

ORIGINAL PAPERS

PROVISIONAL REPORT ON AUSTRALIAN DIVING-RELATED FATALITIES, 1985

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SUMMARY

There have been thirteen diving-related fatalities identified as having occurred in Australian waters during 1985, three being breath-hold divers and ten divers using scuba. The breath-hold fatalities were due to an epileptic seizure in a known epileptic, a shark attack, and to misjudging adverse water conditions. In examining the critical factors in scuba diving deaths three cases were noted where death was apparently due to cardiac factors. Two cases illustrated the danger of being dependent on the scuba tank air supply for buoyancy vest inflation. There was one unfortunate case where equipment failure was crucial, when the faulty buoyancy vest plus the jamming of the weight belt buckle by a weight which had slipped forwards changed a low-air ascent into a drowning. It was noted this year that six of the victims were described at the inquest as being experienced (one had dived for years but taken a scuba course only recently). Though avoidable adverse factors were present in most cases there were no instances of gross ignorance, or of culpable loaning or hiring of equipment to the unqualified. Once again the extreme danger to divers in dams of straying close to outflow pipes has been dramatically illustrated. In five cases a low-air situation was a factor in the course of events, which is strange as all were wearing contents gauges. One death occurred as soon as the victim reached the sea bed, before his buddy descended to join him, and this is unexplained, while the reasons for the air embolism death of an instructor are similarly a mystery. Special attention is drawn to the apparent occurrence of two instances of air embolism which occurred while the victim ascended underwater.

CASE REPORTS

These case reports are based on the evidence collected by way of depositions by the witnesses and presented to the Coroner, this being added to by the evidence given before the Coroner, except in those cases where no inquest was thought to be necessary. In some few instances additional information has been obtained from other sources which has added to the official documentation.

Identification of these fatalities has been largely dependent on the goodwill of persons who are persuaded of the value of this ongoing attempt to identify the critical factors which may result in the demise of a diver, their hope being that these reports will improve awareness of diving safety factors. It is possible there are cases known to readers which do not appear in this review and readers are invited to communicate such information to the author of this report.

Case BH 85/1

The victim was an epileptic on medication spending a weekend with three friends at a caravan park. Despite his having an apparently correct level of "Dilantin" in his blood he had had an epileptic fit two weeks previously. The dive plan was that one remained

ashore as the safety man while the others dived. Because the water was rough the first to enter the water was not followed by the other two, who chose to enter where it was calmer, about 200 metres away. This pair, the victim and his buddy, gradually became separated as they drifted at the surface and after about 5 minutes the buddy looked up and saw the victim floating face down with no snorkel in his mouth. He thought at first that his friend was playing a joke on him so he swam over and turned him over. He then saw that the victim was unconscious and had froth coming out of his mouth so attempted to keep his face above the water and to tow him to the shore but found he was unable to manage this. So he yelled out to attract the attention of two men he saw standing on the rocky shore. One of them, thinking that the diver he could see and hear must have shot a spear into himself, immediately took off his shoes and swam out to the buddy. It was only when he reached the diver who was calling for help that he saw there was a second diver there who was floating face down. He turned him face up and noticed that his mask was full of water and he was unconscious, so he towed the victim to the shore, 20-25 yards away, where the other man waded out and helped him get the victim up onto the rocks, the two then attempting resuscitation by "working on him, pumping him". They described getting "heaps of water and froth from his mouth and brown stuff out of his nose" and did not attempt "mouth-to-mouth" resuscitation because they "could not clear his throat of all the saliva coming out". It is not known whether they were applying an effective version of external cardiac compression (EEC) or, as described, "massaging and pumping". The son of one of these men was present and was stated to have at sometime "done lifesaving" but did not apparently seek to use his training. This raises questions concerning the effectiveness of a lifesaving course in preparing a person to manage the problems of mouth-to-mouth when froth and vomit continues to come up and fill the victim's mouth. Death was due to drowning which followed loss of consciousness due to an epileptic seizure.

DROWNED FOLLOWING EPILEPTIC FIT. EPILEPTIC ON MEDICATION. EXPERIENCE NOT STATED. SURFACE SEPARATION OF SHORT DURATION. FOUND ON SURFACE, UNCONSCIOUS, FLOATING FACE DOWN. BUDDY ATTEMPTED RESCUE BUT NEEDED HELP FROM BYSTANDERS. MOUTH FROTH FRUSTRATED RESUSCITATION ATTEMPT.

Case BH 85/2

Shark attacks are rare in Australian waters and this one was unexpected although a large shark had been seen five weeks previously by people in a boat near where the attack occurred. The victim was among those warned of the shark's presence but had not taken the shark story seriously, nor had other people, there being many people at the beach that day. The victim was about 10 metres inshore of the rocky reef which was their objective, the nearer of the other divers being 10 metres or less distant at the time when the attack occurred. They each carried a catch bag which then held eight scallops. The third diver was about 100 metres behind them, trying to catch up after returning to the beach for some piece of equipment he had forgotten. The water was clear, calm, and only two metres deep where the victim was

attacked. The tide was coming in, covering the reef. There was no warning until the victim cried out and was seen lifted waist high from the water. The dorsal fin of a large shark was now seen, then the victim disappeared leaving behind only a single flipper and blood stained water to show where the victim had been. A boat quickly responded to the cries of the other two divers and brought them back to shore. Despite vigorous searching by police divers, using shark proof cages borrowed from local abalone divers and a helicopter search, nothing further was ever recovered, and an intensive shark catching campaign failed to catch any large sharks. Some fishermen saw a large white pointer estimated 5.3 to 6 m (18-20 feet) long (which agreed with the estimate made of the shark seen five weeks previously), about three hours later, in a channel leading to deep water from inshore of the reef. This was the last time the shark was sighted and there were no further shark attacks reported on people anywhere else that year.

A Game Fishing competition had been held in the area only a short time previously, this ending 10 days before the attack. As competitors were permitted to "burley" (put blood and meat into the water) to attract sharks, although not in the immediate vicinity of the beach, this was held to be an obvious reason for the appearance of the shark, though others held that a tuna boards offal was responsible. Naturally both of these theories were vigorously disputed by the respective parties named and a "rogue shark" was blamed. Sharks had been seen in the beach area previously but no attacks had occurred. It is indeed fortunate that this monster shark decided to return to its usual deep water hunting grounds after this single attack.

SHARK ATTACK. EXPERIENCED. CALM, CLEAR WATER 2 M DEEP NEAR OFFSHORE REEF. VICTIM TOTALLY DESTROYED. TAKEN BY 5.3 TO 6 M WHITE POINTER.

Case BH 85/3

Despite what was described as "a very rough sea with a moderate swell and some current" the victim and his 16 year old son attempted to snorkel out to a sandbar about 50 metres off the beach. He was said to be "a capable swimmer" but nothing is known of his snorkelling experience. The victim was able to stand on the sandbar but the water was too deep for his son to do likewise. He told his son to return to the beach and said he would follow him, but during his return swim he got into difficulties, cried out for help, then disappeared and was drowned. His son heard him but was too tired by swimming in the rough conditions to attempt to offer any assistance. When last seen the victim was floating on his back. He was not described as having fins, weight belt or wet suit.

WATER POWER. SURFACE PROBLEM IN ROUGH SEA. SNORKEL EXPERIENCE NOT STATED. NO FINS. NO BUOYANCY VEST. SURFACE SEPARATION IN ROUGH SEA. LAST SEEN FLOATING ON HIS BACK, THEN DISAPPEARED. BUDDY TOO FATIGUED BY ADVERSE CONDITIONS TO ASSIST. DROWNED.

Case SC 85/1

This boat dive outing was organised by the dive shop where the victim had recently completed a scuba course. He had at first been considered medically unfit because he was on propranolol (Inderal) for hypertension (BP 160/100). He was also overweight.

However the doctor who performed this "diving medical" suggested that the desired Fitness to Dive certificate would be issued if he was put on some other tablets, and this was done by his regular doctor, who apparently said he would not be fit. The instructor accepted this decision reluctantly, continuing to have misgivings concerning the health of this pupil. However he had not had time to contact the doctor who had done the "diving" medical before the fatal dive. Neither doctor had thought he was unfit to dive, it was solely that propranolol (Inderal) was not considered a safe drug for use in a diver. His medical history was not fully revealed till later, and then incompletely.

Due to his concern about the diver's doubtful fitness and health the instructor had taken care to accompany him for all the course dives and even now, following his qualifying, took care that he accompanied him. There were several divers on the boat and the instructor arranged to accompany the victim and another novice on their dive. It was an uneventful dive in 6 to 7.5 m (20-25 feet) and the victim was buddied to the surface by the instructor as soon as his gauge read 500 psi remaining air. They were about 20-30 metres from the dive boat and at no time, then, during or before the dive, was there anything to suggest that the victim was other than perfectly fit, so after he had inflated his "horse collar" buoyancy vest it seemed safe to let him swim back to the boat unaccompanied. He started his return to the boat lying on his back, his vest inflated, at the surface in calm water. After observing his progress for a few moments the instructor again descended, rejoining the other novice until he also became low on air and was brought up to the surface and left to swim back to the dive boat while the instructor again descended as he had been using his air less rapidly and wished to use his remaining air with a solo dive. However he heard the dive boat's outboard engine start up after about 5 minutes, an arranged order of recall, so he surfaced. Only 8-9 minutes had passed since he had left the victim at the surface.

When the second novice reached the dive boat he was asked where the victim was, which surprised him as he expected him to be already in the boat. It was only now that anyone looked round and saw a brightly coloured buoyancy vest about 20 metres away, and on looking closer it was seen that it was supporting the victim face up, his weight belt still on. Unfortunately nobody thought to note whether the inflated "horse collar" buoyancy vest was maintaining the victim's face above the water surface. He was quickly brought aboard and cardio-pulmonary resuscitation (CPR) started, oxygen was also given, and a Mayday radio call made. The helicopter rescue team soon arrived but the victim could not be revived. There was no police check of the equipment, but the instructor looked at it and found no faults: the remaining air was noted to be 50 psi and the vest well inflated.

The autopsy disclosed the presence of frothy fluid in the bronchi and atheroma of the anterior descending branch of the left coronary artery. It was concluded that he drowned when incapacitated by an anginal attack due to the ischaemic heart disease (the myocardium was macroscopically normal). There was no evidence presented that indicated any interest in his previous medical history. It is now known that he was pensioned out of his previous employment on the grounds of ill health and had at some previous time complained of chest pains, been investigated, and told there was no evidence of a heart disease. It is not

known whether he revealed any of this to the doctor performing the diving medical. The striking silence of his dying is to be noted, those in the boat noticed nothing.

HYPERTENSIVE AND OVERWEIGHT. ON UNNAMED MEDICATIONS. INSTRUCTOR NOT HAPPY WITH MEDICAL ASSESSMENT OF DIVING FITNESS. NEWLY TRAINED, INEXPERIENCED. SEA CALM. BOAT DIVE 6-7.5 M. SEPARATION FOR SOLO SURFACE SWIM TO BOAT. FOUND ON SURFACE, UNCONSCIOUS, FLOATING FACE UP. RETAINED WEIGHT BELT, 10 KG. LOW ON AIR. BUOYANCY VEST INFLATED. HIRED EQUIPMENT. RAPID SILENT DEATH. CPR, OXYGEN, BUT NOT REVIVED. INSTRUCTOR SOLO DIVING AFTER TWICE LEAVING NOVICES. POLICE-DID NOT TEST EQUIPMENT. HEALTH HISTORY INCOMPLETE. ATHEROMA ONE CORONARY ARTERY. CARDIAC DEATH.

Case SC 85/2

The power exerted by a comparatively modest pressure head of water in a dam when given the opportunity to flow through an exit pipe has been fatal to divers who unwarily enter the area close to the mouth of such pipes. This man, a keen and experienced diver, was responsible for the upkeep of a small dam and had noted a metal plate had recently been removed from its position on the top of the dam wall. He suspected that children were responsible, throwing it into the water to watch the splash it caused, as there was no obvious use anyone could make of the piece. He first made a few breath-hold dives below the dam but found no disturbance of the bottom to suggest the plate had fallen there so next he dived in the dam waters, which he found to be cold and dark. He had been wearing only mask and swim trunks so decided to wear his wet suit and use scuba to make a more effective search, asking his friend, a long time diving companion and a fellow employee, to help. The job was not expected to prove difficult.

There was a scour valve in the dam and he decided to have this opened to lower the water level so that the top of dam could dry, thereby making it possible to fix the plate back in its place without delay. He asked another person, a truck driver without any knowledge of the dam, to operate the sluice while he and his friend went to collect their scuba gear.

The two divers entered the water from where the piece was missing at the centre of the dam, diving separately without lines. The buddy found there was nil visibility below 10 feet and became disorientated so surfaced. He found himself much further from the dam wall than he had expected. At this time the man in control of the sluice outflow valve saw the victim's bubbles coming nearer to his position, which was about 30 feet from where the metal section was expected to lie, then noticed a sudden change in the sound and flow of the water from the pipe. He guessed that the diver was in trouble and across the intake but could not decide whether it was safe to try to close the valve, possibly trapping the diver, or to open it wider to allow him to flow through. He decided to open it and heard the flow increase, then saw the victim slide out and his regulator with hose attached float out near him. He called out to the other diver who retrieved the body from below the dam. It was obvious the victim was dead.

There was no current in the dam and no appreciable inflow current into the pipe except immediately in

front of its mouth so it is assumed that the victim lost his orientation and swam along the foot of the dam wall further than he realised, then started to ascend but unfortunately this brought him in front of the pipe. He would have been sucked onto the mouth of the pipe too forcefully for him to have been pulled free even had he worn a line. The water depth close to the foot of the dam was about 6 metres. The mouth of the pipe was at about 3.6 metres from the surface and its diameter 24 inches.

The autopsy showed that there had been no fractures, death resulting from drowning. There had been blunt trauma to the head and shoulders. When held by the water flow across the partly open mouth of the pipe he would have been unable to breathe even had he retained his regulator in his mouth, his chest muscles being quite unable to counter the compression forces acting on him.

EXPERIENCED DIVERS. DAM DIVE. NIL VISIBILITY. COLD WATER. SEARCH TASK. SEPARATION/SOLO DIVE. VICTIM ORDERED OPENING OF OUTLET PIPE VALVE. DISORIENTATION. FORTUITOUS ASCENT ACROSS PIPE INLET. TRAPPED ACROSS INLET FULLY OPENED VALVE ALLOWED FLOW THROUGH. VICTIM FORGOT THE DANGERS OF WATER FLOW THROUGH OUTLETS.

Case SC 85/3

Three divers decided to go scallop collecting from a launch owner and skippered by a non-diver friend. Their dive plan was changed when the wife of one of them was unable to come along on the trip, the decision being taken to make a drift dive. Though all were trained and experienced two were unused to drift diving.

The method used was for the boat to drift with the current, its anchor hanging down a few feet above the sea bottom. There was a potato bag attached to the anchor into which they could deposit scallops when their collecting bags were full, and a rope was also attached to the anchor at its centre with a loop at each end about 20 feet from the anchor so that the two "novice drifters" could maintain station one each side of the boat's line of drift. The diver who was experienced in this method of diving had a separate line tied to the anchor and remained in the rear of the others, searching in the centre portion of their line of advance. One of the group had a reputation as a poor buddy. He used a lot of his air and energy swimming back and forth into the territory allocated to the other two divers, stirring up the mud and aggravating his companions. Not surprisingly his air ran low first. He showed his contents gauge to the rearward diver, let loose his line, and commenced his ascent solo. The rearward diver was the next to ascend, which he did away from the anchor line, surfacing near the dive boat's storm. He was surprised not to find the first diver waiting for him in the boat but before he could react the third diver surfaced supporting the victim. He had made his ascent up the anchor line and come across the victim tethered by his own hand line which had tangled around his tank valve after he had let it float free.

When the victim was found his tank was empty, his buoyancy vest was inflated, and his knife was in its sheath on his leg. The line tension was being maintained by the pull exerted by the vest and as soon as the body was pulled down a little the line floated free. If the

victim had not left his ascent till low on air there would have been time for him to assess calmly the possible reason for his inability to continue his ascent, to choose an appropriate course of action, and to set himself loose. However he had no such gift of air time and he had no buddy near at this critical moment to disentangle him from the line. As a result he drowned tethered by the line to the anchor hanging below him. It is quite possible that he had little, if any, experience of diving with lines and had no awareness of the way they can float about and entangle if they are given the chance. Certainly this was his first drift dive and a high price was exacted from him for the absence of buddy diving procedures on this dive.

TRAINED. EXPERIENCED. GROUP OF THREE DIVERS. DRIFT DIVE FOR SCALLOPS. FIRST TIME THIS TYPE DIVING FOR TWO. LINES FROM DIVERS TO ANCHOR. BUOYANCY VEST INFLATED. SOLO ASCENT. LOW ON AIR. HAD CONTENTS GAUGE. FLOATING LINE SNAGGED TANK VALVE AND PREVENTED HIM REACHING SURFACE. OUT OF AIR DROWNING. ENTANGLEMENT.

Case SC 85/4

Any assessment of the circumstances of this fatality will be coloured by the philosophy of life of the observer. There are valid arguments concerning the pros and cons of allowing this particular man to take a scuba course and despite the outcome all those involved may well be considered to have acted correctly and in a responsible manner. The victim was a diabetic on insulin for ten years, who had completed his first scuba course 10 days before the fatal dive. However he had been scuba diving on occasions for 15 years and was an experienced snorkel diver, an athletic man who was apparently healthy although hypertensive and taking Minipress and Chlotride. Before acceptance for the scuba course he had full medical evaluation, including a stress ECG.

There were three divers, his buddies being two younger men who had been on the scuba course with him. After they completed a trouble free morning dive they had a good lunch before collecting their refilled tanks from a dive shop and preparing to dive again. They snorkelled out from the beach in mildly rough water to reach the chosen dive area. After diving at 17-20 metres for 40 minutes they checked their contents gauges and found each now showed 1050 psi. One of the group surfaced to check their position then again dived and rejoined the other two. He showed them the direction to take but because they had no compass and there was a current they all surfaced after swimming about 200 metres to check again. They found they were among the rocks off the headland so decided their best plan would be to snorkel back, keeping close together. At one time the victim seemed to be resting on a rock, then a wave washed him off, the same wave also washing his buddies along near to him. They exchanged "OK?" signals with him then resumed their attempts to make progress beachwards against the power of the currents and waves which was thwarting their strenuous efforts. Then one buddy noticed that the victim had stopped swimming and was now floating on his back near to them, his "horse collar" buoyancy vest inflated and keeping his face above the water. They ditched his weightbelt and scuba backpack, then managed to pull him onto a rock ledge and commenced CPR. This they continued until help arrived. At no time was any response to their efforts.

Autopsy showed there were signs of drowning and the heart had normal valves and ventricle. The right coronary artery arose from the aorta 2 cm distal to the usual place of origin, the right aortic sinus, was dominant and was generally free of atheroma. The left coronary artery was normal except in the anterior descending branch, which showed a 50 per cent atheromatous stenosis distally, and in the posterior branch there was some minor atheroma. The official cause of death was given as drowning following a loss of consciousness, cause not known. There was no discussion of the part possibly played by his diabetes or comment on the significance of the observed degree of stenosis of the branch of the left coronary artery on his ability to match the physical demands of the rough water conditions.

DIABETIC ON INSULIN. HYPERTENSIVE, ON MEDICATION. NEWLY TRAINED, BUT SOME PREVIOUS EXPERIENCE. MILDLY ROUGH, CURRENT. DIVING OFF BEACH. 17-20 M. FOUND ON SURFACE, UNCONSCIOUS, FLOATING FACE UP. DITCHED WEIGHT BELT. LOW ON AIR. BUOYANCY VEST INFLATED, HEAD ABOVE WATER. BORROWED EQUIPMENT. DRAGGED FROM WATER BY BUDDIES. CPR ATTEMPTED, BUT NO RESPONSE. CURRENT CAUSED STRENUOUS SWIM TO SHORE. 50% STENOSED CORONARY ARTERY. DROWNED FOLLOWING LOSS OF CONSCIOUSNESS.

Case SC 85/5

The inquest documents are not yet available but some information is available from another source. The victim had been taking a class of pupils on their first sea dive. He was regarded as a safety conscious and experienced instructor and the dive had been trouble free apart from him possibly pricking himself on one of the spines of a Crown of Thorns starfish. However he showed no signs of being in pain and continued the dive in an unhurried and calm manner so he may not have been "stung". They ascended at the approved rate and it was only when he collapsed 1-2 minutes after boarding the dive boat that any problem was suspected. There was no sign of injury noted at this time. There was oxygen on the boat and among those present were two nurses and a doctor so when he collapsed resuscitation was commenced immediately. This enabled him to survive to reach hospital, but there immediately had been too much damage from his cerebral arterial gas embolism (CAGE) for him to survive despite recompression and Intensive Care Unit treatment.

There were two unusual features about this dive, though of uncertain significance. First, the dive was to 16 metres whereas a first dive was normally 12 metres or less. The second point was omission of the routine decompression stop included in every dive ascent. Whether his ascent was truly made at the correct rate is not exactly known and of interest as indicating his state of mind rather than being of causal significance. He handed his equipment up, then climbed aboard unaided and in an apparently normal manner so the onset of symptoms 1 to 2 minutes later, though typical of text book descriptions of CAGE, was totally unexpected.

EXPERIENCED INSTRUCTOR. BOAT DIVE. 16 M. COLLAPSED IN THE BOAT AFTER APPARENTLY NORMAL ASCENT. RESUSCITATION, RECOMPRESSION AND INTENSIVE CARE. POSSIBLE CROWN OF THORNS STING. CEREBRAL ARTERIAL GAS EMBOLISM (CAGE).

Case SC 85/6

Both the victim and her brother were newly trained and making their first post-certification dive using equipment hired from the dive shop with which they had trained. They were allowed free choice from the shop's store of hire equipment. Both the coxswain of the dive boat and the dive leader were dive-master qualified.

Buddy groups were arranged, two pairs and a threesome plus the dive leader, and the dive plan explained when the boat reached the dive location. It was arranged that all were to accompany the dive leader, who would indicate items of interest and keep a watch on their contents gauges. As soon as anyone's gauge showed 50 mPa they and whoever had next lowest remaining air would be ordered to ascend, the buddy groups being re-allocated. At the pre-dive check one of the dive masters noticed that the victim's weight belt was low and loose, with its free end tucked into the belt such that it compromised release of the belt, and corrected the problem. He saw also that she was carrying 12.15 kg (27 lbs) but assumed that she had used this amount during the recent course. When one diver's contents gauge showed only 50 mPa the person with the next lowest remaining air (the victim) was told to join him and ascend. They were seen to start ascending in a normal manner before the others continued their dive. Five minutes later a further three followed to the surface, the final trio lasting a further five minutes.

When the first pair to start ascending reached 20 fsw the victim lost one of her fins but was able to continue ascending at a faster rate than her companion, the diver whose lower air status was the indicator for the ascent. He caught her floating fin, then attracted her attention and got her to wait for him by tugging on her other fin. It was at this time he became aware he was running low of air so he indicated to her to inflate her vest and then he inflated his. By this time they had drifted into a channel with a 3 knot current and as he began a rapid ascent she started to sink deeper. The dive master in the boat overhead saw their ascent but could not see whether she attempted to inflate her buoyancy vest or ditch her weight belt. He quickly got the buddy into the boat, checked that he was in no state to dive again, so himself donned a tank and dived to try to assist the victim. Unfortunately he was unable to locate her as her air bubbles had ceased, and subsequent searches were equally unsuccessful. The body was located the next day, all equipment still in place. Her tank was empty and buoyancy vest was 1/3 full of water.

Checking revealed that the vest was faulty, a matter well known to the manufacturer but which had not been regarded as more than a source of costly complaints from customers. It had not been regarded as dangerous to the users. The effect of the fault was to make it impossible to inflate the vest. The spring clip holding the deflation plunger had broken and as a result the deflation valve remained open and venting. Her chances of survival were further compromised as one weight had moved forwards and was jamming the buckle of her weight belt making the belt impossible to ditch in an emergency. She drowned because she was out of air, had an inoperative buoyancy vest and a weight belt with a jammed quick release buckle. Unfortunately her buddy could not retain his grip on her and she sank.

NEWLY TRAINED, GROSS INEXPERIENCE, CURRENT MADE SITE UNSAFE. BOAT DIVE. 18 M. SEPARATION DURING ASCENT. FOUND UNDERWATER, NEXT DAY. RETAINED WEIGHT BELT, 12.1 KG. NO AIR LEFT. FAULTY BUOYANCY VEST ON INFLATION. UNSUCCESSFUL IMMEDIATE SEARCH DIVE. LOST FIN, EQUIPMENT HIRED AND FAULTY. DROWNED.

Case SC 85/7

As was their weekly habit, three friends were diving from a boat. There was a fairly strong current, as was usual, while the water temperature was what they expected in July. Water depth was 80 fsw but they were diving on a pinnacle which was at 40 fsw for most of the dive. After checking that their anchor was secure they swam separately but made frequent checks on each other, so as soon as they lost contact with the victim the other two swam back to the anchor, and although they met the missing diver before they reached the anchor they decided to end their dive and ascend. The victim moved the anchor to make it easier to raise later and then the three divers started ascending together, each with a half full air tank. To the surprise of the other two the victim omitted the stop they routinely performed at 3 m (10 feet) and continued directly to the surface. This was so out of character that they realised there must be something wrong and followed him to the surface. There he seemed to be anxious and somewhat distressed and he asked them to remove his fins and weight belt. After doing this they helped him get back into the boat by pushing him, then heard some groans from him and found that he had lost consciousness and was lying at the stern of the boat on a seat, frothing at the mouth. They sent a Mayday call for help by radio then pulled up their anchor and began the return to shore. During the journey they met a Volunteer Coast Guard boat which sent a man aboard, who started giving the victim EAR, which was continued by the ambulance medics after reaching land, although it is probable that death had occurred earlier.

He was described as being a healthy man who rarely needed to attend his doctor, with mild hypertension not requiring medical treatment. The autopsy disclosed minimal atheroma and the absence of narrowing in any of the coronary arteries. However the history of the incident makes it reasonable to conclude that he died from a myocardial ischaemia attack, or an arrhythmia, a "cardiac death".

MILD HYPERTENSION, NOT MEDICATED. EXPERIENCED. CURRENT. BOAT DIVE ON A PINNACLE. 24 M. BEHAVIOUR CHANGE ON SURFACING, COLLAPSED IN BOAT. ONSET OF ILLNESS ON ASCENT SO OMITTED SAFETY DECOMPRESSION STOP. DELAY BEFORE EAR STARTED. CARDIAC DEATH.

Case SC 85/8

This newly trained diver was with seven others on a club organised dive. It was a boat dive, four divers in each of the two rubber inflatables. The experienced diver leading the group which contained the victim told them his dive plan took full account of the fact that they would run low on air at different times and he would then send up the two with least air, this allowing the other pair to continue a little longer. The four descended together and the dive leader repositioned the anchor, which was drifting, into a clef. They reached 110 fsw on a slope and after 17

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CASE	DIVE AGE	SKILL VICTIM	BUDDY	DIVE GROUP	DIVE BASE	DIVE PURPOSE	WATER DEPTH	INCIDENT DEPTH	WEIGHT (kg)
BH1	20	Inexperienced	Experienced	3	Rocks Separation	Spearg fishing	Not Stated	Surface	Not stated
BH2	33	Experienced	Experienced	3	Beach Separation	Scalloping	2 m	Surface	Not Applicable
BH3	59	Experienced	Not stated	3	Beach Separation	Recreation	Not Stated	Surface	Not stated
SC1	43	Just Trained Inexperienced	Trained	3	Boat Separation	Club Recreation	9 m	Surface	10
SC2	39	Experienced	Experienced	3	Land Separation	Recover plate from dam	5 m	5 m	Not stated
SC3	29	Trained Experienced	Trained Experienced	3	Boat Separation	(Drift dive)	18m	9 m	Not stated
SC4	50	Just trained Experienced	Trained Inexperienced	3	Beach	Recreation	17 m	Surface	Not stated
SC5	30	Trained Experienced	Part Trained Inexperienced	Class	Boat	Class	16 m	Surface	—
SC6	24	Just trained Inexperienced	Nil Training Inexperienced	4	Boat Separation	Recreation	18 m	5m	12.1
SC7	46	Trained Experienced	Trained Experienced	3	Boat Separation	Recreation	24 m	Ascent?	Not stated
SC8	21	Just trained Inexperienced	Trained Inexperienced	2	Boat Separation	Recreation	35 m	35 m	8.1
SC9	29	Not Trained Inexperienced	Trained Experienced	3	Boat Separation	Recreation	6 m	6 m	Not stated
SC10	28	Trained Experienced	Trained Experienced	Buddy pair Separation	Boat	Recreation	39 m	36 m	Not stated

minutes there the victim's contents gauge was nearing the red zone indicating a need to ascend, the other inexperienced diver's gauge being nearly as low. Both were making their first dive since completion of the dive course a month previously. They were also near the allowance of time for a no-decompression dive at this depth. When shown the contents gauges the dive leader indicated that they should ascend together, however they apparently delayed at least two minutes, being then still at 80 fsw and about to start ascending. The dive leader then lost sight of them as he was distracted by finding an anchor which he immediately swam towards and collected. About 5 minutes later

he and the fourth diver (an experienced diver also) started their ascents, apparently independently of each other.

The diver who ascended with the victim described what had occurred. During their ascent together he saw the latter deflating his vest, which he supposed was through fear of a too rapid ascent leading to decompression sickness. Soon after this he indicated a low-air state and started to buddy breath with the witness, whose own air supply soon also failed. The buddy indicated to the other to drop his weight belt and dropped his own. He tried to maintain a hold on

PROVISIONAL REPORT ON AUSTRALIAN DIVING-RELATED FATALITIES 1985

BELT ON	CONTENTS GAUGE	BUOYANCY VEST	REMAINING AIR	EQUIPMENT CHECK	EQUIPMENT OWNER	WET SUIT	SIGNIFICANT FACTORS
Not Stated	Not Applicable	No	Not Applicable	Not Applicable	Own	Yes	Epileptic, on medication. Separation before incident. EAR problem.
No	Not Applicable	No Applicable	Not Applicable	Not Applicable	Own	Yes	Shark attack. No remains found. No inquest
Not Stated	Not Applicable	No Applicable	Not Applicable	Not	Own	No	Rough sea. Dive aborted. Separation. Buddy returned first. No inquest
On	Yes	Inflated	Low	No	Hired	Yes	Hypertension. Excess weight On medication. Solo surface swim. Cardiac death?
On	Yes	No	Not Stated	Yes	Own	Yes	Sucked through dam outflow pipe by flow of water. Nil visibility.
Not Stated	Yes	inflated	Nil	Yes	Own	Yes	Solo ascent. Low air. Line fouled. Inexperienced in drift diving for scallops.
Buddy drop	Yes	Inflated	Low	Not recovered	Borrowed	Yes	Diabetic. Hypertensive. No inquest. Buddy resuscitation attempt. Cardiac death?
—	—	—	—	—	Own	Yes	CAGE. Sudden collapse in boat 2 minutes after surfacing, "ascent normal".
On Jammed.	Yes	Mechanical failure	Nil	Yes.	Hired	Yes	First post-course dive. Low air ascent. Unable to drop weight belt. Buoyancy vest faulty.
On	Yes	Yes	less than half	Yes	Own	Yes	Ascended without safety stop. Feeling ill. Cardiac death in boat. Delayed start to resuscitation. No inquest.
On	Yes	Inflated then deflated	Nil	Yes	Own	Yes	Deflated vest on ascent. Then no air to reinflate. Aborted buddy-breathing ascent. CAGE.
On	Yes	Buddy inflated	Full	Yes	Own	Yes	Descent before buddy. Found dead on sea bed. Difficult to get into boat. Sudden death. Cardiac cause?
On	Yes	Not Inflated	Nil	—	Own	Yes	Deep dive. Nitrogen narcosis Buddy had mask problems. Separation at start of ascent. Insufficient air to inflate vest. CAGE.

the victim's back pack while he finned hard to increase his rate of ascent. The victim seemed to be conscious but was not moving, a dead weight which was too great for the buddy to manage. Contact was broken and the buddy surfaced alone. Divers from the second boat heard his cry for help on surfacing, towed him back to the other (unattended) boat, then made a surface search seeking to locate the missing diver, an underwater search being delayed until some full air tanks could be obtained. The body was recovered the next day with the weight belt lying close by.

The autopsy was conducted without an awareness of

special methods devised for "diving deaths" so the report has regrettably inadequate detail. There is a statement that both chambers of the heart contained air, there is no record of whether this air was in both ventricles or only in the left side of the heart, this matter not appearing significant enough to be recorded by the pathologist performing this autopsy. The diagnosis of air embolism was made.

NEWLY TRAINED, GROSS INEXPERIENCE. EXCESSIVE DEPTH AND TIME FOR EXPERIENCE. BOAT DIVE. BOTTOM SANDY SLOPE. 35 M. SEPARATION DURING ASCENT. FOUND UNDERWATER, NEXT DAY. WEIGHT

BELT NOT DROPPED IMMEDIATELY, 8.1 KG. NO AIR LEFT. BUOYANCY VEST DEFLATED DURING ASCENT. BUDDY INEXPERIENCED BUT ATTEMPTED ASSISTANCE. DELAYED ASCENT DESPITE LOW ON AIR. NO BUDDY BREATHING AS NEITHER HAD AIR LEFT. CAGE.

Case SC 85/9

Although he had been a member of the diving club for about a year this is thought to have been his first scuba dive in several years. He had probably attended a course in 1978/9 though not completed it, his equipment was in good order, and his total of scuba dives was about eight. His snorkelling experience was slight.

He contacted an acquaintance in the club who had a 75 hp, half cabin, 15 ft fibreglass boat and it was agreed the conditions were ideal for a dive. After reaching the dive site they anchored the boat, checked their equipment, and then started to kit up.

The victim was ready first and they agreed that he should enter the water and check that the anchor was holding securely on the sea bed, remaining there till joined by the buddy (who was not ready to enter the water). The buddy corrected the attachment of the victim's buoyancy vest inflator hose, which had been under instead of over his arm. The victim then made a correct backward roll water entry from the boat, probably surfacing before starting his dive descent. The buddy had no reason to watch his descent as he was then completing his own preparations follow.

When, some 2 to 3 minutes later, he descended he was shocked to see the victim about 2 to 3 metres from the anchor line, floating face down and unconscious, about 1 metre above the sea bed. The buddy immediately dropped the victim's weight belt and inflated his buoyancy vest, then inflated his own and brought the victim to the surface up the anchor line. A chop was now present and this prevented him from successfully performing in-water resuscitation. So he left the victim floating, after first ditching his scuba tank, and swam back to his boat. After buoying the anchor line he dropped it and brought the boat to the victim, who had floated 3 to 4 m (10-12 feet) away by now. Because the victim was so large and heavy the buddy found he was unable to pull him into the boat, so he tied the victim to the boat to keep his head above the water while he was trying to attract the attention of people in a nearby boat.

Two men came across from this other boat and they managed to get the victim into the boat, then they commenced resuscitation attempts. Their other boat carried a radio and a message was sent to ask for emergency assistance. There was no observed response to their resuscitation efforts. During the return the dive boat ran out of fuel but because there was a spare tank this caused no problems.

The cause of death was from drowning, no other cause being identified. The tank was washed ashore two weeks later showing some damage from its time in the sea and now empty of air. It was seen that the tank valve had been incompletely opened. The weight belt was never recovered so it cannot be known whether he was carrying excessive weight and descended uncontrollably. If the air supply was restricted by the part closed valve he would have been hungry for air, not having had time to resolve the overbreathing response found after water entry and receiving less

than a full flow. This would be a panic inducing situation and he would now be likely to inhale water, which could result in a fatal cardiac arrhythmia.

PART TRAINED, NO RECENT EXPERIENCE. "IDEAL", CALM, SHALLOW. BOAT DIVE. 16 M. SEPARATE DESCENT, BUDDY NOT READY. FOUND UNCONSCIOUS, UNDERWATER, 2-3 MINUTES AFTER DESCENT. RETAINED WEIGHT BELT. FULL TANK NOT FULLY TURNED ON. FAILED TO INFLATE BUOYANCY VEST. DIFFICULTY WITH IN WATER RESUSCITATION AND IN GETTING LARGE VICTIM INTO BOAT. RESUSCITATION DELAYED, BUT NO OBSERVED RESPONSE. DROWNED, POSSIBLE CARDIAC ARRHYTHMIA.

Case SC 85/10

This boat dive was being run by a dive store with a diving instructor as coxswain and two trainee divemasters to run the actual dive. The victim was described as having a skill level and experience equal to them. All those on the dive were trained, there being eleven in addition to the three just noted. The buddy pairs were arranged and the dive plan was described, 12 minutes at maximum depth of 120 fsw (the US Navy table allows 15 minutes but a safety factor was deliberately added), before diving commenced.

The dive was onto a scuttled vessel, the divers descending a weighted shot line dropped close to it. A tank was fixed to the line in case decompression became necessary for anyone. After the divers returned to the dive boat a check revealed that there were two still to return but before any action could be taken a single diver surfaced, the victim's buddy. She reported she had last seen him at the vessel's bow about 8 minutes into the dive when he had indicated they should be starting their ascent in 2 minutes. They made an unsuccessful search to locate the shot line, then decided to ascend direct to the surface without the line. They were close together at this time but as they started to ascend she again had trouble with her mask (she experienced trouble during descent, this being resolved and not recurring till now), her attention being on clearing it she lost sight of the victim. She was alone when next she checked but could see bubbles ascending so dumped air out of her buoyancy vest to halt her ascent and allow him time to rejoin her. However the bubbles soon ceased and she could not see anyone below her so she continued her ascent, taking a precautionary stop at 10 fsw depth before surfacing. It is apparent that she was not at that time particularly worried about her buddy's situation.

As soon as this story was given the dive leader swam over to the shot line and looked down but could see neither the victim nor his bubbles, only divers from another boat. To avoid creating a decompression problem for himself he deputed the search task to the skipper as he had not dived that day. After a search he found the victim lying on the sea bed (127 fsw) about 100 feet from the shot line. He was unable to inflate the victim's buoyancy vest as the tank contained insufficient air for this purpose (there is no mention of thinking to ditch the weight belt) so he chose to drag the body to the shot line and attach it there for recovery later. The effort required made him breathless and made him feel worried about his air supply although well aware that he had a sufficient supply. A diver from another boat brought the body up later.

Before commencing this autopsy x-ray films were taken and these showed air in the heart and the major arteries in the neck. There was frothy pink fluid in the trachea and bronchi, similar to that which could be expressed from the cut surfaces of the lungs, but there was no histological evidence of pulmonary barotrauma in the lung sections examined. The cerebral vessels contained large blebs of air. Death was due to air embolism into the brain (CAGE).

Examination of the tank showed it was down to the reserve pressure and the reserve was "on" so no air was available for use by the victim. It is probable that nitrogen narcosis had effected his alertness to his situation. His deep diving experience is not on the record.

TRAINED, APPARENTLY EXPERIENCED. CALM SEA. BOAT DIVE. 36 M. DEEP DIVING EXPERIENCE NOT STATED. SEPARATED DURING ASCENT. FOUND UNDERWATER, UNCONSCIOUS. RETAINED WEIGHT BELT. NO AIR AVAILABLE. FAILED TO INFLATE BUOYANCY VEST. BUDDY SURFACED AND ANOTHER FOUND BODY. LOW ON AIR BUT DID NOT OPERATE RESERVE. NITROGEN NARCOSIS PROBABLE. CAGE.

DISCUSSION

The three breath hold diving fatalities show a remarkably unusual diversity of critical factors. The risk of drowning if an epileptic should have a "turn" while in the water is obvious when considered in the abstract but must appear slight to someone with only rare attacks. This case was particularly unfortunate because his friends were attempting to keep a safety watch on him. It was probably unwise to allow an epileptic having recent break-through attacks while on therapy to go swimming but there was no evidence that he was told this (or that he was not so advised). As in most instances where the victim's previous health may be significant, the records fail to cover all matters of interest because inquest investigations are intended to find the cause of unexpected deaths rather than be an investigation into every detail of the critical path of the incident. Epilepsy, particularly if poorly controlled, must be regarded as a contraindication to in-water activities.

The shark attack was totally unexpected and a tragic reminder that on rare occasions a "rogue" shark may show the power of this species. The possible significance of burleying to attract sharks for the amusement of big game fishermen must remain undecided. The third case is a reminder of the factor one cannot afford to ignore, the power of the sea.

In the group of scuba diving related fatalities there are several factors whose significance deserves fresh consideration:

- a. Buoyancy vests relying on the tank air will not function if there is insufficient available air pressure in the tank.
- b. Resuscitation is particularly difficult if there is profuse froth or vomit coming from the victim's mouth.
- c. It can be very difficult to pull an unconscious person into a boat unaided.
- d. Cardiac health factors are not necessarily predictable.

- e. Nitrogen narcosis impairs correct responses by the diver.
- f. Equipment problems, though rare, can occur devastatingly.
- g. Water flowing towards and through exit pipes in dams exerts irresistible pressures at the pipe entrance.
- h. Entanglement need not be extreme to be fatal if the diver is alone.
- i. Air embolism can occur without the victim surfacing. Many people believe that air enters the circulation only when lung overpressure is relieved on taking a breath after surfacing. This is incorrect. From the autopsy results of cases SC 85/8 and SC 85/10 and the previously reported case RB 83/1^{1,2} is apparent that air embolism can occur as a result of ascents which never approach the surface. Two such cases were reported by Harpur.³ No other published autopsy reports of such incidents have been traced.

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PROJECT STICKYBEAK

This is an ongoing confidential investigation seeking to collect information relating to all severities and types of diving-related events. Correspondence giving information or commenting on case reports is welcomed.

DIVING AND DENTAL PAIN

RS Hobson

Scuba diving is one of the most rapidly growing adventure sports today, and this, together with the use of divers in industry, especially for oil exploration, has resulted in a great deal of medical research into the physiology of diving, usually in order to achieve longer and deeper dives for the professional diver. More recently, attention has focused on the problems encountered by the sports diver, and a number of papers^{1,2,3,4,5,6} describe disorders of the ears, nose and sinuses. A few papers^{7,8,9} describe dental problems