THE NO-AIR PROBLEM IN SCUBA DIVING

An alternative approach to prevention

Douglas Walker

The recent SPUMS Workshop on Emergency Ascent Training[1] appears to have been based on the assumption that making a few "emergency ascents" during the basic scuba training course produces a diver who will be safer when he or she encounters an "inevitable" low/no air situation.

The same inappropriate assumption was made during the Workshop run by the Undersea Medical Society (UMS) in 1977.[2] There is no report that anyone seriously questioned this assumption at either the SPUMS or UMS Workshop. Indeed, no diving experts who held other views were represented. Discussion was limited to a comparison of the various ascent options. At least there was one dissenter in the printed report of the UMS Workshop, Dr Eric Kindwall,[3] though he was neither present at the meeting nor was his paper presented there. Although McAniff[4] gave a highly negative opinion of the proposal to include such practice as an essential part of basic training, he failed to follow the logic of his own data and apparently accepted statements of opinion that the practice was essential. A cautious legal opinion[5] was ignored, if the printed report accurately conveys what was discussed.

A more appropriate subject for a Workshop would have been an examination of the factors which favour the development of a low/no air situation, and whether the inclusion of a few practice "emergency ascents" during a training course can be shown to influence the course and outcome of such a situation.

There is a chronic dichotomy of approach to the subject of safety and this can be illustrated by considering the example of how to make a cliff edge path safe for users. One can either construct a fence at or near the cliff edge to stop people from falling over the edge or one can accept that such accidents are inevitable and provide an ambulance service at the foot of the cliff plus a short course in cliff climbing. Although this rather over simplifies the options in the scuba diving situation it identifies the basic differences in how one can approach the management of any safety related problem.

It has been well said that for every complex problem there is a solution which is simple, appealing, and wrong. The essence of criticism directed at the design of the SPUMS Workshop was distilled by G K Chesterton through the words of his creation Father Brown, who said "It isn't that they can't see the solution. It is that they can't see the problem". So what is the problem which requires attention ?

The purpose of all basic scuba training courses is to produce a diver who is aware of the problems he or she is likely to meet, is able to recognise them at an early stage in their development and respond correctly and calmly to them and is aware of the limitations of his or her knowledge and ability. The time available for training is necessarily limited by financial considerations, so it is mandatory for courses to concentrate attention on developing those skills which are demonstrably essential, and the primary one is to avoid allowing a low-air situation to develop. The Provisional Reports[6] on diving-related fatalities show that nearly half (64/153) of the diving deaths in Australia occurred in grossly inexperienced divers (Table 1). This a very clear indication that the above level of training is not achieved by a proportion of those certified. Eleven others had not dived for a long time

The case for regarding practice in out-of-air ascents as essential has three main elements :-

1 That it is inevitable that however well trained the diver is, he or she will, at some time, unexpectedly run out of air.

2 That practice under controlled conditions on a few occasions of some form of "no personal air supply" ascent procedures will produce a skill which will persist, and work faultlessly, in some for-real situation at some time in the future.

3 That absence of such an item in the training will decrease the safety of the diver after certification.

This paper was written to refute these propositions, in the hope that it will stimulate a long overdue investigation of the low-air problem in scuba diving. I have made several unsuccessful attempts to persuade two major diving organisations to take part in such an investigation. It is unlikely that this paper will alter the training philosophy of any of the main American based instructor organisations, as this subject has become one of faith and dogma and as such is beyond being influenced by argument. This may be the reason why no investigations have ever been made into whether the emergency ascent training produces any practical benefit, and the lack of requests for input into the discussion from the Royal Australian Navy (RAN), the Royal Navy (RN) or the British Sub-Aqua Club (BS-AC).

Is running out of air inevitable ?

There are only two basic reasons for a scuba diver to run out of air during a dive, either there has been some equipment malfunction, or the diver is responsible for the situation. The "acceptable" example of the former occurs in cold water diving where a freeze-up of the regulator can result in a free flow of air. However training can prepare divers to meet such situations.[7]

TABLE 1

LOW EXPERIENCE LEVELS (78 OF 153) SCUBA DEATHS 1955-91

DIVERS UNDER INSTRUCTION OR WITH MINIMAL EXPERIENCE (64)

Case	Experience	Comment	Equipment	Remaining Air
SC 72/6	Just trained		Hired	None
SC 72/10	Very inexperienced		Hired	Low
SC 72/11	During training	Panic ascent	Own	Low
SC 72/12	During training	Surface change to snorkel on 1st OW dive	Diveshop	Yes
SC 73/1	2nd OW dive	1st OW was on just-completed course	Own	Yes
SC 73/6	2nd use of scuba		Own	Not stated
SC 73/7	Newly trained		Own	None
SC 73/8	Part trained, inexperienced		Own	Yes
SC 73/9	1st dive after course	Cardiac death	Own	Yes
SC 73/10	Very inexperienced	Alcohol involved	Borrowed	Not stated
SC 74/1	1st use of scuba	In a muddy dam	Borrowed	None
SC 75/1	1st use of scuba		Hired	Yes
SC 75/4	1st use scuba lesson	Not wearing fins	Not stated	Yes
SC 76/1	2nd use of scuba		Not stated	Yes
SC 76/2	Not trained, inexperienced	9th dive	Own	Yes
SC 76/8	Probably 1st use of scuba	Cardiac death	Not stated	Not stated
SC 77/1	2nd use of scuba	1st time was in a rock pool	Borrowed	Yes
SC 77/3	1st sea dive		Hired	Low
SC 78/1	2nd use of scuba	Entangled in weeds	Own	Not stated
SC 78/2	2nd use of scuba		Own	None
SC 78/3	Just trained		Own	Low
SC 78/4	Probably very inexperienced		Hired	Yes
SC 78/5	Part trained	Dangerous dive location	Borrowed	Yes
SC 78/7	During training	Deep dive in dam	Own	Yes
SC 78/8	Untrained	9th use of scuba	Hired	None
SC 79/1	1st dive after course 14 months before		Own	Not stated
SC 79/3	4th dive after course		Own	Low
SC 79/5	During training, OW course		Diveshop	Yes
SC 79/6	3rd use of scuba		Hired	Yes
SC 80/1	3rd or 4th use of scuba		Borrowed	Yes
SC 80/2	3rd dive after course		Own	Low
SC 80/3	2nd use of scuba		Hired	Not stated
SC 80/4	3rd OW dive		Own	Low
SC 80/5	During training, 3rd OW dive, end of course	Current	Diveshop	Not stated
SC 80/6	3rd use of scuba	Buddy similarly inexperienced	Buddy hired	Yes
SC 81/2	2nd use of scuba		Hired	Yes
SC 81/4	1st use of scuba		Hired	Yes
SC 81/5	1st use of scuba		Buddy hired	Yes
SC 82/1	Probably 3rd use of scuba		Buddy hired	Yes
SC 82/5	1st use of scuba	1 buddy also 1st scuba dive	Buddy hired	None
SC 83/3	Untrained, a few dives some years age,		Hired	Low
SC 83/6	No training, inexperienced,		Buddy hired	None
SC 84/10	Just trained, 3rd OW scuba		Hired	None
SC 85/1	Just trained		Hired	Low
SC 85/3	1st drift dive		Own	None
SC 85/4	Just trained		Borrowed	Low
SC 85/6	1st dive after course		Hired	None
SC 85/8	1st dive after course		Own	None
SC 85/9	9th dive	No dives in the previous 12 months	Own	None
SC 86/2	2nd dive after course		Hired	Yes

SC 86/3	2nd dive after course	1st night dive, tight wet suit	Club	Yes
SC 86/4	Taken on class dive	Cardiac death	Diveshop	Yes
SC 87/1	6th or 7th dive	4th or 5th dive after course	Own	Low
SC 87/2	1st dive after course		Own	None
SC 88/1	10th dive	1st dive after "Advanced Diver" course	Hired	Low
SC 88/3	Just trained	1st dive after course, epilepsy	Club	Yes
SC 88/4	1st dive after course		Hired	Low
SC 89/4	1st use of scuba		Borrowed	None
SC 90/4	7th after dive course	1st cold water dive	Own	Yes
SC 90/6	6th use of scuba	No dives in the previous 12 months	Own	Not available
SC 91/3	During training	Cardiac death	Diveshop	Low
SC 91/6	1st use of scuba, resort dive,	Cardiac death	Diveshop	Yes
SC 91/7	1st use of scuba, resort dive	Surface drowning	Diveshop	Yes
SC 91/12	1st dive after course	1st night dive	Diveshop	Yes
	ON DEEP DIVE COURSE (2)			
SC 89/8	Deep Dive Course	Practice buddy ascent	Own	Yes
SC 89/9	Deep Dive Course	Inadequate air supply from regulator	Own	Yes
	FIRST NIGHT DIVE (1)			
SC 75/2	Experienced	Solo in harbour	Own	Not stated
	NO RECENT DIVING EXPERIENCE (11)			
SC 72/11	Not dived for a year or two		Own	Low
SC 76/5	Few dives since course 12 months before		Own	Yes
SC 78/6	Not dived for 4 years		Own	Low
SC 79/1	Not dived since course 12 months before		Own	Not stated
SC 83/3	Not dived for 12 years		Hired	Low
SC 85/9	Not dived for 12 months		Own	None
SC 89/1	Not dived for 12 months	Buddy 1st dive after course	Borrowed	Low
SC 89/2	Not dived for 12 months		Hired	Yes
SC 89/5	Not dived for 12 months		Hired	Low
SC 89/6	Not dived for 12 months		Own	Low
SC 91/13	Not dived for 12 months		Own	Yes
	SPECIAL NOTE			
SC 84/7-8	Newly trained divers saved an unconscious diver			

Over half of all fatalities occur in divers low on air or out-of-air (Table 2). The majority of those who run low on air are both trained and have some, though sometimes slight, diving experience (Table 3). This is a serious indictment of the training they have received.

TABLE 2

REMAINING AIR IN 153 AUSTRALIAN SCUBA DEATHS 1972-1991

None	47
Low	37
Adequate	49
Not available	3
Not stated	17
Total	**153**

TABLE 3

TRAINING AND EXPERIENCE IN 84 AUSTRALIAN SCUBA DEATHS WITH NO AND LOW AIR

	No air	Low air
Training		
None	9	5
Some	4	4
Trained	28	26
Not stated	6	2
Experience		
None	10	10
Some experience	19	15
Experienced	17	12
Not stated	1	-

TABLE 4

CRITICAL EQUIPMENT DEFECTS AND FAILURES IN 153 AUSTRALIAN SCUBA DEATHS

Case number	Critical defect or failure	Other factors
82/5	Tank "blew off"	Vest had no CO_2 cylinder. Inflator hose was not connected. Untrained. First ever use of scuba.
84/9	Verdigris and slime in first stage Rust in (small) tank	
85/6	Vest failure Weights jammed belt release	Spray of water from regulator when used. Novice.

In only three of 153 Australian scuba diving fatalities was equipment failure the basic critical factor (Table 4). Police investigation of such deaths routinely includes examination of all the equipment. Although a significant error in the contents gauge was found in four cases (Table 5), in none of these was it a factor which affected the course of events. The report by Dr Chris Acott on the analysis of the DIMS reports[8] notes a higher incidence of contents gauge errors than was found among the diving deaths. This implies such gauge problems infrequently have fatal consequences. From his report it is not possible to determine whether the contents gauge errors were significant factors in the incidents or whether they were admitted rather as a stand-in for the diver's own carelessness.

Other faults in equipment, such as a hard-to-breath regulator, should become apparent and ascent started long before any significant lack of air problem developed.

Running out of air in the absence of any equipment failure can be regarded as an avoidable error which good training and a correct dive procedure would obviate. To offer a simile, one would look with suspicion at the teaching standards of a driving instructor who was so certain that his pupils would be likely to run out of petrol after they obtained their licence, that he had them practice siphoning up petrol from another car on a public highway to prepare them for such an eventuality. Air is the diver's essential fuel. In the UMS report the late Dr Charles Brown gave as an example of the need for emergency ascent skill the case of four divers who managed to make an out-of-air ascent from 30 m sharing a single regulator, this being the first open water dive performed by three of them. While accepting that they had been well trained in buddy breathing, it was almost criminal to take three novices to such a depth and a sign of incompetence that three ran out of air. An alternative view of this incident is that fools can survive, rather than ascent training was a vital part of their scuba training. These divers were unfit to be allowed to dive, even though they survived, because they were so ignorant and should never have received certification.

Do a few in-course "emergency ascents" create a skill ?

There is general agreement that it requires the practice of a new and complex skill possibly 15 times under varying conditions before it can be regarded as "overlearned" so that it will be performed both correctly and without need for conscious thought in an emergency.[9] None of the recreational diver training organisations offer this intensity of training in their courses (it would make courses too costly), although this intensity of training was provided, and perhaps still is, by the University of California at Los Angeles (UCLA) and the National Oceanic and Atmospheric Administration (NOAA) in 1977 for the divers they employed. As these divers were more thoroughly trained and regulated than most recreational divers, they should be the ones who are at least risk of making the mistake of running out of air. NOAA required a diver to make 15 open water dives to attain the category of limited diver, and 100 before being granted unlimited diver status.[10]

That actual training practice may not be an essential factor in order to perform a successful out-of-air ascent is illustrated by both positive and negative examples. On the positive side, evidence given at Inquests on fatalities among abalone and pearl (hookah) divers shows that their usually untrained colleagues have frequently made emergency out-of-air ascents after some failure of their air supply. These are all solo true "free ascents" and are regarded as a normal event by these divers, whose tolerance of poor equipment is not to be commended. On the negative side, the DIMS study shows that problems are still arising despite the inclusion of some emergency ascent practice in courses run according to the protocols of the three main instructor groups in Australia.

The first ever successful escape from a sunken submarine was made in 1851 by Corporal Bauer and his two companions from the *Brandtaucher* (*Sea Devil*) at Kiel, from 60 fsw depth. They had neither training nor breathing apparatus.[11] A more recent case which illustrates the

TABLE 5

CONTENTS GAUGE INACCURACY IN 153 AUSTRALIAN SCUBA DEATHS

Case number	Comments
81/2	Resort dive. Over-reading gauge was not responsible for fatality
88/2	One of the group required a decompression stop at 3 m in open water. The victim was deputed as companion. Separation occurred just before they were due to surface together. The victim was found floating at surface, with an empty tank. The gauge read 50 bar but had a loose indicator needle. The cause of death was Acute Myocarditis
88/4	Experienced as a hookah diver but was making first scuba dive. Diving alone. Was seen at the surface calling for help. The backpack was ditched. The tank was empty when found and the gauge read 200 psi.
89/6	Trained 6 years before, then made 2 dives before having a serious road traffic accident. Had only done 3 more dives and none in the last year. Separation occurred during the return to boat on the surface. Died from the effects of inhaled vomit. The gauge over-read by 200 psi

benefit of knowledge even in the absence of any actual practical experience of performing an ascent occurred in 1992. A novice diver was making his first ever hookah dive, at the invitation of a friend who had given him a short trial dive in a garden pool. He had made one scuba dive 9 years before and was totally untrained. Fortunately for him he had at some time heard that one should breath out while making an ascent and this he did when his weight belt came loose, taking the attached hose and regulator with it. He reached the surface successfully and it was his friend who died on a dive later that day. This incident will be more fully described in a later Provisional Report (case H 92/2).

Dr Kindwall[3] has described how he and Dr Glen Egstrom in the early days of diving, before commercial scuba equipment was readily available, frequently experienced equipment failures and had to perform free or swimming ascents. He admitted to being unaware of air embolism at that time and was relaxed about the procedure, but he became uneasy after working at the submarine escape training tower (SETT). He stated his belief that being sufficiently relaxed in the water is the secret of making a successful out-of-air ascent. He told this tale. In the 1940's, while Dr Charles Shilling was supervisor of training at the New London SETT, he took a mongrel dog down to 100 ft in the roving bell and there threw the dog into the water. The dog swam towards the surface exhaling all the way and suffered no ill effects. The dog had received no previous escape training, though as it had been provided by Harvard University it may have been smarter than some. In the current climate of respect for animals it is unlikely permission would be granted to repeat this experiment.

It is noteworthy that while several of the experts offering their opinions at the UMS Workshop stated that numerous practices were an essential prerequisite if the desired skill level was to be achieved, and they were discussing the simpler skills of scuba diving, none drew the logical conclusion that the actual training given to novices was critically inadequate by their standards.

Although McAniff[4] stated that it was unacceptable to have any fatalities during training unless it could be clearly shown that such training saved a greater number of lives, he offered no analysis of the matter and his statement did not seem to lead to a discussion of this important point. When Wenzil[5] spoke to present the legal aspect of this problem he gave a carefully cautious assessment. He believed that there was uncertainty as to the outcome should a diver, or the heirs, bring a case for damages against the instructor and organisation involved if morbidity resulted from performing any form of practice emergency ascent. He suggested that it would be best to re-examine the fundamental need for the skill in the first place. Sixteen years later this has still not been done.

It should be noted that the Royal Australian Navy (RAN) decrees[12] that basic training in emergency ascents is to be performed as close to a recompression chamber as is possible, "after a few accidents".[13] Proponents of the proposition that it is safe to practice emergency ascents can rightly state that there have been no reports of morbidity in divers under instruction in Australia, but neither has there been any attempt to seek out this type of information. One should remember that sub-clinical lung and brain damage has been shown in those performing SETT ascents[14,15] and it is likely that such pathology sometimes occurs in association with civilian training.

Proponents of the inclusion of this element in training usually ignores three factors.

1 That its inclusion takes up time possibly far better spent on other items in the training program,
2 that it may not provide any actual benefit, and
3 that indeed it may lead divers to undervalue the necessity of avoiding becoming low on air.

These are significant considerations. It is not sufficient to declare that the skill could be useful, it has to be shown that it is imparted and cannot otherwise be achieved.

Is omission of such training deleterious to safety ?

This is unsustainable as it has been the policy of the British Sub-Aqua Club (BS-AC) for more than 30 years that no such practice be performed in its training programs. This has been on the advice they have received from the RN on numerous occasions. Possibly the secret of their excellent safety record has been the absence of hurry in their diver training programs, much criticised by many as being too careful. That BS-AC divers make stupid mistakes and sometimes die is due to the tendency of divers to fail to behave responsibly rather than to any omission of free ascent in their training. Knowing the psychology of divers, the RN allows a few BS-AC divers to make supervised ascents in the SETT each year. The BS-AC is the only training organisation which not only actively attempts to collect Incident Reports, but which publishes its findings annually and discusses their import ![16] It is from these reports that one learns that BS-AC divers suffer low-air and out-of-air situations and have to perform shared or solo emergency ascents. The records show these are successfully performed. It is a great pity that none of the main Instructor organisations in Australia show such a dedication to obtaining information.

At the present time the majority of divers are likely to have received training which includes an "emergency ascent" module of some type.[17] But being out-of-air still appears to be a significant item in the analysis of adverse factors in diving fatalities. There is an obvious need to review training programs in order to produce more careful divers. While the "octopus" system is the most logical and potentially fool proof response to an out-of-air situation it has the limitation that the donor is likely to be almost as low on air as is the recipient. The suggested solution of carrying a supplementary air cylinder ignores the probability that only responsible divers (such as cave divers) would resist the temptation to use its contents to prolong their dives. After all, the divers who run out of air have almost always already ignored the reading of the contents gauge on their main air cylinder.

The reprinted papers by Dr Harpur contain two statements of very special relevance to this discussion.[7,18] The first is that "teaching a technique does not necessarily involve practicing it". The second is that "we have not been able to document a single case in which equipment malfunction directly caused a diver's death or injury. It has always been the diver's response to the problem which results in the pathology. Recognition of the malfunction and effective management of it are part of good diver training."

Conclusion

There is an old adage, dating back long before the days of AIDS, that if you can't be good, be careful. This could well apply to air management. When the instruction of divers includes a greatly increased number of practice "emergency ascents" (preferably near a manned recompression chamber) there will be less need for discussions such as this. But surely avoidance of predictable dangers has precedence over accepting them as inevitable ? Nature is not malevolent, and if it seems so, you are doing something wrong. As air is essential to a diver's survival underwater, surely every effort should be bent to ensuring this is always available. Anything less is inferior.

The recent SPUMS Workshop was "designed to develop a policy on EAT and to illustrate that a Workshop is an appropriate method of deciding on a SPUMS policy".[19] I contended that this objective has not been achieved. This is in part because the terms of reference were seriously defective. It was concerned solely with which of several emergency ascent options should be practised and not with the wider, and more important, question of ascertaining whether the out-of-air status is inseparable from scuba diving rather than being an unusual and avoidable event. There should have been questioning of the value of such training based on facts rather than unsubstantiated opinions. It was defective in that there was no input from those who were known to oppose the proposal or had reservations concerning the benefits of the training provided. One should remember the countryman's reply when a traveller asked him the way to a distant city, "If I were you I wouldn't start from here". Hopefully a serious attempt will now be started to investigate the low-air and out-of-air problems which occur far too frequently during scuba diving.

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THE CASE FOR DIVING DIABETICS

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Up until the mid 1970s, the British Sub-Aqua Club (BS-AC) allowed diabetic divers to dive provided they were well-controlled and had not had an attack of hypoglycaemia within the past year. However, in 1975 a diabetic diver was diving on a wreck off the south-west coast of England called the *Persier.* This cold water wreck is at a depth of about 28 m. The diver had ascended normally, well within the no-stop time according to the BS-AC/ RNPL 1972 tables, and had signalled "OK" to his buddy on the surface. On swimming back to the boat, he was noted to be having some difficulties and had to be dragged on board the boat, where he collapsed. His problems were ascribed initially to diabetes and not to decompression illness. He was therefore not recompressed for some hours. Unfortunately, even after the symptoms of decompression illness were recognised and treated, he was left with permanent paraplegia from a level of approximately T10 down. He later committed suicide as a result of his confinement to a wheelchair. The ban on diving by diabetics was introduced by the BS-AC as a direct result of this accident.

This diabetic diver suffered from sudden onset decompression illness. There was no evidence that his diabetic condition had caused this. A post-mortem showed the presence of a patent foramen ovale (PFO)[1] which may or may not have contributed to this particular incident. Further, it was known from an unpublished survey carried out by Eno that several diabetic divers had continued to dive despite the ban on diabetics and that none of these divers had suffered from an increased incidence of decompression illness or, more importantly, suffered from hypoglycaemic attacks whilst diving.

Given this data, three of us (Edge, Lindsay and Wilmshurst) came to the conclusion that there was no reason, given the current state of knowledge and medical technology, for prohibiting diabetics from diving with the BS-AC, *provided certain strict medical criteria were met by the potential diving diabetic*.[2] Independently, Bryson had come to the same conclusions on behalf of the Sub-Aqua Association (SAA).

To be allowed to dive, the diabetic must not only satisfy medical criteria, but he or she must take additional precautions when diving, both to ensure the well-being of him/herself and also the well-being of the diving buddy and the rest of the party of divers. These conditions are set out below:

Medical conditions

Stated briefly, the diver should not have any of the long-term complications of diabetes. The medical conditions apply to both insulin dependent and non-insulin dependent diabetics. Although hypoglycaemia is a relatively uncommon in non-insulin dependent diabetics the risks are not negligible and any potential diver should be using a short-acting anti-diabetic drug, if such medication is necessary.

However it does appear that non-insulin dependent diabetics can generally exercise without fear of a deleterious metabolic response.[3] The BS-AC issues forms for the