that SPUMS and the Australian Thoracic Asthma Society could perhaps together produce new guidelines. There is a mechanism for doing that within the Thoracic Society. It would not be difficult to do, and it would probably be extremely helpful and clarify the position. At the moment there seems to be a lot of emphasis on provocation tests which are not very helpful, so it is certainly something which could be very easily facilitated. All that needs to be done is to write to the President of the Thoracic Society and the request will be passed on to our committee. The Australian Standard would then follow on from the SPUMS medical so that could be done and then the Australian Standard would change as well.

Drew Richardson, PADI

Paul Langton's study last year showed that we already teach asthmatics to dive, albeit unknowingly.[2] We certainly do not want to put people in harms way and if the diving medical community feel that prohibiting well controlled asthmatics from diving is an outdated "sacred cow" that now is no longer supportable, then I think we would happily accept such people. There is no inherent barrier to accepting asthmatics. I think it is a medical clearance question which may not be an issue from what we are hearing here.

Cathy Meehan

The SPUMS medical does not state that a person is fit to dive. It says "I can find no conditions which are incompatible with compressed gas, scuba and surface supplied breathing apparatus (SSBA) and or breath-hold diving" and the student accepts the risks of diving which have been explained to him or her, which is informed consent. From being on the Australian Standard Committee for recreational diver training I got the impression that the training agencies felt that a certificate that did not state "this student is fit to dive" puts undue pressure on the dive instructor.

Drew Richardson

We try to keep the dive instructors out of any interpretation of medical standard or patient condition. We do not want them practising medicine. However it is difficult, I appreciate your situation. In 1995 we had a workshop at SPUMS ASM where we came up with some language about, finding no conditions which would render this person incompatible with diving which can mean that there may have been a discussion between the physician and the diving candidate about how to monitor their health situation. James has brought up the change from the UK. The bottom line is from a legal, ethical, approval point of view, we look for the tick at the bottom of the form. If a physician is not willing to do that we would not be comfortable accepting them. So you may be able to advise that patient on how they might monitor their health condition and still feel comfortable ticking approval. However if there is anything that conditions approval for an asthmatic to dive we would advise our instructors to not accept that certificate. There has got to be a medical yes or a no in this type of situation from our point of view.

Simon Mitchell

I have been using the SPUMS medical certificates for years which employ the kind of language that Drew was just describing and I have never had a problem with them being accepted by diving instructors. We have all tried to avoid making a clear cut statement of fit or unfit to dive because we all agree that it is nonsensical to say fit or unfit. But I have certainly used statements like, I can find no conditions that are incompatible with diving.

That middle ground suits our desire not to make a blanket statement of fitness but it also seems to meet the diving instructors requirement for an indication from a physician that this person is able to go diving. I think that's the middle ground that we have struck and it seems to work.

Mike Bennett

This brings up the question of ethics. As I understand it, Cathy, you measured the bronchial responsiveness in a group of commercial divers. I think that you implied that at least some of them would be defined as asthmatic and therefore unfit to fulfil their occupation. Were there any ethical problems raised?

Cathy Meehan

To correct your assumption, the divers were not all occupational divers. They were all volunteers and some were recreational, some were occupational. The agreement with the volunteers before the trial was that the results would be kept confidential because the occupational divers would need to be protected. It was passed by the Ethics Committee.

Mike Bennett

Does anybody have a comment about that?

James Francis

One must have to have a confidentiality clause in a protocol like that otherwise, quite simply, there would be no volunteers.

Mike Bennett

Does anyone have an ethical problem when you are now in possession of new knowledge which would clearly disqualify someone from their occupation?

It is only a problem if you believe that asthma is a danger to divers. James is someone who does not believe it. Is there someone in the room who believes asthma is a risk? Because if there is not then we have no ethical conflict.

Guy Williams

Would it be in the diving community's best interests if SPUMS and the Australian Thoracic Society got together at a not too future date and perhaps had a meeting where this was discussed to come up with a consensus statement?

Robyn Walker

I would not encourage an acute asthmatic, or someone who has highly variable asthma, to dive. But there are circumstances when people who have well controlled asthma, at that particular time, might be fit to go diving.

We have no data on the population of asthmatics who might have gone diving and who have stopped diving because they got into trouble or they did not feel comfortable in the water. Not necessarily had pulmonary barotrauma or decompression illness, but needed assistance from a buddy or to get back to the boat.

I do not believe that all asthmatics should go diving. We need to be careful how we approach a relaxation of the rules banning asthmatics from diving. Although there is not a lot of data to support it, that does not mean that there is no problem. We just need to be careful.

Barbara Trytko

I know that everyone keeps saying the risk to the diver of asthma is theoretical, but if an asthmatic develops bronchoconstriction at 20 m the consequences could be disastrous. The fact that we do not have a huge number of asthmatics who end up with barotrauma or CAGE does not mean that it is not going to happen. It just means that it is uncommon or even rare.

John Knight, Melbourne

The only evidence we have got of deaths associated with asthma in Australia point to the fact that they do not die from pulmonary barotrauma, they die on the surface from being unable to keep their heads out of the water. They get short of breath and drown.

Debbie Yates

I do not think anybody would want to send an uncontrolled asthmatic diving. There are fairly good data that demonstrate that using inhaled corticosteroids does not only alter the methacholine broncho hyper-responsiveness, but also the shape of the dose response curve. So those on inhaled steroids are actually much less likely to undergo catastrophic bronchoconstriction, at least as far as we know because we tend not to do too many dose response curves on these people.

It is really important that we do examine asthmatics properly and we do not just look at the asthmatics who do dive, because there are problems with bias and so on. We need to do a proper cross-sectional study. That is not too difficult to do because, if we liaise with the Thoracic Society, there are a number of epidemiological studies being done. It is very easy to pull out people from the larger studies where we have the data already. I think that would be really useful.

I totally understand that it takes years to go through the process of changing things and caution should always be exercised. But we should have open minds as we know that things have changed in the UK and that is probably the sort of direction we should be going because of the fact that inhaled corticosteroids are actually very useful.

James Francis

For some reason I get the feeling that people think I would let all asthmatics go diving. At no point have I said that and I do not think anybody in the room has said that.

I am a sceptic and I do not believe that asthma is a very serious risk factor for pulmonary barotrauma.

Certainly, if somebody has got an acute attack I think it is very likely they will be at an increased risk of barotrauma. What one then has to think about is the rate of ascent. If there is a very controlled rate of ascent, even though they have narrowed airways, they should get away with it. Their peak flow is going to be down but they should be able to blow out enough air to get safely to the surface. The one situation where they might be at serious risk of barotrauma is having a mucus-plugged airway with gas trapped behind it.

More importantly, somebody with acute asthma should not be paddling in the water, let alone diving.

Cathy Meehan

We have to be very careful about interpreting my presentation, with the 70,000 dives because we have to consider that these divers have naturally selected themselves. The ones that had bad experiences have stopped diving or died. And so we are looking a naturally selected group.

There are triggers in the diving environment and even though these divers did not develop barotrauma other divers have drowned on the surface or not been able to get back to the boat.

James Francis

What we do have is evidence that there is a group of people, who would be diagnosed as asthmatic if they went to a doctor today and got tested appropriately, who have made many thousands of dives uneventfully. That at least should put a question mark in your mind as to whether or not asthma is a disqualifying condition.

Simon Mitchell

Like James, I am not saying that we should let all asthmatics go diving. There is a big difference between my practice and what is said in the Thoracic Society guidelines, no wheeze for 5 years. I let a lot of people who have wheezed within 5 years go diving, but only after the application of a fairly stringent protocol of assessment and education. And I document it.

I would like to see the Thoracic Society guidelines move to a system of a little bit more like that, in recognition of what James and Cathy have pointed out.

But no one is saying "Let's let all asthmatics go diving". Definitely not. It is really important we understand that.

Robyn Walker

We have to be careful that people reading about asthmatics and diving do not get the impression that diving is for every asthmatic. It is not. It is only for those who are at no greater risk than the general population.

I do not believe any of us rigidly follow the guidelines but we interpret them according to our own experience and the patient's background. Twenty years ago we did not have the data on inhaled steroids which we do have today. And we do need to move on, but I feel the need to caution doctors, who may not do diving medicals very often, that not every asthmatic can dive safely. We need to be very careful in how we document our position.

Drew Richardson

PADI will still be sending divers to you, even when they utilise the RSTC form, as asthma is still screened, so affected divers are going to be ticking it and looking for advice. Perhaps what Simon has just put forward is the best approach to come up with: advice to provide to clinicians around the world who have to review prospective divers who have ticked in the yes column that they have a history of, or presently are suffering from, wheezing or asthma.

Mike Bennett

Points well made. Can we resolve then from this discussion that at some level SPUMS and the Australian Thoracic Society will investigate a joint and possibly modified position?

References

1 Simpson G and Meehan C. Prevalence of bronchial hyper responsiveness in a group of experienced scuba divers. *SPUMS J* 1995; 25 (4): 249-253
2 Cresp R, Grove C, Lalor E, Valinsky L and Langton P. Health status of recreational scuba divers in Western Australia. *SPUMS J* 2000; 30 (4): 226-231

ARTICLES OF INTEREST REPRINTED FROM OTHER JOURNALS

MECHANISMS OF DECOMPRESSION ILLNESS III

Bill Hamilton

Key Words

Barotrauma, cardiovascular, cerebral arterial gas embolism, decompression illness, equipment, physiology, reprinted.

Organised and chaired by James Francis, this series of popular one day precourses originally created by David Elliott and now being ably continued on this topic by James Francis, examines decompression disorders in a comprehensive way. One objective is to show what is not known as well as what is. Although intensive discussion was encouraged and did indeed occur, Dr Francis makes the point that these are not workshops, and there is no attempt to reach consensus on complex issues. This year's program collected topics not yet covered, mainly limb and skin bends, cardiopulmonary disorders, spinal DCI, and ear barotrauma.

Simon Mitchell of Brisbane summarised the status of the search for the mechanism of pain in joint bends. He offered several hypotheses, including gas formation in the joint itself, gas in the bone marrow cavity, venous sinusoids, or under the periosteum autochthonous bubbles in pain-sensitive tissues like tendons and ligaments; a central location from which pain is referred to the joint; or the relief of inflammatory substances. The latter may explain the resistance of some cases to recompression and the tendency of some pain to migrate; bone medullary gas is consistent with the characteristic of deep and poorly localised pain.

Tom Buttolph of NMRC told about the various forms of skin bends, spanning the familiar itching and rash due to inert gas bubbles and related to skin blood flow, to cutis marmorata, the potentially more serious marbling type of lesion which may be neurogenic and related to neurological decompression sickness. He mentioned also the distinctive white lesions seen in counter diffusion situations. The final common pathway of skin rash and itching may be histamine release.

Alf Brubakk of Trondheim covered cardiopulmonary decompression illness, the most prominent form of which is the always-serious chokes, due to bubbles lodging in the lung vasculature. These bubbles cause endothelial damage. The lungs are also a site of long-term effects of diving such as reduced CO diffusivity; these effects may also be due to oxygen exposure. Some pulmonary artery bubbles (VGE) are present after most decompressions, but lung symptoms, although rare, are statistically related to DCI. In a slide more or less unrelated to this topic Dr Brubakk showed a series of dives with interesting VGE data. An ABB profile with a slow linear ascent showed fewer VGE than a standard US Navy profile, and when these ascent rates were doubled and the stop times halved there were even fewer bubbles. There were enough replications in different animals to confirm the validity. Possible explanations for this were discussed.

Hugh Greer of Santa Barbara led off the section on spinal cord diseases with a description of spinal DCS as a unique trauma model, because single clinical lesions can be precisely located, whereas spinal DCS is multifocal. For example, if symptoms are generally one-sided one should think of arterial gas embolism, but a painful, paralysed limb is often spinal cord disease. In an interesting hypothesis he suggests that apoptosis (programmed cell death) might be a pathway, the mechanism for initiation being the withdrawal of metabolic support, presumably due to bubbles or other congestion. Loss of circulation for half an hour causes no effect, after 1 hour paresis results, and blockage over 1 hour may lead to late changes. Dr Greer did not offer other mechanisms for spinal injury; three of these were covered by the next three speakers.

Ian Calder from Cambridge, UK, dealt with gas embolism, the apparent blockage by bubbles of circulation to certain spinal tracts, and offered some philosophy about the process in general. He quoted the old adage, "Know syphilis and all things medical will come unto you" and applied that to a nasty little bubble. As a pathologist he has examined many spinal cords, including those of divers without overt decompression sickness or illness who died of unrelated causes, and found many focal cord lesions that could well have been caused by bubbles. He mentioned fat embolism as an alternative possibility, and he acknowledged the cascade of effects of disturbance to the intima of blood vessels.

Fred Bove of Temple University presented the hypothesis that venous infarction may be a mechanism for spinal cord decompression sickness. Brain blood flow is 80 times that of the cord so arterial bubbles should go there preferentially, but the brain is normally spared. This venous infarction hypothesis and elegant experiments to support it were presented, with colleagues Elliott and Hallenbeck, at the Sixth Underwater Symposium in Freeport in 1972. Dogs were given spinal DCS and X-rays taken in the chamber showed no venous plexus blood flow, and this correlated with pressures measured during lung inflation. Coagulation and microscopic studies agreed.

James Francis made the case for autochthonous bubbles forming directly in spinal tissue as the cause of the spinal DCI symptoms. He pointed out that venous infarction normally takes time to develop, but that the onset of spinal symptoms is prompt, and that clinical venous infarction symptoms are not the same as those of spinal bends. Dogs wired for somatosensory evoked responses (SSEP) were exposed to a profile of slightly higher pressure with a shorter exposure, decompressed, and monitored for a drop in the SSEP. The spines of those showing a drop were fixed and stained, and non-staining, space-occupying lesions (NSSOLs)(that looked an awful lot like bubbles!) were found. These were predominantly in the white matter despite the 6:1 dominance of gray:white. These NSSOLs were not found in controls. Other animals given gas embolism by injection of bubbles showed oedema of the gray matter but none of the "bubbles." The time course of these events agrees with the concept that a short blockage does not damage a cell, but also that there are delayed effects due to inflammation and lipid peroxidation. In submarine escape accidents with no gas loading, the bubbles go to the brain.

The next presentations considered ear barotrauma. Andy Meredith of Hastings, UK, gave a succinct history of inner ear barotrauma (IEBT), followed by a review of mechanisms and methods of diagnosis. Mechanisms include perilymph bubbles, counter-diffusion, vascular embolism, impaired performance, and membrane rupture. The diagnostic process includes consideration of the profile and time of occurrence, the counter-diffusion situation, audiometry, electrocochleography, and some specialised tests. He pointed out that one has to treat these cases early lest they get well on their own, but when there is damage to the hair cells they do not regenerate. He takes issue with Otto Molvaer's recommendation not to recompress IEBT cases and feels that suspicion of IEBT should not preclude recompression. Divers who have gone back to diving after IEBT have shown no problems.

Ian Calder looked at the pathology of ear barotrauma and decompression sickness (due to "effervescent gas"). Ear damage as a result of pressure has been known for a couple of centuries, with much of this involving the middle ear and the round and oval windows. In the inner ear, vestibular hair cells may regenerate but those in the cochlea do not.

Andy Meredith began a look at the middle and outer ear with a review of the physiology and anatomy of the Eustachian tube. Septal and sinus surgery can be effective, but the physiology can be more important here. When middle ear barotrauma does occur it is treated with pain relief, occasional decongestants, steroids, and antibiotics. Outer ear barotrauma or "reversed ear" is due to blockage of the outer ear canal. This can often be prevented with perforated ear plugs.

Frank Butler of the US Naval Special Warfare Command dealt with equipment barotrauma. Such cases can result when a heavily-weighted diver falls off the stage. Suit barotrauma or squeeze is caused by not inflating the suit during descent and may lead to skin lesions. A case shown had a pattern resembling a lightning strike. Failure to equalise a mask can cause eye damage. He presented a case of vision-threatening orbital haemorrhage with a successful outcome. He admitted, however, that bar fights cause more orbital haemorrhage than diving. He also mentioned the reverse problem, such as over-inflation of a buoyancy device leading to uncontrolled ascent and the possibility of pulmonary barotrauma and arterial gas embolism.

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INTERNAL CAROTID ARTERY OCCLUSION FOLLOWING SPORTS DIVING

P J Hughes

Key Words

Case report, injury, medical conditions and problems, reprinted, trauma.

Abstract

A case of internal carotid artery occlusion following a sports dive is described. The investigation and management of this condition is discussed with particular reference to blunt trauma being a risk factor for carotid artery occlusion.

Case report

HISTORY

A 28 year old lady returned from a two-week holiday in the Indian Ocean where she had been sports diving during the beginning of the second week. The day before returning home she experienced some diarrhoea. This rapidly settled with kaolin and morphine.

On the day of her return to the United Kingdom she complained of headache. She awoke several times that night and when she attempted to talk had great difficulty with word-finding. This was attributed to tiredness.

By the following morning this problem had worsened and there was evidence that both her short- and long-term memory were impaired. For example, she was unable to remember her own age, address or even her boyfriend's surname. Her writing had become all "jumbled" and her boyfriend felt that her walking was impaired and described her walking as "slow". There had been no further bowel disturbance and no urinary disturbance. Although she felt rather stiff there had been no rigors and no symptoms to suggest seizure activity.

Whilst on holiday she had sustained numerous mosquito bites. She had drunk only bottled water. Previous surgical intervention included an appendicectomy and right knee cartilage operation. Her only medication was the oral contraceptive pill.

EXAMINATION

She was orientated in person but not time nor place. Her speech was slow, answering "Yes" or "No" to most questions with evidence of a profound nominal dysphasia. Her memory was poor. The formal examination of the cranial nerve territory was otherwise normal. On examining the motor system she was able to obey simple commands. The limb examination revealed normal tone and power. There were no involuntary movements. There was no reflex asymmetry but the right plantar response was consistently extensor. Light touch was normally perceived. The general medical examination revealed a pyrexia of 38°C per axilla. Her pulse rate was 100 per minute and in sinus rhythm: she was normotensive. The remainder of the clinical medical examination was normal.

INVESTIGATIONS

The haematological and biochemical profiles were normal. Blood cultures were negative and films were negative for malaria parasites. Chest X-ray and CT head scan both normal. A CSF examination was undertaken, this revealed clear, colourless CSF at normal pressure; the protein was slightly elevated at 617 mg/l (NR<500); less than 1 WBC, no organisms were seen; virus was not isolated in cell culture. The CSF IgG was also increased at 40 mg/l (NR up to 30 mg/1) isoelectric focusing for intrathecal oligoclonal IgG bands was negative. An EEG examination revealed left central to temporal slow wave disturbance.

MANAGEMENT

The combination of pyrexia, speech disturbance and alteration of higher function with mild EEG changes resulted in a presumptive diagnosis of viral encephalitis. She was commenced on acyclovir.

A subsequent MRI head scan revealed areas of increased signal on the T2-weighted scans in the territory of the left middle cerebral artery which were interpreted as a recent infarct (Fig 1). No additional lesion was seen. Angiographic sequences revealed a long tapering segment of narrowing, extending from just distal to the origin of the left internal carotid artery, and the artery was completely occluded several centimetres from the origin (Fig 2). Both vertebral arteries were large and patent and the opposite carotid artery appeared to be normal. There was no evidence of arteritis. No intimal flap could be identified.

On obtaining the results of these vascular studies the patient was anti-coagulated with heparin and subsequently warfarin. Prior to anticoagulating the patient, a thrombophilia screen was requested including Protein C, Protein S and lupus anticoagulant. This detailed screen did not reveal any abnormality.

Her clinical condition improved and she was discharged home after 14 days having made a full recovery. Out-patient follow-up at six months confirmed a normal neurological examination. Repeat MRI examination at six months confirmed that the internal carotid artery had become patent with normal flow.

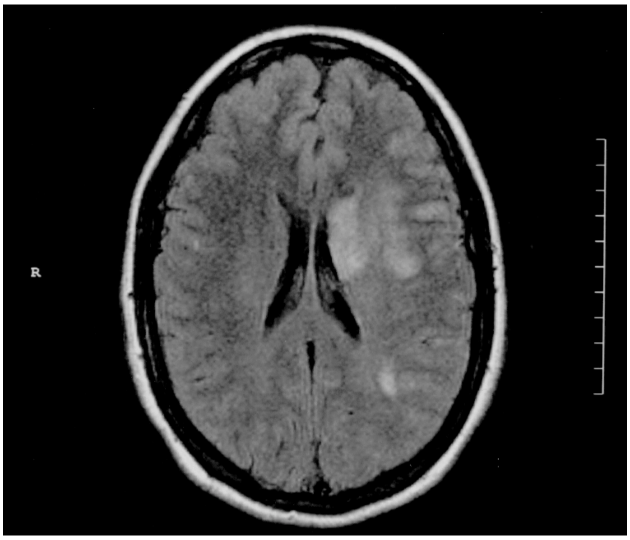

Figure 1. MRI demonstrating left hemisphere infarct.

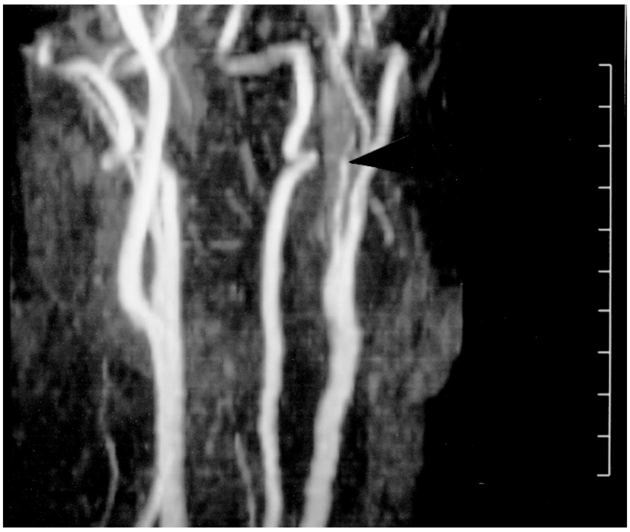

Figure 2. MRI demonstrating occlusion of the left internal carotid artery (arrow)

Discussion

It subsequently emerged that this lady had been having difficulty using her diving equipment. She recalled that there had been blunt trauma to the left side of her neck on several occasions whilst struggling with the harness. It was concluded that this lady had sustained intimal damage as a consequence of this blunt trauma which evolved to internal carotid artery occlusion.

The onset of focal neurological disturbance following diving should always raise the spectre of decompression illness (DCI). However, such events normally occur within 72 hours of diving and although the possibility of DCI was considered by her referring doctors, the combination of a history of a diarrhoeal illness with mild pyrexia suggested, at least on the initial assessment, that this could be an infective process.

Although changes of infarction can occur in an encephalitic illness, the characteristic MRI changes are those of bitemporal and/or bifrontal signal change and the unilateral nature of the MRI changes prompted further evaluation. Carotid artery occlusion may be a spontaneous or trauma-induced event and can occur in children, adolescents and adults. Dissection of the wall of the internal carotid artery may cause a distinctive headache syndrome with pain involving the neck, the ipsilateral head and the periorbital area. The headache may be associated with an ipsilateral Horner's Syndrome and/or contralateral focal neurological symptoms or signs.[1]

Blunt neck injuries are more subtle causes of ischaemic stroke and TIA because the injury may have seemed rather trivial at the time or the stroke occurs days or weeks later. Blunt trauma usually causes intimal tearing or dissection with complicating thrombosis or embolism.[2] The internal carotid artery and, very rarely, the common carotid artery, are more vulnerable to a direct blow to the neck or to compression, whereas the vertebral arteries are more prone to rotational and hyperextension injuries at the level of the atlas and axis.[3,4]

Patients may deteriorate because of artery to artery embolism arising from the thrombus found at the site of dissection and, from the evidence from uncontrolled series of small numbers of patients, many clinicians recommend anticoagulation. The prognosis is generally good with a low frequency of recurrence.[5]

This patient experienced an, as yet, unreported complication from sports diving: internal carotid occlusion secondary to blunt trauma to the neck whilst manhandling breathing apparatus.

References

1 Fisher CM. The headache and pain of spontaneous carotid dissection. *Headache* 1982; 22: 60-65
2 Davis JM and Zimmerman RA. Injury of the carotid and vertebral arteries. *Neuroradiology* 1983; 25: 55-69
3 Hughes JT and Branwell B. Traumatic thrombosis of the internal carotid artery in the neck. *J Neurol Neurosurg Psychiat*r 1968; 31: 307-314
4 Frisom GB and Anzola GP. Vertebro basilar ischaemia after neck motion. *Stroke* 1991; 22: 1452-1460
5 Zetterling M, Carlstrom C and Konrad R. Review article. Internal carotid artery dissection. *Acta Neurol Scand* 2000; 101: 1-7

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NEW DIVERS TOO AMBITIOUS SAYS COASTGUARD

Key Words
Deaths, decompression illness, incidents, recreational diving, reprinted.

A Maritime and Coastguard Agency report on 1999 diving accidents that involved emergency call-outs has highlighted three main areas of concern over sport-diving incidents: the number of cases involving rapid ascents, the dangers of deeper diving, and problems relating to divers and their boats. The concerns reflect closely views expressed in the BSAC's 1999 *Diving Incidents Report* (see *SPUMS J 2000;* 30 (2):117-118).

British diving fatalities, according to the MCA, numbered 16, against 15 in 1998. Four occurred on 5060 m dives, reinforcing the BSAC finding that a relatively higher proportion of incidents below 50 m lead to a fatality. There appeared, said the MCA, to be a trend for "some sport divers... to push the limits". Of the 185 attended incidents involving divers at sea, the MCA reports that 105 required medical treatment. The "overwhelming majority" were due to rapid ascents.

"Divers are simply failing to maintain correct buoyancy control." said Reg Hill, MCA Diving Officer and a diver. "The main reason seems to be a lack of adequate training, which I also suspect is responsible for situations involving unnecessary panic." His comments echoed the BSAC's view that better training is required in use of drysuits and BCs. "I get the feeling that increasing problems with deep diving, rapid ascents and other matters are partly due to newcomers to the sport expecting to do too much too quickly," Reg Hill told Diver. Hill added: "I take phone calls from people who want to take up diving and, almost in their second breath, they're talking about nitrox, tri-mix, rebreathers and the lure of deep wrecks. Magazine treatment of deep-diving, including stunts for the record books, probably hasn't helped, because some people will inevitably see those people as heroes and role models." Last month the BSAC's Brian Cumming called for divers to stay within their limits and build experience gradually.

Finally, the MCA recorded a "significant increase" in boat failures, 39 compared with 24 in 1998. As a result, the number of boat-to-diver separation incidents attended had also risen, from 33 to 43. Although denoting similar trends, MCA and BSAC figures vary because only the BSAC includes inland dives and sea incidents not involving the rescue services. MCA statistics cover the calendar year, the BSAC's October to September.

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CIGARETTE SMOKING AND TRANSCUTANEOUS OXYGEN TENSIONS: A CASE REPORT

Strauss MB, Winant DM, Strauss AG and Hart GB.
Undersea Hyper Med 2000; 27 (1): 43-46

We report the effects of acute smoking cessation on transcutaneous oxygen ($PtcO_2$) measurements in room air and with hyperbaric oxygen (HBO_2) of an extremity at risk for amputation. The reports on cigarette smoking and $PtcO_2$ do not discuss acute smoking cessation. $PtcO_2$ measured 46 h after smoking cessation increased 10% while breathing room air and 34% with HBO_2, as compared to measurements made before smoking cessation.

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Key Words
Abstract, hyperbaric research, medical conditions and problems, oxygen, reprinted.