ORIGINAL ARTICLES

QUEENSLAND SCUBA DIVERS AND THEIR TABLES (CORRECTION)

Jeffery Wilks and Vincent O'Hagan

We regret that the table below did not appear with the above paper (SPUMS J 1991; 21(2): 11-14).

TABLE 1

CORRECT ANSWERS FOR THE TWO DIVE PROFILES: PERCENTAGE OF RESPONDENTS BY SEX AND TIME SINCE CERTIFICATION*

Group	Profile 1	Profile 2
Males	47	38
Females	39	34
Time since certification (months)		
0-12	50	44
13-24	45	39
25-36	37	27
37-48	52	42
>48	49	44

* Percentages are rounded to the nearest whole number.

LEARNING FROM THE MISHAPS OF OTHERS

John Lippmann

Towards the end of 1990 Coronial Inquiries were held into the deaths of four divers who died in Victorian waters in between October 1989 and April 1990. The Coroner decided to conduct the inquests together to determine any common threads and lessons to be learned, and to investigate whether government regulation of the diving industry is warranted. The hearings were held over 8 days and I had the opportunity to attend a number of the sessions.

I believe that there are a quite a few lessons to be learned from the misfortunes of these divers.

Case 1

The first fatality occurred during a Deep Diver Training Course. The victim was a 31 year old ex-RAN Clearance Diver who had started diving at 17 and who, apparently, had extensive diving experience, including a substantial amount of deep diving.

There were eight divers in the group (including the instructor) and they conducted the dive on the wreck of a paddle steamer, "The Coogee", situated off Port Phillip Heads in approximately 33 m of water. The divers were briefed to ascend after a pre-determined bottom time. When the bottom time had expired, the instructor ascended with five of the students, leaving the victim and his buddy unsupervised during the ascent. The instructor had thought it would be safe to do so as he believed the diver who died to be a more experienced diver than himself, which he probably was. The buddy began to ascend the anchor line but was pulled down by the victim, who appeared to be acting irrationally. When the victim removed his regulator from his mouth, the buddy handed him her primary regulator, transferring to her octopus, which she found more difficult to breathe from. After her mask flooded, the buddy became very anxious and indicated that they should ascend immediately. The victim then took the regulator from his mouth and began to ascend rapidly, without an air supply. He failed to reach the surface and his body was later located on the sea bed. When found, the victim had about 100 bar of air remaining in his tank and the recovery diver was able to breathe from the victim's regulator on the bottom. His weight-belt was still in place. Post-mortem examination revealed evidence of massive arterial gas embolism.

It is impossible to determine exactly what caused this accident and a number of scenarios have been suggested. It seems likely (because of the depth and some of the diver's behaviour) that nitrogen narcosis was a contributing factor.

Nitrogen narcosis affects all divers to some extent at depths approaching and beyond 30 m (some are affected at

far shallower depths from time to time), whether the divers are aware of it or not. Since most diving does not require a lot of focused, logical thought or fine movement, we may not notice the narcotic effects as we swim around at depth. Although reflexes and thought processes may be slowed down, most diving situations do not require an immediate, rapid, rational assessment and co-ordinated reaction. However, if a problem develops, we need to think and act swiftly, and this is when the effects of narcosis, previously unnoticed, may prove debilitating. We may act irrationally and clumsily and are more likely to panic, so endangering ourselves or our buddies, or both.

Experienced divers, such as this victim, are still susceptible to narcosis, especially if they have not dived deeply recently, and, at times, experienced divers may act irrationally and may panic under certain adverse circumstances. Experienced divers, just as any other divers, must be vigilant for the effects of narcosis on deeper dives and must monitor their buddy, and, in turn, be monitored by their buddy.

When the victim's regulator and cylinder were tested a number of interesting observations were made. The cylinder valve was a "J valve" (i.e. fitted with a reserve mechanism) and when the reserve lever was in the "on" position the air flow was greatly reduced, even at relatively high cylinder pressures. Unfortunately, no record was kept of what position the valve was in when the diver was found so it is not clear if this potential problem did, in fact, contribute to the accident. In addition, the diver had recently fitted a high-flow (Oceanic) second stage to what was possibly an incompatible first stage (Apollo). The police tests indicated that it was likely that a diver, breathing rapidly at depth, could out-breathe the regulator.

The following is a possible explanation for the accident:

The victim may initially have had difficulty getting enough air from his regulator at depth. After transferring to his buddy's regulator he appears to have had problems using his buddy's regulator. These problems are likely to have been exacerbated by nitrogen narcosis which would itself be exacerbated by carbon dioxide retention, caused by a hard-breathing regulator, and by anxiety. It appears that the victim then decided to "free ascend" (which he would have been trained to do in the Navy). He failed to exhale appropriately and, consequently, suffered an arterial gas embolism, losing consciousness underwater.

Lessons from Case 1

First, all divers, especially those who dive beyond about 24 m, must familiarize themselves with the manifestations and management of nitrogen narcosis, and be vigilant for signs of it in themselves and their buddies during deeper dives.

J valve reserve mechanisms can, and do, malfunction. They are best removed completely and replaced with a blanking plug. Taping them down in the open position does not guarantee that the mechanism will always remain deactivated. If a diver wishes to keep an operational "J valve", he or she should ensure that it is inspected and serviced regularly by an appropriately experienced service technician.

Certain second stage regulators may be incompatible with certain first stage regulators. A diver should ensure that his equipment is compatible and functions adequately.

Many octopus regulators can be difficult to breathe from, especially in deep water when the cylinder pressure is relatively low. Divers should ensure that they have an octopus that is properly maintained and is capable of supplying air to a rapidly breathing diver at the depths to which the diver dives.

An instructor should endeavour to keep all his or her students in sight, and within relatively easy reach, throughout any training dive. This is important during deep dives when narcosis may affect a diver's behaviour, an air supply problem is more likely and ascent more difficult. It is often very difficult for an instructor to monitor a large group of divers and, consequently, instructors should think carefully about how many divers they can adequately monitor during a particular training dive. Ratios should be chosen with diver safety, rather than commercial pressures, as the primary consideration.

A diver, who finds himself in a situation where he fears he may become unconscious during ascent, should either make himself positively buoyant or, alternatively, remove his weight-belt and hold it in his hand and away from his body. If he becomes unconscious the belt will fall away and the diver should rise to the surface. A diver on the surface generally has a far greater chance of being successfully rescued than one on the bottom.

When dives deeper than about 30 m are conducted it is often a good idea to attach a full cylinder (capacity of at least 400 litres) with a properly functioning regulator to the bottom of the ascent line. It should be attached by an easily removable clip. A diver who is low on air on the bottom can remove the tank and use it on the way to the surface.

Case 2

Another fatality occurred near "The Coogee". This victim was a 25 year old man who had done his initial dive course in 1983 and had been diving regularly over the past

few years. He, too, was diving from a commercial dive charter vessel.

The sea conditions were relatively poor. According to the buddy, the divers descended to the bottom (at 33 m) and the victim swam away quickly, making it difficult for the buddy to keep up with him. Apparently, the victim then turned to his buddy and signalled that he wanted to buddy-breathe. Since the buddy did not have an octopus, the divers decided to share the one regulator. It was reported that they exchanged the regulator for about four cycles without leaving the bottom. As they were incorrectly positioned for buddy-breathing, the buddy was passed the regulator upside down, causing him to inhale water. They began to ascend slowly, too slowly for the buddy's liking, so he inflated his buoyancy compensator (BC) and very rapidly ascended to the surface without his regulator in his mouth, leaving the victim behind. The buddy arrived relatively safely at the surface, but the victim never reached the surface. When his body was later recovered from the sea-bed there was damage to the his mask and face. His weight-belt was still in place. About 130 bar of air was left in his cylinder. Post-mortem examination showed evidence of arterial gas embolism but death was recorded as due to drowning.

When the victim's gear was tested a number of observations were made. The cylinder was only turned on approximately one-quarter of the way. This may have been sufficient to supply air at the surface but would have made it difficult to get adequate air at depth, especially when under exertion or stress. In addition, the line pressure in his regulator was far lower than it should have been, and this, too, would have reduced the air supply, as would have the dirty sintered filter. It appears that the victim serviced his own gear but had inadequate training to do so safely. He had attended an Equipment Specialist Course, but the course was not designed to teach divers how to service their regulators. His BC filled only slowly at the surface and very slowly at depth.

It is probable that the victim could not get enough air from his own regulator on the bottom as the line pressure was too low, the filter was dirty and the valve inadequately turned on. The divers failed to buddy-breathe successfully due to lack of practice (by both himself and his buddy) and the effects of nitrogen narcosis. When the buddy inflated his BC and rapidly ascended, the victim may have been forced to rise without exhaling adequately and suffered an arterial gas embolism. At some stage he lost consciousness, sank to the bottom and drowned.

Lessons from Case 2

Divers should ensure that their equipment (i.e. regulator(s), cylinder and valve, BC and gauges) are inspected/serviced at appropriate intervals by by an adequately experienced service technician.

A diver must ensure that his or her cylinder valve is turned on adequately. Divers are generally taught to open the valve fully and then turn it back some amount (often one quarter or half a turn, or thereabouts) so that if, knocked, the valve will not jam on. However, with some valves, turning back half a turn may reduce the air flow significantly. In addition, on a number occasions I have seen well-meaning divers inadvertently turn off their buddy's valve and turn it on a quarter turn, creating a very dangerous situation. I believe that it is generally simpler and safer to teach divers to turn the valve on fully (valves rarely jam) and then check the air flow by watching the contents gauge while purging the regulator. If the needle on the gauge fluctuates, there is probably too little air getting through.

Buddy-breathing is often unsuccessful as it is a technique that needs constant practice by both participants and requires a great degree of presence of mind in an emergency. I believe that all divers should carry a properly functioning "octopus regulator" (or similar device) and should ensure that they can use it properly. It should be positioned where it is rapidly accessible to its wearer (not tucked away in a pocket!).

Case 3

The fatalities included one snorkeller. The victim was an Assistant Scuba Instructor/Snorkel Instructor who was a very experienced and enthusiastic diver. He was also an asthmatic.

The victim was with a group of ten people, mainly diving instructors. They had just done a pre-Christmas "pleasure dive" and decided to anchor the boat in shallow water and snorkel for crayfish. The snorkellers went off individually, and, since they were all very experienced, there was no pairing off and on-one was assigned to be a look-out. It was Christmas Eve and the mood was very relaxed.

When all the other divers had returned to the boat and the victim could not be seen anywhere, the group became worried and instigated a search. The victim was found a number of hours later on the bottom in about 3 m of water. He was lying in kelp but was not tangled in it. The recovery diver released the victim's weight-belt (which was still in place) and brought the body to the surface. Post mortem examination showed nothing other than signs of drowning. It is not known whether asthma played any part in this misadventure.

Since no-one witnessed this diver's difficulties, one cannot be sure what caused this fatality. However, many of

us who knew the victim feel that it is likely that he hyperventilated before a breath-hold dive. Among other aspects, he enjoyed the risks of diving and at times was known to push safety to the limits. Most divers are taught the dangers of hyperventilating before a breath-hold dive (i.e. the possibility of losing consciousness underwater or shortly after ascending), but some divers still hyperventilate to increase their breath-hold time. The likelihood of a post-hyperventilation blackout varies from person to person and, within an individual, from one time to another.

The victim, who was an ardent crayfish hunter, may have spotted a crayfish and hyperventilated to extend his dive time enough to catch the creature. It appears that the victim was too heavily weighted, so, when he lost consciousness he would have sunk to the bottom, rather than rising to the top as he may have if he had been positively buoyant. Since no-one witnessed his failure to surface, drowning was inevitable.

Lessons from Case 3

Hyperventilating before a breath-hold dive can, and does, cause some snorkellers to become unconscious in the water, often leading to drowning. Some instructors teach that it is safe to hyperventilate a few breaths before a duck-dive, but I believe this to be foolhardy. As previously mentioned, there is a lot of variation and, what may have proved safe on one occasion may not be safe on another. Some snorkellers have been known to blackout after a very long breath-hold dive, even without hyperventilating. A number of highly experienced snorkellers have suffered post-hyperventilation blackout, and many of them subsequently drowned. Since regular breath-hold divers can learn to endure high carbon dioxide levels and suppress their urge to breathe, they have an increased risk of becoming unconscious from the lack of oxygen, caused by delaying inspiration.

Snorkellers should never be negatively buoyant. They should be slightly positively buoyant so that they are likely to rise to the surface (or remain on the surface) if they become unconscious.

Snorkellers should, where possible, avoid diving alone. The buddy system should be encouraged for many snorkeling activities.

Case 4

The final victim was a 51 year-old man who had very limited diving experience in Queensland waters, and had completed a scuba diving course, during a cruise on board the Fairstar, a few months before his death. He had been medically examined prior to his dive course but it appears likely that the examining doctor lacked the appropriate training in diving medicine. His fitness and health were quite poor and he was taking a medication that affects the heart rate. He had recently bought new diving equipment, including a 7 mm wetsuit, and this was his first dive in relatively cold Victorian waters.

The victim was diving from a commercial dive charter vessel at a relatively safe, although current prone, site, with a maximum depth of around 12 m. After entering the water and signalling "OK" to his buddy, the victim deflated his BC but only descended slightly and began to drift away from his buddy and the boat. When he signalled he was in trouble, the skipper raised the anchor and brought the boat alongside the diver. A rope was thrown to him and, although it landed over his shoulder and in front of him, he did not take it. The victim still had his regulator in his mouth and bubbles appeared to be coming from it. The rope was thrown again but the deceased drifted away and sank. Those present thought he had begun his dive, alone and in the current, rather than in the sheltered area. When the bubbles could not be seen the skipper became concerned and organised a search. The deceased's body was found some hours later. Post-mortem examination found that death was caused by drowning.

The Coroner suggested that a number of factors may have contributed to this diver's death. It was his first dive in relatively cold water and, probably, with a full 7 mm wetsuit. The cold water, the wetsuit, anxiety and the medication he was taking could have made breathing difficult, clouded his consciousness and, eventually, may have caused his heart to stop beating effectively, leading to unconsciousness and subsequent drowning.

Lessons from Case 4

This fatality is a reminder of the importance of ensuring that we are healthy enough and fit enough to dive safely. Although most divers are now encouraged to have a medical examination before taking up the sport, unless the examining doctor has knowledge of underwater medicine he or she may not be fully aware of the dangers certain medical conditions may pose to a diver. Many hyperbaric experts believe that it is important for divers to be examined by a doctor who is appropriately trained in diving medicine, to determine whether they have any conditions that may predispose them to a serious diving accident. As our health changes from time to time, it is wise to be re-examined after any significant change in health status. Some diving certification agencies recommend that divers be examined every five years until the age of thirty, every three years from thirty to fifty and annually thereafter.

Since diving has inherent risks it is inevitable that some fatalities occur. However, if we consider the number

of divers and thedives that are done each year, the fatality rate seems to be very low. We can never completely guarantee our safety during a dive, but we can certainly minimise the chances of a problem by ensuring we are healthy, fit and prepared enough to dive, that we have suitable and serviceable equipment, that we are adequately trained and experienced to do the particular dive, and that we use our common sense, and do not push the limits of safety.

The above article has been slightly edited from the form in which it will appear in a future issue of "Sportdiving in Australia and the South Pacific" and is reprinted here by permission of the author and of the publisher.

We look forward to publishing a lawyer's view of these inquests.

John Lippmann is the author of "The DES Emergency Handbook", "The Essentials of Deep Diving" and "Deeper Into Diving", all of which are available from J.L.Publications, P.O. Box 381, Carnegie, Victoria 3163, Australia.

ASTHMA AND DIVING.
Some Observations and Thoughts*

Carl Edmonds

People keep asking me for reprints of papers that I wrote on asthma years ago, in such literary papers as the SPUMS Journal, Pressure Newsletter, Undercurrent, etc. I do not keep copies of the past. In the hope of deflecting further requests, I present here selected excerpts from the 3rd edition of Diving and Subaquatic Medicine, which is in press and which will be distributed by the publisher, Butterworths, possibly in 1991-2. Requests for complimentary copies should be sent to them, not to me.

Asthma and diving deaths.

Only 1 % of American divers have a history of asthma, as judged from the 1988 DAN diver survey.[1] The figure is probably less in Australia, where medical questionnaires and examinations are required before diving. However at least 9 % of the deaths in Australian and New Zealand recreational divers[2] were in asthmatics and in at least 8% it was a major contributing factor.

* Edited excerpts from *Diving and Subaquatic Medicine,* 3rd Edition Butterworths (in press)

Most of these deaths were in clinically mild asthmatics who are otherwise physically fit young men.

The possible trigger factors for asthma provocation in scuba diving are;

1 Exertion (from overweighting, equipment drag, swimming against tides etc.),

2 Inhalation of cold, dry air (adiabatic expansion of dehumidified compressed air),

3 Hypertonic saline inhalation (bubbling or leaking regulators),

4 Breathing against a resistance (increased gas density, regulator problems, low air supply).

Many of these stresses are used clinically to initiate asthma as diagnostic provocation tests, and so the problems with this disorder are understandable. In a number of cases the diver was returning to obtain a salbutamol (Ventolin) spray; in others it had been used immediately before the dive.

Asthmatics, even more than others, had multiple contributions to death. The relative frequency of a compromised air supply, salt water aspiration, panic and fatigue, prior to drowning, was evident from the statistics

Asthma and diving accidents

Most experienced diving medical physicians are appalled at the though to asthmatics diving. This attitude stems from a number of places. They include:

1 Involvement with asthmatics who died;

2 The catastrophic histories from those who survived;

3 Differential diagnostic difficulties with asthmatics who have near-drowning and possibly also pulmonary barotrauma;

4 Therapeutic complexities in these cases, both regarding depth and oxygen exposures, and drug complications;

5 Training from their teachers, whose experience often

TABLE 1

ASTHMA DEATHS FROM 100 RECREATIONAL DIVING FATALITIES IN AUSTRALIA AND NEW ZEALAND

Autopsy cause of death	
drowning	7
pulmonary barotrauma	2
Other medical contributions	
salt water aspiration	5
fatigue and/or panic	5
Technique problems	
Compromised air supply	6