

ORIGINAL PAPERS

PROVISIONAL REPORT ON AUSTRALIAN DIVING-RELATED DEATHS IN 1995

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Key Words

Accidents, deaths.

Summary

This review reports on four (4) persons swimming using snorkels, nine (9) scuba divers, three (3) who were using surface supply and two fatalities which are of interest although not strictly falling within the usual field of this investigation. Attention is directed to the apparently inappropriate overconfidence shown by some who achieve an "advanced diver" qualification after minimal diving experience.

Breath-hold and snorkel-using swimmers

BH 95/1

While staying with compatriots during a back-packing holiday this man decided to try snorkelling with them. He borrowed a mask with a fitted snorkel and joined them and other swimmers. He was reputed to be a poor swimmer and to avoid venturing into water where he was out of his depth. The water chosen was only up to the top of his chest. After a while his friends left the water but he remained. They watched him as they sat on the rocks, though not continuously. When, about 5 minutes later, they could no longer see him they walked along the beach to look for him. They became worried and asked for help from the nearby surf club. This search was also unsuccessful. His body was found floating 42 hours later, in the area where he had last been seen. Nobody had noticed any signs of him being in any trouble. It is assumed that he panicked and drowned, not thinking to remove his mask and stand up.

FIRST USE OF SNORKEL. SHALLOW WATER. POOR SWIMMER. LACKING CONFIDENCE. SILENT DROWNING. SNORKEL ATTACHED TO MASK. SEPARATION.

BH 95/2

The sea was calm and visibility good when this experienced spear fisherman was diving solo about 50 m off the beach. His wife watched his snorkel at the surface and only became alarmed when he failed to return at the arranged time. She then realised that the buoy he had attached to his spear gun had remained in the same area for far too long. She saw another spear fisherman and asked

him to check. He found the victim beneath the buoy. The water was too shallow (3 m) to require him to hyperventilate to assist his hunting efforts, though he possibly did so and suffered a blackout. There was no health reason for him to drown. There was a history of asthma but this appears non-contributory.

EXPERIENCED SPEARFISHER. SOLO. SEA CONDITIONS GOOD. RELATIVELY SHALLOW WATER. ASTHMA HISTORY. DROWNED.

BH 95/3

The reason for this death is similarly unexplained as he was snorkelling in waist deep water watched by his wife and a friend in a nearby dinghy. He was seen standing in waist deep water when he called out for help and then collapsed. The pathologist was unable to identify the cause of death as his coronary arteries were healthy and there was no evidence of a "stroke". Possibly a cardiac arrhythmia, which leaves no evidence, was the reason for his death.

SNORKELER. SUDDEN UNEXPLAINED DEATH. STANDING IN SHALLOW WATER.

BH 95/4

Despite his disabilities (a spinal lesion and operations on both shoulders and one hip which left him with restricted function of his left upper limb and weakness of his lower limbs) he was described as being a good swimmer. He and his wife were among many others making the day trip in a boat to a pontoon moored off a reef. He was last seen alive as he pulled himself back towards the pontoon along a rope after losing one fin. There were no signs of distress and other swimmers were close by. When next seen he was floating quietly, face down and did not respond when a small wave passed over him. There was an efficient surface watch and he was reached rapidly and brought back to the boat, but resuscitation efforts failed. Although his coronary arteries were patent this was clinically a cardiac type of death. He was taking many medications but they do not appear to have contributed to his death.

SNORKELER. SILENT SURFACE DEATH IN CROWD. GOOD SWIMMER DESPITE DISABILITIES.

Scuba divers

SC 95/1

A Resort Dive two years before had led him to join this course to learn to scuba dive. The pre-course diving medical check passed him as fit to learn to scuba dive, but

he was advised that he was too heavy and his age (59 years) was a matter for caution when considering taking up an active sport. The first dive of the course was to 4 m. He died on the second dive. There were five pupils in the care of an instructor and his assistant. After a safe, planned, dive for 23 minutes at 9-18 m they made a controlled ascent together when one of the pupils' contents gauge showed it was time to ascend.

At the surface they all gave "OK" signals. A check showed that two of the pupils had enough remaining air for a short further dive and the instructor descended with them while his assistant had the task of returning to the shore with the remaining three pupils, a surface swim using snorkels. After only a short distance the victim complained of feeling tired so the assistant started to tow him. Although initially alert he soon ceased to respond and the assistant started in-water resuscitation. It was rapidly apparent that this was not effective so he resumed his tow. At first witnesses on the shore though they were watching a practice of rescue but swam out to assist when they realised the truth. On at least one occasion the victim became submerged during the rescue effort.

The pathologist requested a pre-autopsy X-ray performed but failed to recognise the significance of the finding of air in the right side of the heart, arch of the aorta, blood vessels in the neck, and hepatic veins. He was later persuaded by a more experienced pathologist to give pulmonary barotrauma as cause of death, with drowning the final element. He also added that he had found "small air-filled cysts in association with haemorrhage at the top of the lungs", a fact omitted from his formal autopsy report. The suggested course of events was that he suffered a small cerebral arterial gas embolism (CAGE) during the (apparently) normal group ascent and this blunted his level of consciousness and he drowned at the surface. The resuscitation efforts may have forced more air to enter the circulation, but this is only supposition. He had adequate remaining air but may have been troubled at the surface by being overweighted.

PUPIL IN CLASS. NORMAL GROUP ASCENT. COLLAPSE DURING SURFACE SNORKEL RETURN TO BEACH. RAPID CORRECT MANAGEMENT OF INCIDENT. OVERWEIGHTED. ADEQUATE AIR. CAGE.

SC 95/2

This man's buddy, who owned the boat they were using, had loaned him the scuba equipment. Being aware that he was untrained and making only his 4th scuba dive, the buddy remained close by him for about the first 15 minutes as they spearfished at 20-24 m depth. Then the buddy indicated that they should return to the anchor and ascend. Unfortunately the buddy then saw a good sized fish and darted away to spear it. When he returned to the

anchor there was no sign of his friend, so he ascended, but found he was not in the boat so descended again. His search was limited because he suffered some sinus barotrauma. He called out to some divers in a nearby boat and one of them dived, using his scuba equipment, locating the victim on the sea bed. There was insufficient air remaining to inflate the victim's buoyancy vest. The buddy had obviously used far less air as there was sufficient remaining to support this search. There was evidence of a mask squeeze and it was suggested this occurred as he sank after ascending solo while his buddy was hunting the fish. It is not known whether the two divers began with tanks which contained similar amounts of air. Certainly at one stage the victim had returned an "OK" response after he was given a sign to check his contents gauge, but it is not known whether he was aware of the significance of whatever reading he noted, and his buddy (an experienced diver) did not check the gauge.

The victim was using a borrowed 96 cu ft cylinder and there was no declaration that it was checked before the dive by either the victim or by his buddy (its owner) although this may have occurred. Possibly, being inexperienced and likely to over-ventilate, he ran out of air more rapidly than his buddy expected. But the more likely explanation is that he was ignorant of the significance of what the gauge showed. Cause of death was given as drowning, no evidence of a health factor or CAGE being present.

UNTRAINED. 4th USE OF SCUBA. SPEARFISHING. SEPARATION WHEN BUDDY SAW AND HUNTED FISH. SOLO OUT OF AIR ASCENT. FAILED TO DROP WEIGHTS. NO AIR TO INFLATE BUOYANCY VEST. PROBABLY UNAWARE OF SIGNIFICANCE OF CONTENTS GAUGE REMAINING AIR READING.

SC 95/3

This was a wreck dive, a popular one with local divers, the sea bed being at 28 m and the upper side of the wreck at 18 m. The victim had been trained for 20 months and had made 20 dives, including a night dive and one to at least 30 m. He was paired with a diver who appeared to be more experienced and they entered the water with another pair but separated during descent as the victim was slow descending. As they had planned, they first swam to the stern close to the sea bed, then ascended and began to swim forward on the upper side of the wreck towards the bow. It was there that the ascent line was attached. The current was significant and, although his buddy was able to swim forward without holding onto the wreck, the victim needed to pull himself forward. The buddy now realised that he was getting low on air (41 bar) so they ascended obliquely towards the line. The buddy saw the victim descend again to join a trio of divers; an instructor, his son and a relatively inexperienced diver. They were just approaching the wreck to start their dive.

PROVISIONAL REPORT ON AUSTRALIAN

Case	Age	Training and Experience		Dive group	Dive purpose	Depth in metres		Weights	
		Victim	Buddy			Water	Incident	On	kg
BH 95/1	26	No training No experience	No training Some experience	Group Separation before incident	Recreation	1.5	Surface	None	-
BH 95/2	64	Trained Experienced	No buddy	Solo	Spear fishing	3	Not stated	On	Not stated
BH 95/3	53	Training and experience not stated	No buddy	Solo	Recreation	1	Surface	None	-
BH 95/4	66	No training Experience not stated	Training and experience not stated	Buddy Separation before incident	Recreation	Not stated	Surface	None	-
SC 95/1	59	Some training No experience	Trained Experienced	Buddy No separation	pupil	18	Surface	Buddy ditched	15
SC 95/2	30	No training No experience	Trained Experienced	Buddy Separation before incident	Spear fishing	24	Not stated	On	Not stated
SC 95/3	43	Trained Some experience	Trained Experienced	Buddy Separation before incident	Recreation	27	15	Off	Not stated
SC 95/4	36	No training Experienced	No buddy	Solo	Recreation	30	Not stated	On	12
SC 95/5	42	Trained Experienced	Trained Experienced	Group Separation during incident	Recreation	5	Surface	On	Not stated
SC 95/6	29	Trained Some experience	Trained Some experience	Buddy Separation before incident	Recreation	38	38	On	Not stated
SC 95/7	44	Trained "Experienced"	Trained Experience unknown	Group Separation before incident	Recreation	21	21	On	Not
SC 95/8	28	Trained Some experience	Trained Experienced	Buddy Separation before incident	Club dive	3	Surface	On	7
SC 95/9	29	No training No experience	No buddy	Solo	Abalone poacher	Not stated	Surface	On	13
H 95/1	27	Some training No experience	Trained Experienced	Buddy Separation before incident	Work Pearl diver	3	3	On	Not stated

DIVING-RELATED DEATHS IN 1995

Buoyancy vest	Contents gauge	Remaining air	Equipment Tested	Owner	Comments
No	Not applicable	Not applicable	Not applicable	Borrowed	Separation at surface. Drowned silently.
No	Not applicable	Not applicable	Not applicable	Own	Solo. Spearfishing.
No	Not applicable	Not applicable	Not applicable	Own	Stood up and died. Cause unknown. "No asthma for 25 years".
No	Not applicable	Not applicable	Not applicable	Hired	Surface death. Possibly cardiac. "had disabilities but not disabled".
Not inflated	Yes	Low	Adequate	Dive shop	Pupil in class. All made a normal ascent. At surface complained he was tired and died. CAGE.
Not inflated	Yes	None	Adequate	Borrowed	4th dive. Under water separation when buddy left to spear fish. Out of air. Drowned.
Not inflated	Yes	None	Some adverse comments	Hired	Inexperienced. In a current so air used fast. Low air. Buddy breathing attempt led to CAGE.
Not inflated	Yes	None	Adequate	Own	Short dive then surfaced out of air. 2nd dive same tank ? Solo. CAGE. History of cannabis use.
Not inflated	Yes	++	Adequate	Own	Sudden wave hit trio divers during water entry. Cold water. Kelp caught regulator. Unfit. CAGE ?
Not inflated	Yes	++	Adequate	Own	Unexplained underwater separation. Adequate air. Middle ear haemorrhage. Atrial septal defect. CAGE.
Not inflated	Yes	None	Adequate	Own	Group of "advanced divers" but had inadequate experience. Current. Separation CAGE ?
Not inflated	Yes	None	Significant fault	Hired	Overweighted. Some current. Night dive. Separation. Snorkel surface swim. Vest difficult to inflate.
Not inflated	Yes	Adequate	Some adverse comments	Borrowed	5th scuba dive. Dangerous water. Entered water with tank valve closed. Solo. Abalone poacher.
No vest	Not applicable	Not applicable	Not tested	Employer	Inexperience with hookah. Panic ascent? Drowned. Ill health factors?

PROVISIONAL REPORT ON AUSTRALIAN

Case	Age	Training and Experience		Dive group	Dive purpose	Depth in metres		Weights	
		Victim	Buddy			Water	Incident	On	kg
H 95/2	29	Trained Experienced	No buddy	Solo	Work Abalone	8	Not stated	Not stated	Not stated
H 95/3	40	Trained Experienced	No buddy	Solo	Work	4	4	On	Not stated

He appeared to tap one of them, a boy aged 15, on the shoulder and indicate he wished to buddy breath and this diver signalled to his buddy (father) that a diver was wanting air. When the father looked round he failed to see the victim, although he saw the victim's buddy who showed him his contents gauge. Although low on air he seemed to have sufficient for a safe ascent and these two divers watched him ascend before the boy saw the victim lying on the sea bed a short distance away, regulator out of his mask and gasping. Unfortunately, due to his intellectual condition, this did not seem remarkable to him and he did not attract his father's attention to what he had seen. The body was found later on the sea bed. A massive air embolism was shown by a pre-autopsy CT scan but the pathologist decided to be cautious and declared this was a drowning death. The accounts given by the instructor and his son of what occurred differ in some particulars and it is uncertain whether the victim attempted to use the boy's octopus regulator before drifting away.

The victim's buddy had reportedly made over 30 dives to this depth on previous occasions. All the divers on this boat had to declare their training and experience but there is no evidence that log books were viewed. Although the victim and his buddy agreed to dive with another pair of divers, who had requested this because of their inexperience, this arrangement did not eventuate.

SEPARATION WHEN LOW AIR AND ABOUT TO ASCEND. LEFT BUDDY TO APPROACH OTHER DIVERS FOR AIR. MADE INEFFECTIVE REQUEST TO BUDDY BREATHE. FAILURE OF ANOTHER DIVER TO RECOGNISE THE VICTIM WAS IN TROUBLE. CAGE NOT DIAGNOSED BY PATHOLOGIST AFTER BEING CLEARLY DEMONSTRATED.

SC 95/4

This man always dived solo, a practice he had followed during his 20 years of diving. He had never received formal training. On this occasion he had collected his two newly filled tanks from the dive shop the day before setting out in his boat with his brother-in-law, who was not a diver. After his dive, which lasted 30 minutes, he

remarked that it had been a deep dive but did not state its depth. The next day two more friends came with them in the boat and, once again, he has the only one diver. The water depth was 30 m by the depth sounder. They were surprised when he reappeared at the surface some distance from the boat after only 15 minutes. When they reached him it was apparent there was something seriously wrong with him. They pulled him into the boat and started CPR but realised after 10 minutes that he was dead.

Autopsy was preceded by an X-Ray examination but there is no record of what, if anything, this showed. During the autopsy a few gas bubbles were seen to escape from the right pleural cavity when it was opened, and a small quantity escaped from the aorta and vessels at the base of the brain and in the mesentery. There was some focal coronary atheroma but no vessels were stenosed. Subpleural focal air trapping was noted but no pleural lacerations. The cause of death was given as drowning but clinically CAGE had occurred. He appeared to have made an emergency, out-of-air ascent and had not ditched his weight belt. His buoyancy vest leaked but it is unknown whether he had tried to inflate it at any time. One possibility (unchecked) was that he mistakenly used the same cylinder for both dives and omitted to check the contents before diving.

EXPERIENCED BUT UNTRAINED. SOLO. SUDDEN ASCENT SOON AFTER STARTING DIVE. BUOYANCY VEST LEAKED. FAILED TO DITCH WEIGHT BELT. OUT OF AIR EARLY IN DIVE. POSSIBLY FAILED TO CHECK AIR GAUGE BEFORE STARTING DIVE. CLINICALLY CAGE.

SC 95/5

The trio of divers consisted of the victim and a 16 year old, both with Advanced Diver certificates gained during the previous 12 months, and a second 16 year old youth who was making his 4th scuba dive. He was part way through his basic open water training course. There were waves but they chose the sheltered side of the point for their water entry. The two youths entered by walking backwards, the victim walking directly into the water. Just before they were hit by a large wave the victim was heard

DIVING-RELATED DEATHS IN 1995 (Continued)

Buoyancy vest	Contents gauge	Remaining air	Equipment Tested	Equipment Owner	Comments
No vest	Not applicable	Not applicable	Not tested	Employer	Shark attack. Abalone diver..
No vest	Not applicable	Not applicable	Adequate	Employer	Unsafe work situation.

to call out. After it had passed they could no longer see him. They were both washed back onto the beach and there they removed their equipment before returning to look for the missing diver from some high ground before seeking help. A surf rescue swimmer retrieved the body after a fin was seen to break the surface. There was no response to resuscitation efforts. A piece of ribbon kelp was found round the regulator, which led to a suggestion that he had attempted to swim underwater beyond the surf line but lost his regulator. This, combined with the water power, is believed to have resulted in his drowning.

TRIO HIT BY WAVE AS ENTERING WATER. EXPERIENCED DIVER. KELP ROUND REGULATOR. WATER POWER. DROWNED.

SC 95/6

Although the victim was more experienced (30 compared with 11 dives) and had obtained Advanced and Rescue diver qualifications, his buddy was the dive leader. The reason for this was probably that he was following the request made by the instructor that he “keep an eye on his buddy” as he was the more experienced diver. He had some difficulty in equalising but managed to reach the sea bed at 30 m and followed as his buddy pointed out a crayfish and a stingray. The buddy looked back from time to time and observed no sign of his companion having any problem. He started the return swim when his gauge showed he had used about half his air and was surprised soon after this to find he was alone when he next looked back. A 360 degree visual search was unavailing so, after a short wait, he surfaced. There was no sign of the missing diver at the surface and after 20 minutes the dive group (the buddy and three other divers who had dived separately) returned to the shore. Three instructors from the dive shop returned to the dive area and made a line abreast search, taking care to examine all crevices. They found him at 35 m with all equipment in place, except that the regulator was out of his mouth, and brought him up carefully with his head back. The autopsy showed evidence of bilateral inner ear haemorrhage, a perforated left ear drum, and of CAGE. Of interest, and not mentioned in any previous autopsy reports, was the presence of a small atrial septal defect. As he had adequate remaining air no reason can be advanced for his

sudden ascent let alone making this in a manner which resulted in him suffering pulmonary barotrauma and cerebral air embolism.

TRAINED. 30 DIVES EXPERIENCE. SUDDEN SEPARATION. INNER AND MIDDLE EAR HAEMORRHAGE AND PERFORATED EAR DRUM. ADEQUATE REMAINING AIR. CAGE.

SC 95/7

Dive trip organisations may experience problems in ensuring the safety of their clients for many reasons but a major one is where a group is not only non-English speaking but have a different scuba diving philosophy, as in this case. There is heightened importance in such circumstances in having an experienced and safety-orientated crew in charge of the diving. There was a interpreter with this foreign group but it is probable that he did not understand the instructor’s pre-dive briefing, and did not pass on to the members of the group that there was a current and that they should commence their dive with a snorkel swim till they reached the bommie where they were to dive.

A significant additional adverse factor for safety was the presence of two dive master trainees on board. They were trading service for experience and, being unpaid, were technically not covered by regulations which governed professional divers. They had not been formally advised of their responsibilities and appear to have either been lacking in motivation or fearful of speaking out of turn. This resulted in them omitting to inform the diving instructor of their observation that the victim had a habit of surfacing with an empty tank, appeared anxious, had poor diving skills, and seemed to be very inexperienced for someone who had an “advanced diver” certification. This was a qualification held by many of this group. He, like most of the group, tucked in the end on his weight belt, making its quick release difficult. The dive philosophy of the group was to dive as a group rather than as buddies, a matter which the instructor found he was unable to change. The true diving experience of members of the group, not being written in English, was unknown to the diving instructor and had to be taken on trust as being indicated by their certificates of

training. The two trainee dive masters failed to regard it as their responsibility to alert the divers about the strength of the current.

The dive boat was anchored in an area off a reef, sheltered from the strong currents. The currents varied with the depth and locality, the reason for recommending the surface swim before descending and information probably not passed on to the divers. This was the fourth dive of the live-aboard trip and they descended as a group of six but soon became separated by the current. The victim assisted one of the group for a time but after she rejoined the others they never saw him again. The watch from the boat saw him surface, heard him call out (but naturally could not understand what he said), then observed his head fall forward. When reached he was unconscious, floating face down, his tank empty. He failed to respond to resuscitation efforts although showed an initial response.

The autopsy failed to reveal any signs of air embolism but this was clinically a "text book" example.

TRAINED. "ADVANCED DIVER" BUT APPEARED INEXPERIENCED. HABIT OF ENDING DIVE OUT OF AIR. UNSAFE DIVE HABITS OF GROUP MEMBERS. LANGUAGE PROBLEM DESPITE INTERPRETER. FAILURE OF TRAINEE DIVE MASTERS TO ALERT INSTRUCTOR OF OBSERVATIONS. CURRENT CAUSED GROUP SEPARATION, BUT DIVE CONTINUED. SURFACE SIGNAL THEN COLLAPSED. CLINICALLY CAGE.

SC 95/8

The majority of the divers making this club night dive had been trained by the club president, a dive instructor. He remained in the boat as safety diver during the dive. The boat was anchored in the calm water within a crescent of stone blocks set in the open sea, a popular dive site. The victim and her buddy were the last pair to enter the water. They swam underwater towards the entrance of the crescent but soon realised they were taking too long to reach it so they surfaced and then snorkelled to the entrance. The buddy led on each occasion, on each finding himself well ahead. When he reached the rocks at the entrance he shouted an "OK?" to the victim, then allowed himself to drift in the current along the outer wall of the crescent in the belief that the other was following him. After a short delay he heard her call for help so he climbed the rocks and called for the dive boat to come. During the short time this took the victim was lost to view. A surface search was about to start when two divers surfaced supporting the body of the missing diver and said they had found her on the sea bed, led there by seeing a torch. Resuscitation efforts were unavailing.

No reason could be given for her to drown, but there were the factors of anxiety because this was a night dive,

separation, and failure to drop her (excessively heavy) weight belt or inflate her buoyancy vest when in trouble. Its inflation button was described as difficult to reach. She had been using her snorkel when she drowned and might well have survived had she resumed use of her scuba regulator. Her weight belt carried 12 kg, probably 3-6 kg in excess of what she should have required. She had made 26 previous dives, including two night dives

TRAINED. NIGHT DIVE. SURFACE SNORKEL SEPARATION. CALM SEA. FAILED TO DITCH WEIGHT BELT. POSSIBLY EXCESS WEIGHTS. FAILED TO INFLATE BUOYANCY VEST. INFLATOR BUTTON DIFFICULT TO REACH AND TO OPERATE. DROWNED.

SC 95/9

There were several significant adverse factors present and operative in this fatality. The diver was untrained and making his 5th scuba dive, using borrowed equipment. He was a successful and highly regarded "cockatoo", a look out for illegal abalone poachers, but inexperienced in being the diver. The nature of this work required the dive to be conducted unobtrusively and in conditions which inspectors would deem adverse to such activities. This resulted in him diving solo, his "helper" leaving the scene with his clothing as soon as he was ready to enter the water, it being his responsibility to return at the appointed time to meet the diver and spirit away his catch. The sea was rough and entry was from rocks. The safest method was to jump in and immediately descend and swim to deeper water. For this reason the helper was not surprised to see no sign of him after he jumped in.

When the diver failed to make his expected return the helper was alarmed but phoned the person who supplied the equipment, who was, naturally, in complete ignorance of the purpose of the intended dive although known to be involved in such activities. The advice he received was to shine his torch out to sea in the hope that the missing diver was waiting to be reassured that there were no fisheries inspectors about. Only after this was unavailing were the police informed.

The tank, battered, was washed ashore before the victim's body was found. The valve on the tank was closed so it was suggested that he checked it was full then turned it off while walking across the rocks and forgot to open it again. If he entered the rough water without air his fate was certain drowning. Earlier notification of the police would not have altered the outcome.

UNTRAINED. 5th DIVE. ROUGH WATER SOLO DIVE. ABALONE POACHER. DELAYED NOTIFICATION OF HIS BEING MISSING. AIR TURNED OFF WHEN ENTERED WATER. WEIGHTS ON. DROWNED.

SC 95/X

This case is reported because of its unusual nature. During her overseas holiday she had injured her leg while boarding the dive boat after a dive. No particulars are available but she was able to fly home as arranged, a flight which took about five hours. About a month later she became breathless and sought medical advice. By a process of exclusion a diagnosis of asthma was made, there being no evidence of cardiac failure and her blood pressure and ECG were normal, although there was no real evidence to support the diagnosis. A fortnight later she became suddenly breathless and failed to respond to emergency care. At the autopsy organised thrombus was found in both pulmonary arteries but no source of the thrombus could be found in her leg. She never reported having any chest pain.

MINOR LEG INJURY BOARDING BOAT WHILE SCUBA DIVING. BREATHLESSNESS DEVELOPED FOUR WEEKS LATER. CAUSE NOT IDENTIFIED. SUDDEN FATAL HEART FAILURE 2 WEEKS AFTER THIS. NO PAIN. BILATERAL ORGANISING THROMBUS IN PULMONARY ARTERIES. SOURCE OF THROMBUS NOT FOUND.

Surface Supply (Hookah) divers**H 95/1**

The pearling industry off Western Australia and the Northern Territory has traditionally been serviced by those divers who survived their introduction to diving, although this situation is now being regulated and replaced by training schemes.

There is still, on occasion, a divergence between what the regulations set as procedure and actual practice. Such was the case here. This youth was interested in becoming a diver and was given permission to have a trial period on a pearl lugger before a decision was made to sign him on. This was to commence after he passed a basic medical examination, but he actually started before this was performed. He was permitted to make a few dives under the supervision of a licensed diver. On this day he was with a possibly inexperienced diver and diving from a dinghy in an effort to find an area worth a drift dive for pearl shell by the full team. It was revealed later that the skipper had forbidden him to dive, having watched how he managed the equipment and formed the opinion that he was far too inexperienced, although he held an Advanced Diver certificate as a scuba diver and was probably experienced with scuba. Unfortunately another person gave him permission to dive when he and his "teacher" were in the dinghy away from the boat. This person acted as their tender and communicated with the pearl boat concerning their reports on the amount of pearl shell on the sea bed in the area.

He was seen to surface several times in an area of shallow water, at least initially keeping near to the licensed diver. The other person in the dinghy, who was in charge of their hoses, was distracted for a time while watching the approach of another pearling boat which appeared initially to be on a collision course with their boat. When he next looked he saw that the victim's hose had gone tight, then that there were no bubbles. He pulled the hose in and brought the unconscious victim to the surface. He failed to respond to resuscitation efforts. Drowning was the cause of death. There had been no interruption to the air supply. Post-accident checks showed that harnesses were not used so the air hose was attached to the weight belt. There was no bail-out bottle. He was still wearing his mask and weight belt when pulled to the surface.

Through error it was only while the victim was in transit to join the boat that it was noted that he had not yet had a medical examination, but it was thought reasonable to let him join the trip and obtain the certificate on their return. As he had a history of taking medications for depression and hypertension and other unspecified conditions and was a user of cannabis, he would probably have "failed" his medical. However this was his first use of the hookah equipment and he had not impressed the skipper with his approach to the equipment and the only "training" he had received was a few words on emergency ascent as he was about to start his dive. He had been told to hold onto the other diver's line and watch his actions but evidently separated from him, although the latter apparently remained unaware of this until he surfaced.

1st HOOKAH DIVE. NO TRAINING. NO INSTRUCTION IN ITS USE. ESCAPED PRE-DIVE MEDICAL CHECK. EXPERIENCED "ADVANCED" SCUBA DIVER. INEXPERIENCED APPROACH TO HOOKAH APPARATUS. SEPARATION FROM TEACHER/BUDDY DIVER. ON MEDICATION FOR HYPERTENSION AND DEPRESSION. CANNABIS ? ON DIVING ASSESSMENT BEFORE EMPLOYMENT. DROWNED.

H 95/2

This abalone diver disliked using a cage while working but was aware that this was a dangerous time for period for shark attacks because the seals and whales were calving. Like the other local licensed abalone divers he was required to dive in controlled locations and defined times; restrictions which the divers consider to be unwise and unsafe. The shark attack was unexpected and lethal. The tender in the boat found it beyond his strength to pull the victim's body back into the boat and it was lost during the trip back to shore, though later recovered.

ABALONE DIVER. HIGH RISK AREA. SHARK ATTACK.

H 95/3

The “can-do, must-do” ethic of small commercial diving firms is based on the (correct) assumption that there are plenty of others willing to take on any job which might require too troublesome an attention to safety regulations and procedures. Such factors operated in this case. The task was to clear rubbish from within a water inlet tunnel which supplied several pumps, and to check the filter. This task was infrequently performed and, unlike most procedures at this works, there was no pre-prepared job protocol. As the work was not performed in-house, and the successful tenderer was using a sub contractor, the stage was set for each level to assume that another group had clarified safety practices. The diving firm employed had previously undertaken this job and were aware that they should check with the pump attendant that the relevant pump was closed down, and this they did. But they were unaware that another intake pump was also taking water from this passage.

The three man team were advised not to park their truck too close to the pit which gave access to the tunnel because there was risk from a nearby coal heap. When the work diver entered the tunnel his tender, with a safety line attached, kept hold of his air hose. Suddenly he felt a pull and then found the hose was no longer attached to the diver. He quickly descended and found a part of the torn hose but not the victim or his weight belt (found later). Greatly distressed, he reported his findings. A police rescue unit attended and one of the officers, realising there was still a slight chance the missing man might be alive, donned the spare set of hookah equipment and descended to search for him. This was particularly brave, but stupid, as he had never previously dived. By this time all the relevant pumps had been turned off. He managed with great difficulty to drag the victim from the pump impeller into which one foot had been drawn, and brought him back to the surface. CPR was sufficiently successful for him to reach hospital and there one leg was amputated, but he later died from the anoxic brain damage he had suffered. The dive team had not been made aware of the design of the water intake system and the works’ safety officer had not adequately checked the plans for this work.

COMMERCIAL HOOKAH DIVER IN WATER INLET TUNNEL. ONE PUMP ALLOWED TO CONTINUE WORKING WHILE DIVER IN TUNNEL. HEROIC RESCUE EFFORT BY NON-DIVER POLICEMAN. TRAUMA. DELAYED DROWNING DEATH. INADEQUATE PRE DIVE SITE DESIGN INFORMATION AVAILABLE TO DIVERS.

SW 95/1

This fatality is included for its information value although it cannot strictly be considered to come into any of the above categories. This man was taking part in a dive master course and their boat was anchored only 150-200 m

from another dive boat. It was suggested that this man and another have a swimming race to the other boat and back, in part a fitness test. The victim reached the other boat first and exchanged a few words with a person he knew aboard it. He was the faster of the two swimmers and was not puffed by the swim, unlike his fellow swimmer. He then led during their return swim. They were watched from both boats and when the other swimmer was seen to be going off course, due to swimming back stroke, all attention was on him until he corrected his course and completed his swim. Then it was noticed that there was no sign of the victim.

He had been swimming strongly and completed about half of the return swim when last seen. One of the divers immediately dived in and swam to where he had last been seen and was able to see him lying on the sea bed 12 m below. He was unable to breath hold dive so deep and called out for help. As soon as the victim was brought to the surface, by one of the instructors wearing scuba, and his 1-tooth dental plate had been removed, EAR was commenced.

It was later established that he had a history of epilepsy but had neither taken medication nor suffered any known fits for many years. He had probably assumed he was totally free from fits. He had been a scuba diver, without any problems, for 8 years and was an experienced diver. No reason can be advanced for him to suffer a fit at this time other than over-vigorous swimming. He drowned during the short time he was unobserved but the outcome could well have been the same even had the delay before he was rescued been shorter.

SCUBA DIVER. SWIMMING TEST DURING DIVE MASTER COURSE. SILENT DROWNING AT SURFACE. EPILEPTIC FIT AFTER MANY YEARS WITHOUT FITS.

Discussion

It is a matter of repeated observation that death can come silently to some of those who are using a snorkel, even while they are leisurely swimming at the surface in apparently safe conditions. Such was the case in three of the four fatalities in this report. As no adequate reason for such fatalities is readily apparent, a sudden reflex inhibition of cardiac function following inhalation of salt water is invoked as the critical factor in the absence of any significant coronary artery disease. In BH 95/1 it is highly probable that poor swimming ability and a fear of being out of his depth played a part, aggravated by this being the first time he had used a snorkel and he was separated from his friends. Even the shallowness of the water offered no safety in the presence of such factors. In cases BH 95/3 and BH 95/4, sudden death occurred in persons with healthy coronary arteries. It is hard to see how even improved supervision of a crowd of swimmers could prevent this type

of fatality. While the disabilities for which the swimmer/snorkeller was taking medications are unlikely to have been a factor in his death, too few details of his medical condition are recorded to be certain whether this is so. In case BH 95/2, the reason for the tragedy is even more elusive as even the possibility of blackout post-hyperventilation appears unlikely.

The problem of understanding the reason for one person suffering CAGE while another does not is highlighted by case SC 95/1. While it is convenient to believe that the victim failed to exhale correctly during his ascent, such a conclusion would be the consequence of extrapolation from theory rather than one based on evidence of witnesses to this incident. There must be innumerable occasions where divers fail to exhale "correctly", but few pay with their lives. The delay in symptom onset should be noted. Two other victims were untrained and grossly inexperienced (SC 95/2 and SC 95/9). Both were using borrowed equipment. In case SC 95/4 the diver also was untrained, but he was experienced. As he was solo diving there is no witness to what occurred.

In case SC 95/3 the victim broke the primary rule that if one is becoming low on air, ascent is imperative before running out of air. This diver, who claimed to have made 20 dives, including one to 30 m (100 ft), swam deeper in an ineffectual attempt to find an air donor when aware, rather belatedly, that he was nearly out of air. A critical "loading" factor in this incident was a strong current, which had required him to use most of his air supply. Failure to monitor the contents gauge adequately can be fatal. Four of the fatal episodes were associated with low/no-air situations. Two (SC 95/3, SC 95/7) included the factors of excess use of air due to currents while SC 95/4 appears to have omitted to check his contents gauge before he entered the water and probably chose, mistakenly, to use the tank he had used the previous day. In case SC 95/2 the victim should never have been taken diving by his buddy.

The night dive fatality occurred at the surface while using a snorkel. As the victim had an almost full tank of air, and was in no danger from surface conditions, her death is hard to explain. Adverse factors may have been the wearing of excessive weights, anxiety resulting from separation from her buddy, and the difficulty in reaching the inflation button on her BCD.

Water power was obviously critical in SC 95/9 but it was also important in three additional instances. In case SC 95/3 the victim probably used much of his air fighting a current, in SC 95/5 the rough water led the diver to attempt to swim through kelp, which apparently entangled his regulator and pulled it from his mouth, while in SC 95/7 the current was apparently greater than the group had previously experienced in their home country (and their range of diving experience is unknown).

There were four instances where pulmonary barotrauma was either probable or was demonstrated at autopsy as CAGE. It is to be noted that in two instances (SC 95/1, SC 95/3) the doctor who performed the autopsy was aware of the need for either an X-Ray or CT before commencing but appeared to be unaware of how to interpret the findings.

The critical factors in the three hose-supply diver fatalities were strikingly different. In H 95/1 the youth was making his first such dive and was doubtless keen to show his abilities in the water after failing to impress the skipper of his alertness in learning. His scuba diving ability is not known but his health history would probably have proved a block to his being taken on as a trainee. Unfortunately the undoubtedly kindly meant offer of a chance for him to dive proved fatal in this instance.

The shark attack of H 95/2 was made possible by the diver's dislike of working from a shark cage combined with a severe financial imperative to work in known dangerous conditions and blamed, rightly or wrongly, on the regulations which governed licensed abalone divers.

There is probably always an interplay between divers and those for whom they work. In H 95/3 the apparent reluctance of the works' safety officer to recognise the necessity for stopping all pumps which worked on the passages which the divers were to enter, and their ignorance of the true anatomy of the tunnel system, conspired fatally. There can only be praise for the policeman who recovered the victim, though his inexperience could have resulted in this becoming a double tragedy.

Finally, to demonstrate the element of chance which can influence the occurrence of an "incident", and indeed its outcome, consider SW 95/1. This experienced scuba diver had a forgotten history of epilepsy and, even had this been known, it is unlikely he would have been forbidden to swim, though he would not have been accepted for scuba training without an assessment by a neurologist.

Absolute safety is an impossible dream, so always keep alert and follow safe diving rules at all times. Remember the one rule which follows no rules is Murphy's Law !

Acknowledgments

This investigation is an attempt to increase diver safety by indicating problems which others have not survived. It would not be possible without the unstinting and continued support of the Justice/Law/Attorney-General's Departments in every State, their Coroners and Police Departments. This invaluable assistance in this safety project is greatly appreciated.

PROJECT STICKYBEAK

All who are interested in improving diver safety are asked to assist by sending information concerning fatalities (personal reports or news cuttings) because even events receiving great local publicity may be unknown to the compiler of this report. Please write (in confidence) with information to :-

Dr Douglas WALKER
PO. Box 120
Narrabeen
New South Wales 2101

Dr D G Walker is a foundation member of SPUMS. He has been gathering statistics about diving accidents and deaths since the early 1970s. He is the author of REPORT ON AUSTRALIAN DIVING-RELATED DEATHS 1972-1993 which was published in 1998 (see Book Reviews on page 24). His address is PO. Box 120, Narrabeen, New South Wales 2101, Australia. Fax + 61-02-9970-6004.

FUNCTIONAL CHARACTERISTICS OF THE WRIGHT RESPIROMETER AND THE DRÄGER VOLUMETER UNDER HYPERBARIC CONDITIONS

John Whittle, Christopher S Butler and Ray Muller

Summary

An accurate and reproducible method for measuring minute volume under hyperbaric conditions is desirable for the safe conduct of assisted ventilation in the hyperbaric chamber. The Wright respirometer and Dräger 3000 volumeter were compared under normobaric and hyperbaric conditions (1, 2 and 3 bar or 101, 202, 303 kPa) to determine their precision and accuracy at physiologically relevant flow rates.

Although both devices demonstrated a high degree of precision, the accuracy of the Wright respirometer varied with both gas-flow rate and pressure. In contrast the accuracy of the Dräger 3000 volumeter was dependent on flow rate but independent of pressure. Both instruments are suitable for hyperbaric use so long as their limitations are understood.

Key Words

Equipment, hyperbaric research, treatment.

Introduction

Standard testing of commonly used volumeters under normobaric conditions has demonstrated an accuracy approaching $\pm 5\%$.^{1,2} Some published data exists on the functioning of the Wright respirometer under hyperbaric conditions, indicating over-reading by up to 18%.^{3,4}

The high partial pressure of oxygen in the hyperbaric chamber imposes safety limitations on equipment such that devices requiring mains electrical power, heated wires or using touch button controls are unsuitable for use in the chamber. This excludes the majority of commonly used flow and volume meters leaving only mechanical meters (e.g. Wright respirometer and the Dräger volumeter) suitable for use. Sidestream end tidal CO₂ measurement, outside the chamber, may in future prove a useful alternative.⁵

Increases in gas density lead to reduced performance of ventilators, particularly if fluid logic controlled.⁶ The reduction in the delivered tidal volume of set volume under hyperbaric conditions can lead to hypercarbia. As the Wright respirometer has been noted to over-read under hyperbaric conditions, this error is potentially compounded. The monitoring of ventilation with volumeters must therefore be conducted with an understanding of their limitations.

The Wright respirometer contains a light mica vane which rotates within a small cylinder (Fig 1). The wall of the cylinder is perforated with a number of tangential slits so that the air stream causes the vane to rotate. The rotation of the vane activates a gear chain which in turn drives the pointer around the dial. Calibration is performed using a sine wave pump to adjust the relationship between the number of rotations of the vane and the volume of gas which has passed through the meter.⁷ This system has an inherent inertia so that the meter tends to over-read at high tidal volumes and flow rates. The instrument is suitable for use in conditions of high relative humidity (>60%) and temperatures up to 50° C.¹

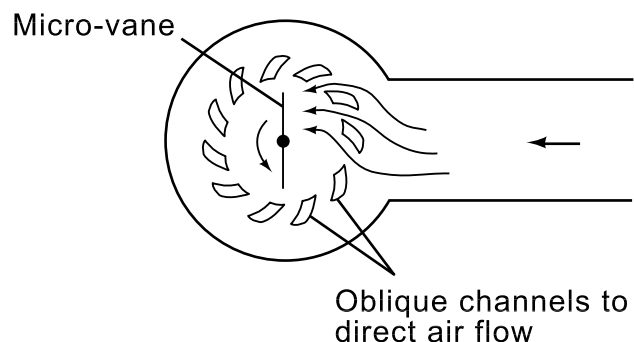


Figure 1. Wright Respirometer in cross-section (reprinted, with permission, from Sykes, Vickers and Hull⁷).