ORIGINAL PAPERS

PROVISIONAL REPORT ON AUSTRALIAN DIVING-RELATED DEATHS IN 1990

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Summary

During 1990 there were fourteen identified fatalities in divers. Four were breath-hold divers, eight were, or had been using scuba, and two used hookah (hose supply) equipment. Cold was a significant contributing factor in two of the scuba divers, cardiac disease in two, and an acute gastric haemorrhage in one. Significant coronary artery disease was found in two snorkelers. Neither was known to be other than healthy. It is uncertain whether coronary disease was co-incidental or was the reason (angina) for one man's fall, which resulted in a subdural haemorrhage while standing on a reef. Trauma was the reason another snorkeler drowned. Apparently he lost his footing and fell off a pontoon, hitting his head. None of the medical factors could have been identified at a routine pre-dive medical check. One man was lost in waist deep water while standing on a reef, a shark attack being the presumed reason.

Breath-hold divers

BH 90/1

While on a day trip visit to a Barrier Reef island this 61 year old tourist decided to hire a mask and snorkel and go for a swim off the beach. Others were also snorkelling in the area. She was reputedly a good swimmer, but this was the first time she had used a snorkel. There is no report of the water conditions but there is nothing to suggest the sea was not calm. There were no witness statements mentioning the recognition of her being in trouble, or describing the recovery of her body. She failed to respond to efforts to resuscitate her.

The autopsy showed marked atheroma of the left coronary artery but an apparently healthy myocardium. It is assumed that she suffered a sudden cardiac arrhythmia and drowned quietly, none of the other people apparently being aware of her need for help. It is possible this occurred as a primary malfunction but it may have been secondary to inhalation of water through the snorkel as she was totally inexperienced in its management.

FIRST USE OF SNORKEL. SOLO BUT NEAR OTHERS. GOOD SWIMMER. SILENT DEATH AT SURFACE. SEVERE ATHEROMA ONE CORONARY ARTERY. POSSIBLE CARDIAC DEATH.

BH 90/2

As a social outing during a conference those attending were taken to visit the Barrier Reef and were given an opportunity to swim from a moored pontoon. There was some wind and the water was moderately rough but some at least of the visitors accepted the opportunity to have a swim using the masks, fins and snorkels available. There was a person appointed to watch the swimming area but nobody particularly noted the victim until he has seen not to react when a wave passed over him. It was then realised that he was drifting slowly away from the pontoon under the influence of the wind and a boat was sent to check whether he was in trouble. He was floating face down, his mask and snorkel in correct position, when he was reached.

All attempts to resuscitate him were unsuccessful and at the autopsy the reason became obvious. There were abrasions and a bruise on his lower back and subdural haemorrhage was found covering the occipital lobes and this extended down into the posterior fossa. It is probable that he slipped while on the pontoon, hitting his back and head forcefully and drowned because he was too dazed to save himself. As nobody was looking in his direction at the time, and he made no cry for help, he had no chance of surviving. It is obviously not possible to watch all persons in a crowd simultaneously and this was thought to be a safe swimming area.

SOLO IN A GROUP. SLIPPED AND HIT HEAD. SUBDURAL HAEMORRHAGE.

BH 90/3

This fatality is believed to be due to a shark attack as no other cause can be suggested for the sudden disappearance of an alert and physically fit person from the top of a reef in close proximity to others who heard no call for help or indeed anything untoward. No trace of him or any portion of his equipment was ever found. At the time of his disappearance he was a short distance behind his buddy as they returned to the reef edge where their two companions were trying to free their outboard motor boat to return to their dive base boat. They were on contract to collect trochus shells but had found the area unrewarding. There were some deep channels into the reef and it is postulated that a shark had reached him through such a channel, taking him underwater before he could cry out.

UNEXPLAINED DISAPPEARANCE FROM A WATER COVERED REEF. PRESUMED ATTACK BY SHARK.

PROVISIONAL REPORT ON AUSTRALIAN

Case	Age	Training and Experience		Dive	Dive	Depth m (ft)		Weights	
		Victim	Buddy	Group	purpose	Dive	Incident	On	kg (lb)
BH 90/1	61	First use	Not applicable	Solo	Recreation	Not stated	Surface	Nil	Not applicable
BH 90/2	31	No training or experience	Not applicable	Solo	Recreation	Not stated	Surface	Nil	Not applicable
BH 90/3	37	Trained Experienced	Trained Experienced	Buddy Separation before incident	Work	1 (3)	Surface	None	Not applicable
BH 90/4	54	Training, experience not stated	Training, experience not stated	Buddy Separation during incident	Recreation	1 (3)	Surface	None	Not applicable
SC 90/1	25	Trained Experienced	Trained Experienced	Buddy Separation during incident	Recreation	33 (100)	<33 (100)	On	12.7 (28)
SC 90/2	34	Trained Experienced	Trained Experienced	Buddy Separation during incident	Shell fishing	11 (36)	Not stated	On	14 (31)
SC 90/3	48	Trained Experience not stated	Trained Experience not stated	Buddy Separation during incident	Recreation	17 (57)	Surface	Off	Not stated
SC 90/4	51	Trained Inexperienced	Trained Experienced	Buddy Separation during incident	Recreation	4 (12)	Surface	On	11.4 (25)
SC 90/5	66	Just trained Experienced	Trained Experienced	Group Present during incident	Recreation	11 (36)	Surface	On	Not stated
SC 90/6	13	Trained Some experience	Trained Some experience	Buddy Separation during incident	Recreation	3 (10)	3 m	On	Not stated
SC 90/7	45	Trained Inexperienced	Some training Inexperienced	Buddy Separation during incident	Recreation	7 (23)	Surface	On	Not stated
SC 90/8	27	Trained Experienced	Not applicable	Not applicable	Recreation	Not applicable	Surface	Not applicable	Not stated
H 90/1	54	Trained Experienced	Trained Experienced	Buddy Separation after incident	Recreation Scallops	7 (23)	Ascent	On	Not stated
H 90/2	39	Trained with scuba	Trained Inexperienced	Buddy Present during incident	Recreation	11 (36)	Surface	On	13 (29)

DIVING-RELATED FATALITIES 1990

Buoyancy vest	Contents gauge	Remaining air	Equipment Tested	Equipment Owner	Comments
Nil	Not applicable	Not applicable	Not applicable	Hired	Found floating. Dead or unconscious. One coronary atheroma ++.
Nil	Not applicable	Not applicable	Not applicable	Hired	Found floating. Dead or unconscious. Subdural haematoma. Fell, hit head ?
Nil	Not applicable	Not applicable	Not applicable	Own	Shark attack on reef ? Body never found.
Nil	Not applicable	Not applicable	Not applicable	Hired	Unconscious but paddling. Coronary artery disease. Subdural haematoma.
Partially inflated	Yes	Yes	Significant fault	Own	Poor air supply. Failed buddy breathing. CAGE
Not inflated	Yes	Low	Some adverse comments	Own	Cold. Separation. Solo. Drowned.
Not inflated No air	Yes	Nil	Failure no air	Hire	Separation. Solo. Previous angioplasty. GI tract bleed.
Not inflated	Yes	Yes	Some adverse comments	Own	Cold. Unfit. 1st use of thick wetsuit. Inderal for tremor. Drowned.
Not inflated	Yes	Not stated	Not tested	Dive shop	Cardiac death as exiting. Overseas cardiac check.
Not inflated	Yes	Not applicable	Some adverse comments	Hire	Water power at reef. Gauge caught in cleft.
Partially inflated	Yes	Yes	OK	Own	Had panic attacks on previous dives. Surface panic then blackout. Inhaled water or arrythmia. Sudden death.
Not applicable	Not applicable	Not applicable	Not applicable	Own	Rapid cardiac death asleep on dive boat.
Not applicable	Not applicable	Not applicable	OK	Own	Cold, poor visibility, made normal ascent. Surface collapse. CAGE. Recent myocardial infarction.
Inflated	Not applicable	Not applicable	Some adverse comments	Borrowed	First use of hookah. On surface after panic. Fatigued. Inflated vest did not keep head out of water. Aspiration.

BH 90/4

It is not always immediately obvious to others that some person is in trouble, and such is true in this case. The victim was standing close to another person on the edge of the reef to which the Barrier Reef boat trip had brought them. He was seen to fall back into the water but his companion was not alarmed because he saw he was on his back and making paddling actions with his hands. A short time later he noticed that the victim was staring at him in an expressionless manner before he rolled over, face down. When he saw this the companion called out for help. Attempts were made to resuscitate him, made difficult by the vomit and mucus which was coming from his mouth, but these were unavailing. He was still making hand movements when reach but whether there was any possibility of his recovering at this time is problematical.

At the autopsy he was found to have marked atherosclerosis of the coronary arteries (although there was no known history of him suffering ill health) and a subdural haemorrhage resulting from a ruptured right transverse sinus. Whether he fell because of a heart attack pain and hit his head on the reef, or slipped without any such reason cannot be known.

STANDING CLOSE TO COMPANION THEN FELL INTO THE WATER. INITIALLY FLOATED ON HIS BACK MAKING HAND MOVEMENTS. EXPRESSIONLESS STARE. MARKED CORONARY ATHEROMA. SUBDURAL HAEMORRHAGE. RUPTURED LEFT TRANSVERSE SINUS.

Scuba Divers

SC 90/1

This dive got off to a poor start as they were late arriving at the pier. However they had been booked for the dive on a scuttled vessel lying in 39 m of water and the others waited for them. They had adequate time to fully recover from their rush during the trip out to the dive location, and further time when the skipper was unable to locate the wreck as one of the shore "marks" was not visible and proceeded to a nearby dive boat to ask the name of the wreck to which it had a shot line. As this wreck was at a lesser depth, 33m, the four divers agreed to the skipper's suggestion they dive here. Permission was obtained for them to descend the other boat's shot line and then their skipper would place his line on the wreck after the other boat had retrieved its divers and left the site. This involved some element of rush as the other divers were soon due to surface.

The particulars of this wreck were given but the buddy took little notice as he was accustomed to accepting whatever his friend did, in spite of the habit the latter had of very fast swimming which left the buddy struggling to catch up. There was another pair of divers on the boat but their dive on this wreck was uneventful and neither pair of divers saw the others at any time after entering the water. The victim descended rapidly, followed by his buddy, leaving the shot line before coming within sight of the wreck. Indeed they found themselves on a barren open sandy sea bed and were unable to locate the wreck. After reaching the sea bed and adjusting their buoyancy, by putting a little air into their buoyancy vests, the victim started swimming quickly a little above the sea floor, followed by the buddy. The latter was soon somewhat short of breath and anxiously hopeful his friend would stop and wait for him, so was pleased but surprised when he turned, returned and indicated he wished to start buddy breathing. The buddy stated afterwards that he thought the intention was to practice buddy breathing, something they sometimes did, or that his friend had noticed his breathlessness and was trying to help him, opinions indicative of his confusion concerning the events.

Although the victim had an "octopus" rig and the buddy a single regulator, it was the buddy who was the donor. After a few successful exchanges the buddy was made more breathless when he inhaled some water from the regulator and had it snatched from his grasp and started to cough. It was returned to him upside down and again he obtained a mouthful of water, which unsettled him so much that he gave a signal to indicate he was going to ascend. He then further inflated his buoyancy vest and started finning to start his ascent. The pair became separated at this time and despite his cough and being unable to replace his regulator in his mouth the buddy reached the surface safely. The victim, a more experienced diver, failed to surface. Two experienced divers were sent down and made a grid search, locating the body some distance from the wreck as they were about to abort their search as low on air. There was insufficient air flow to inflate the victim's buoyancy vest, so one of these divers disconnected the low pressure hose from the vest and attached the hose from his tank and inflated the vest, making it easier to raise the body.

Examination of the equipment revealed the reason why the victim apparently became short of air so early in this dive. The tank valve had been incompletely opened and the line pressure was set too low between the first and second stages. He had taken an advanced diver (equipment specialist) course and learned about regulators but he had been told this did not enable him to perform regulator maintenance, an action he may have attempted. The reduced line pressure combined with the depth was the reason for the slow inflation rate noticed with his buoyancy vest. It was reported that he had sufficient air remaining to have made a successful ascent had he chosen to do so. For the same reasons his regulator was unable to provide him with sufficient volume to match the demand generated by his rapid rate of swimming, and the buddy's regulator was insufficiently efficient for his requirements. There were the additional adverse factors of being without refer-

ence points (as the sea bed was featureless) and nitrogen narcosis. Neither had ever previously exceeded 20 m depth and neither had made any recent deep dives. That the buddy made a successful out-or-air ascent despite coughing and without a regulator is both noteworthy and fortunate. Had the victim recognised the imperative need to abort the dive immediately he realised his air supply was inadequate, rather than attempting to buddy breath, the problem would have resolved during his ascent and he would have been unaware of having been at risk.

The autopsy showed the presence of air in all four chambers of his heart (the amount was not recorded) but the pathologist hedged his diagnosis of pulmonary barotrauma by suggesting the air could have represented outgassing after death. He also suggested that a lack of air rather than drowning had occurred, a quaint conceit which is not unknown in pathologists ignorant of the fact that scuba divers use mouth held regulators, not full face masks.

EXPERIENCED BUT NO DEEP DIVES RECENTLY. DEEPEST PREVIOUS DIVE 20 m. THIS DIVE 33 m. IMPETUOUS DIVE HABITS. DESCENDED AWAY FROM SHOT LINE. FEATURELESS SEA BED. AIR HUNGER SO STARTED BUDDY BREATHING. THIS FAILED AFTER BUDDY INHALED WATER. SUCCESSFUL FREE ASCENT BY BUDDY. SLOW FILLING RATE OF BUOYANCY VEST AT DEPTH. WEIGHT BELT NOT DITCHED. VEST MINIMALLY INFLATED. AIR TANK VALVE NOT FULLY OPENED. INADEQUATE LINE PRESSURE FOR REGULATOR. REGULATOR DETUNED. HAD AIR REMAINING. AIR IN ALL CHAMBERS OF HEART. AIR EMBOLISM.

SC 90/2

This was the first day of the scallop season and nobody was going to miss out just because it was bitterly cold and there was minimal underwater visibility. The victim was a trained and very experienced diver who kept fit through sporting activities and had been diving regularly for crayfish. He was certainly one of the best prepared for these conditions. He and his buddy were taking it in turns to dive from their outboard motor boat, though they were sometimes both in the water at the same time. After a time the buddy decided he had dived enough but the victim, who had not joined him in the boat, stated he was going to make another dive. Their dives had each been of short duration and by now the victim had made some 5 or 6 with a probable total duration of 30 minutes.

The buddy attempted to follow his friend in the boat by tracking the bubbles but soon lost this contact. After about 30 minutes he became alarmed by the failure of his friend to surface and called out to the occupants of a nearby boat. It was then that the victim was noticed floating face up, with his weight belt still on and buoyancy vest uninflated. The buddy was first to reach the victim and immediately ditched his weight belt and then, with the assistance of others, his back pack. Together they managed to get the body into a boat and commenced CPR, although the victim appeared to be dead. This was a correct response on their part, the more so because of the hypothermia factor. There was no response.

Examination of the (recovered) equipment established that it was functioning correctly and still contained sufficient air for a diver to make an unhurried ascent. Nobody saw him surface or heard any call for assistance. The pathologist found no more than those changes he expected from drowning but commented afterwards that he had not been aware of the full implications of pulmonary barotrauma when performing the autopsy. One possible reason for this fatality is that his lips became too cold to feel the regulator in his mouth and were therefore unable to retain it. This must remain supposition.

VERY EXPERIENCED. SOLO. FIRST DAY OF SCALLOP SEASON. COLD. POOR VISIBILITY. HIGH LEVEL OF FITNESS. SURFACE WATCH INEFFECTIVE. BUOYANCY VEST NOT INFLATED. WEIGHT BELT ON. HYPOTHERMIA PROBABLE FACTOR.

SC 90/3

Despite a history of angina treated by angioplasty about a year before, and a near fatal post-operative course, this man was an apparently fit person and certainly his wife was unaware of his having any present health problems. He was a certificated diver, though his experience is not recorded, and had joined a group which planned to dive on the Barrier Reef, while his wife intended to do the Resort Course dive available to non-diving passengers on the same boat. This was a diving experience run by the diving instructor after the trained divers concluded their diving activities.

The water conditions were perfect, a calm sea and good visibility. The instructor arranged buddy pairs and briefed them on the locality before they entered the water. The first dive was uneventful so they retained the same buddy pairs for the second one. This also was without problems, although the buddy noticed that on this occasion his companion showed less interest in the fish and corals and seemed to be over interested in keeping his BC inflator in his hand. However after they surfaced he spoke in a normal manner to the buddy, commenting that it was lucky that the buddy had noticed his contents gauge was indicating a low air state as it was only then he noticed that his own was reading near empty. Their ascent was unhurried and both changed over to snorkel use for the return swim to the boat. Separation occurred and the buddy reached the boat first. He looked back and saw that his companion was floating as if examining the fish beneath,

making no swimming movements. This did not alarm him, but the instructor thought something looked wrong and swam from the boat to check whether there was any problem.

The victim was about 150 m from the dive boat. When the instructor reached him and tried to ditch his weight belt he found it had already been dropped. There was insufficient air remaining to inflate the buoyancy vest so he turned the victim face up and inflated the vest orally before starting to tow him back to the dive boat. The attempt to resuscitate him was unavailing (he was very probably beyond help) and made more difficult by vomit and froth coming into his mouth. The autopsy showed that he had suffered an acute haemorrhage into his stomach, cause not identified, and that his heart appeared to be healthy.

TRAINED. EXPERIENCE NOT STATED. HISTORY OF CARDIAC ANGIOPLASTY. LOW AIR, BUT NORMAL ASCENT. SURFACE RETURN. SNORKELING SEPARATION. SILENT DEATH. DITCHED WEIGHT BELT. INSUFFICIENT AIR TO INFLATE BUOYANCY VEST. ACUTE GASTRIC HAEMORRHAGE. MYOCARDIUM HEALTHY.

SC 90/4

His diving experience was extremely limited, a few scuba dives some years previously and a course on a cruise boat some four months before this dive. This was only the second time he had needed to wear a wet suit and weight belt, previous dives having been made in warm waters. Indeed this was his first dive in a thick wet suit and in really cold water. The dive location was considered so safe that it was used by local instructors while training novices and on this day the water was calm and there was no current in the area chosen for this dive. There were two divers and an instructor in the dive boat. After an initial delay, as the victim's regulator malfunctioned, the two divers entered the water with part inflated buoyancy vests and gave each other the "OK" signal. However the victim then failed to deflate his vest fully and was unable to descend. The buddy had already descended as short distance when he noticed this and came back to the surface. The victim was instructed how to deflate his vest but still remained at the surface so the instructor indicated to the buddy that he should rest on the nearby rocks while this problem was resolved, then drove the boat close to the victim, who was drifting away from them. He threw a line but the victim failed to grasp it, and similarly ignored a second attempt to assist his return to the boat despite the line falling across his shoulders.

By this time the boat drifted away from him and while it was being repositioned he was seen to sink beneath the surface. The instructor expected that he would soon reappear, but this he failed to do and the instructor soon began to feel concerned. A formal search was made and his body was discovered, all equipment in position and buoyancy vest not inflated. The autopsy confirmed that drowning was the cause of death but it was noted that his right coronary artery provided no significant branch to the posterior of the ventricle. It is not known whether this played any significant part in his death or whether the cardiac and respiratory reflex responses to sudden immersion in cold water were the critical factors.

After his death his widow revealed that since receiving radiotherapy for a parotid tumour he had suffered from a left facial weakness and was liable to excessive salivation. He was also subject to episodes of tremor (which was diagnosed as "essential tremor") for which he had been prescribed Inderal (propranolol) 10 mg twice daily. She also described how after his first dive in a wet suit he had suffered an episode of tremors and become so fatigued that he had to retire to bed.

TRAINED. INEXPERIENCED. FIRST TIME THICK WET SUIT AND VERY COLD WATER. SURFACE PROBLEM DEFLATING BUOYANCY VEST. FAILED TO RESPOND TO LINE. SANK WITHOUT INFLATING VEST OR DITCHING WEIGHTS. ONE CORONARY ARTERY INADEQUATE. POST-RADIOTHERAPY EPISODES OF EXCESS SALIVATION AND ESSENTIAL TREMOR. MEDICATION WITH PROPRANOLOL.

SC 90/5

To conform to the regulations this overseas visitor had taken local scuba course although having 20 years scuba diving experience. Before this he had a Diving Medical during which full consideration was given to his story of occasional irregularity of his heart, which had been occurring for over 20 years, and a history of a full cardiac assessment "to please his doctor son" before he came on holiday. A cardiologist advised the examining doctor that there would be no particular reason to declare him unfit to dive as ventricular extrasystoles were to be noted in healthy people.

The dive boat moored at a reef and the six divers aboard made an uneventful dive, surfacing normally about 60 m from the boat. The sea conditions were described as moderately rough as they started their surface return swim. When the victim said that he was feeling tired the dive master swam out with a floating line and assisted his return. By this time he was obviously exhausted and breathless. After being brought on board the boat he said that he felt sick and his pulse was noted to be erratic. He was given oxygen but collapsed and cardiac arrest was noted. He responded to CPR efforts, which were continued as they waited an anxious two hours for the arrival of helicopter with paramedics. The CPR was continued despite the finding of asystole, and this was continued a further 15

minutes by the medical team which arrived later, but he was certainly dead long before attempts were discontinued.

Despite the victim's firm assertion that his angiogram had been normal (for which he provided no documentation) there was found to be partial blocking of the right coronary artery by atheroma and a complete occlusion of the posterior interventricular coronary artery. The cause of death was an acute cardiac failure. As he had been an active scuba diver and mountain climber despite his cardiac irregularity for 20 years it was reasonable for the doctor to assess him as Fit to Dive and it is highly probable an event such as this could have occurred at any time. To restrict people too severely from their desired activity whenever there is some health variation from the template of perfect health cannot be unreservedly justified but is likely on occasion to be called into question.

20 YEARS EXPERIENCE. RECENT DIVING MEDICAL AND CERTIFICATION COURSE. KNOWN OCCASIONAL VENTRICULAR EXTRASYSTOLES. PHYSICALLY ACTIVE MAN. SURFACE SWIM. ACUTE CARDIAC FAILURE. CARDIAC ARREST. CORRECT CPR RESPONSE. DELAY BEFORE RESCUE HELICOPTER, WITH PARAMEDIC AID, ARRIVED. MARKED CORONARY ATHEROSCLEROSIS.

SC 90/6

Misjudgment of water power led to the death of this boy and the permanent invalidism of his father. They were trained but inexperienced and somewhat lacking in self confidence, as shown by their habit of reading diving texts the evening before going diving. When they arrived at the beach some surfboard riders told them the visibility was poor but the father said that he thought it might be better further out from shore, and they then entered the water. The youths watched for a short time but then left the area, the divers then being about 200 m from the shore, still on the surface. The water was cold, visibility poor, the surface choppy, and there were 0.6 m waves. Later a witness on shore saw a diver off shore, apparently swimming at the surface, then he realised that it was strange that he was not reacting as the waves broke over him. He noticed that the diver was drifting rather than swimming and after he entered the surf zone near the beach and made no response the witness entered the water and pulled him ashore. With help from others he brought the diver onto dry ground and the ambulance was summoned. He was unconscious and suffering hypothermia. Although he responded to treatment in the Intensive Care Unit he suffered permanent residual mental impairment and was never able to remember what happened.

The next day the sea had abated somewhat and the police divers were able to make a search for the missing boy. There was still poor visibility and a powerful surge over the reef making it dangerous even for these experienced divers. The body was found on the bottom of a crevice, depth 9 m, all his equipment in place except for the tank and regulator. They were discovered nearby, separated from each other, the contents gauge caught in a small crevice. The autopsy showed the presence of bruising of the back and anterior scalp, but no fractures. It is probable that the unfortunate boy was being moved at the whim of the water surges when his contents gauge became trapped and he was instantly anchored, flailing about on the arc of the gauge's hose. This action would place great force on the attachment of the regulator to the tank and this evidently proved too great, the two parting company and remaining air escaping from the tank.

When it was checked, the retaining knob of the A-piece attachment of the regulator to the tank was fund to be filed to a smooth shape, making it difficult for anyone to get a firm enough grip on it to turn it tight. The dive shop owner, from whom it had been hired, did not admit to letting it leave his shop in such a state but it is unlikely that either the victim or his father had been responsible for its condition. However it was the trapping of the free-hanging gauge rather than any other factor which was the primary cause of this accident.

This was only the fifth post-course dive he had made and the circumstances of this dive were highly unsuitable even for a diver with considerable experience. Although the victim carried a 72 cu ft tank and father an 88 cu ft one, and the latter was most probably filled to a higher pressure, this was not a factor of any significance in his fatality. Separation probably occurred before they reached the rocky area as a result of the surface conditions.

TRAINED. INEXPERIENCED. SEPARATION DURING SURFACE SWIM FROM SHORE. FIFTH POST-COURSE DIVE. COLD. POOR VISIBILITY. WAVES. POWERFUL WATER SURGES AROUND THE REEF. WEIGHT BELT ON. VICTIM TETHERED BY TRAPPED CONTENTS GAUGE. TANK TORN FREE. REGULATOR DETACHED FROM TANK. DROWNING PLUS ACUTE TRAUMA FROM THRASHING ON REEF.

SC 90/7

All the divers making this dive cruise among reef islands were supposed to be both trained and to have adequate experience to manage all the dives, but this was not so in practice. The dive master did not inquire closely about medical fitness, diving experience, or even check that all the claims to be trained were true. The victim was trained but she had not dived in the previous 32 months. The other divers thought that she was somewhat unfit, being overweight. Later checking revealed that she was taking antihistamines, thought this was not an apparent adverse factor, and her diving Log Book recorded epi-

sodes of panic and one occasion she had a "blackout" after surfacing from a dive (though it held not details of these events). Her allotted buddy was later found to have never completed a scuba training course and to be inexperienced. It is not known whether the title "Dive Master" was an earned or a de facto title on this boat.

Before the fatal dive commenced the divers were told that they were over a reef, depth 8-9 m which had a drop off to 30 m and they should avoid descending this. Although some of the divers noticed that the victim appeared to become somewhat hot and flustered during her kitting up, the dive master saw nothing of significance in her behaviour. The buddy was wearing a borrowed weight belt which she had not used previously and when they landed on the reef the buddy found she was too heavy to stand up. Fearing she might fall over the edge of the reef, she partly inflated her buoyancy vest and made a rapid ascent, breathing out vigorously as she ascended. She was shortly joined by her companion, who noticed that she had distressed breathing and was coughing, so loosened the top of her wet suit jacket, put more air into her buoyancy vest, and tried to calm her while waiting for assistance from the dive boat. Her signals had been seen and a diver swam to them. He assessed the situation and told the buddy's dive partner to wait his return, then started to tow the buddy back to the dive boat.

When he returned he found that the situation had changed, the diver who had so recently being advising her buddy to be calm now herself showing signs of panic and complaining she was feeling tired. The rescue diver inflated her buoyancy vest further, told her to keep the regulator in her mouth, ditched her weights, and started towing her, against a current, back to the boat. Soon after this he became aware that she had gone limp and the waves were now washing over her face. He ditched her tank and commenced in-water EAR. In a short time others came to assist and she was brought aboard the dive boat but she failed to respond to their resuscitation efforts. The cause of death was drowning but surface panic was why this occurred.

TRAINED. INEXPERIENCED. NO DIVES FOR 32 MONTHS. LIABLE TO PANIC. BLACKOUT ONCE AFTER DIVE. OVERWEIGHT. HEALTH PROBLEM. CALMED BUDDY AT SURFACE. SEPARATION WHILE WAITING ASSISTANCE. DID NOT INFLATE BUOYANCY VEST FULLY. DID NOT DROP WEIGHT BELT. DROWNED DURING SURFACE TOW TO BOAT. BUDDY PART TRAINED. INEXPERIENCED. EXCESSIVE BORROWED WEIGHTS.

SC 90/8

This fatality, sudden cardiac failure, occurred while this young and apparently very fit diver was asleep on a dive boat the night after making several normal dives. This case been included to illustrate the factor of chance which can govern the time of onset of some illness. He was experienced diver had been required to pass several Medical Fitness examinations to achieve his level of certification and had been closely observed while assisting staff instructors. He became acutely breathless during the night and the rapidly instituted attempts to resuscitate him were unsuccessful.

At the autopsy there was no apparent reason for his death but histological examination of the heart muscle indicated there was evidence of a cardiomyopathy. Although the physical demands of diving were inappropriate in the presence of this condition, there were no reasons to suspect he was other than medically fit, and he certainly gave nobody any reason to think otherwise.

TRAINED. EXPERIENCED. APPARENTLY HEALTHY. ACUTE CARDIAC FAILURE WHILE ASLEEP. CARDIOMYOPATHY SILENT TILL FATAL.

Hookah Divers

H 90/1

This was the scallop season and the cold water was being made even colder by the melting snow run off from the land. There was poor visibility underwater but there were plenty of scallops. The victim was described as obese but physically fit, who took adequate exercise. Although he had reported some chest pain about 6 weeks previously a medical check had been satisfactory. He had taken a scuba course 5 years before but his diving experience is not known. As the hookah equipment he was using his own, very probably he had attained some experience in its use, though he had not made any dives for about 7 months.

They were diving from the victim's boat, one person being left on the boat while the victim and his son were diving. They had a successful first day of collecting scallops and the next day also they kept in close proximity while they were collecting, then ascending at the same time and together after each had managed to achieve a full collecting bag. After emptying these onto the dive boat they then descended for a second time. After 10 minutes the victim was seen to give the signal for ascent and this they performed at the normal rate and close together. There was nothing to indicate any problem concerning the victim as his buddy started a surface swim back to the boat, not looking back till he reached it. He then was surprised and alarmed to notice that the victim was no longer at the surface and there were no bubbles to be seen. He immediately swam back, following the victim's air hose and found him floating at 4.5 m (15 feet) depth (bottom at 7 m) unconscious, with the regulator hanging loose and weight belt on. He ditched the weights and began slowly bringing him to the surface, fearing to cause pulmonary barotrauma

if too rapid in ascending. Their attempts at resuscitation failed to elicit any response.

Before commencing the autopsy a chest X-Ray was obtained and this showed the presence of air within the heart and some of the other blood vessels, including the aorta and cerebral vessels. A pneumothorax was shown but this was not demonstrated during the autopsy despite using the recommended "under water" procedures for opening the chest. This demonstrates the value of X-raying the chest before commencing the autopsy. Apart from the changes of drowning, the autopsy revealed evidence that he had suffered an infarct of the posterior wall of the left ventricle about 3 weeks before his death. It is probable that he experienced some heart pain while he was diving and decided he required to return to the surface without delay, but was distracted by the pain so failed to regulate his breathing adequately during his ascent, although this was not apparent to his buddy. There was an interval after he had reached the surface before the air embolism impacted in his brain and it was during this time that his buddy separated from him and began his solo surface return to the boat. There was histological evidence of a long standing low grade myocardial ischaemia but no symptoms of the infarct he apparently suffered about three weeks before he died had been evident to his family.

TRAINED. EXPERIENCE UNSTATED. NO DIVES IN PREVIOUS 7 MONTHS. COLD WATER. POOR VISIBILITY. HUNTING SCALLOPS. ASCENT WITH BUDDY SEEMED NORMAL. SEPARATION AT SURFACE WHEN BUDDY STARTED SURFACE RETURN TO BOAT. SILENT DEATH. CEREBRAL ARTERIAL AIR EMBOLISM. MYOCARDIAL ISCHAEMIA. MYOCARDIAL INFARCT 3 WEEKS PREVIOUSLY. NO BUOYANCY VEST. WEIGHTS ON.

H 90/2

The originally chosen dive location had a strong current so the dive group, in three boats, moved to a calmer location which had only a slight current. The two divers involved were using the compressor unit which belonged to the buddy, who had taken a scuba course about 6 months before and had since accumulated about 12-14 hours experience of hookah diving. Though the victim had taken a scuba course 2 years before this dive he had not dived during the previous 12 months and his knowledge of, and experience with, hookah was probably minimal. There was one 75 m long air hose from the compressor and this was connected to a T-junction to which were attached 3.6 m lengths of hose to the regulators.

The two divers descended but the victim very soon indicated he wished to abort the dive so they ascended. The buddy helped him back into the boat as he was too fatigued to manage it unaided. He explained that he had begun to feel panicky. After an interval in the boat the buddy made a solo 30 minute dive, then he returned and asked whether the victim now wished to try again.

The victim's second dive lasted 5-10 minutes and then he indicated his wish to return to the surface, which they did in the correct slow manner. Again the reason given was of a feeling that panic was imminent. The buddy told him to replace his regulator, a suggestion he failed to follow, then inflated his buoyancy vest in preparation for their swim back to their boat. However the victim soon said he felt he was "not going to make it back" so the buddy signalled for assistance.

They were a little separated by now and when he looked back he saw the victim was floating face down with his mouth submerged so he quickly turned him face up but found he was so heavily weighted (13 kg) that his face was still often covered by water. He attempted to ditch the weight belt but was unsuccessful because the belt had twisted round and the buckle was now at the side. It was noted later that the tongue of the buckle was broken, which made it more difficult to open. When this damage occurred is unknown.

His signals for assistance were noted and while the hose was being used to pull him back to the boat by one person, another diver was in the water, helping the buddy keep the victim's mouth above the water surface. Effective CPR efforts were started after the arrival of divers from another boat, the lack of CPR knowledge possessed by the buddy and initial rescuers being criticised when the events were recalled at the Inquest.

Examination of the equipment showed the buoyancy vest to be one designed for use with scuba, which when inflated failed to maintain the head of a wearer above the surface and face upwards. It was suggested that the compressor did not produce sufficient air when a single hose was used to service two divers at the depth of this dive, the result being a feeling of air hunger likely to produce panic in a diver who was inexperienced. The autopsy showed there had been aspiration of vomit, though whether this preceded or followed the drowning could not be established.

TRAINED. INEXPERIENCED WITH SCUBA. POSSIBLY NO EXPERIENCE OF HOOKAH DIVING. PANIC CAUSED ABORT OF BOTH DIVE ATTEMPTS. SURFACE PANIC. REFUSED TO REPLACE REGULATOR. BUDDY UNABLE TO DITCH WEIGHT BELT. BELT TWISTED TO SIDE AND HAD BROKEN TONGUE. INFLATED BUOYANCY VEST GAVE INADEQUATE LIFT AND FLOATED WEARER FACE DOWN AT SURFACE. POSSIBLY INADEQUATE AIR SUPPLY.

Discussion

Every death is a unique and personal event and each of the deaths in this review has features which are special. However there are some lessons which can be extracted from a consideration of these fatalities.

The breath-hold divers were all alone at the critical time, a fact which undoubtedly influenced the course of case BH 90/2, who could have survived had there been anyone watching him at the time. Watching a group of independent surface swimmers can never guarantee that every person is in view continuously. Two of these divers suffered fatal cardiovascular troubles, one died from trauma to his head, and one was probably taken by a shark.

Many factors are responsible for the scuba diver cases. It should be noted that though cardiovascular causes were the critical factor in two (one during sleep in an apparently healthy young man) there were two cases where cold water was undoubtedly the critical factor. Sudden immersion in cold water is capable of immobilising a person and plays a significant role in drowning in cold water. Acute illness by its nature is something which cannot be predicted and here the solo situation at the time it occurred was compounded with extreme prejudice to the victim by his failure to wear a buoyancy vest for this dive. Water power was tragically demonstrated in case SC 90/6. The divers failed to appreciate the severity of the water conditions until they were inextricably involved in a tragic sequence of events. The survivor unfortunately illustrates the lesson that the result of resuscitation may lead to less than full recovery and underlines the need for rapid rescue and effective resuscitation efforts in any case of apparent drowning. Such was not an available option in the circumstances of this case.

Panic is always a no-survive situation and it is unfortunate that the victim in case SC 90/7 had not realised it was necessary for her to either recognise the early stages of development of the panic state so that she could respond correctly to the situation before losing the power to do so, or give up scuba diving. While it is a safe recreation while the rules are followed it is far otherwise when panic develops and destroys the victim's ability to respond in a manner conducive to survival.

In case SC 90/1 there were a number of adverse factors which acted to mould the course of events, summating in death for one. The pair of divers were diving deeper than ever previously, probably feeling some effects of nitrogen narcosis, on a featureless sea bed because they had mistakenly left the security of the anchor line which was intended to guide them to the wreck. The buddy over exerted himself trying to keep up with the victim, who was in the lead and experiencing an inadequate air supply. This was due to two factors, the incorrectly adjusted first stage and the incomplete opening of the tank valve. Not surprisingly their attempts to buddy breath failed, despite previously practicing this procedure, as both divers were affected by air hunger. There was another element in the genesis of this incident, the temperaments of the two divers. While one was content to follow without question, the other (apparently) tended to lead without thought for his buddy's swimming ability.

Now that there is debate about the need to include the practice of out-of-air ascent in the primary training courses for scuba divers, defended on the grounds that it will produce far safer diving, readers are asked to consider whether the above fatal incident resulted from an inability to buddy breathe while making a low-air ascent or because the divers omitted to follow commonly accepted safe diving modalities. They were diving outside their experience and had left the anchor line in mid water, then failed to recognise the need for immediate ascent when short of air. It was unwise of the buddy to continue swimming in an attempt to catch up with his leader when the exertion was making him breathless, and it was incorrect of the leader to place his buddy in such a situation. He should also have recognised the inadequacy of his air supply before suddenly demanding buddy breathing. This was a situation which better training should have obviated.

Case (SC 90/1) is also of interest because the buddy survived a panic ascent while not only distressed by the coughing due to inhaled water but with the regulator out of his mouth. There is no helpful moral to be drawn from this, merely the observation that there are a multitude of factors which influence the outcome of even the worst concurrence of circumstances and these sometimes are favourable to those involved. Indeed survival need not be taken as proof that one is a good diver.

Hose supply diving has problems peculiar to the sudden nature of a cessation of the air supply unless a reserve bottle is carried. It is a type of diving requiring training, one where the inexperienced are at as much risk as is the case with scuba diving. While case H 90/1 was factored by cold and the unsuspected cardiac infarction, case H 90/2 involved a diver who was probably totally inexperienced in the use of this apparatus and certainly fatigued and feeling panicky. That his death occurred at the surface, possibly due to inhaled vomit, rather than from pulmonary barotrauma with cerebral arterial gas embolism (for which he was a prime candidate as he had made his ascent tense with near panic) is a tribute to the training he had received 2 years previously. Unfortunately he was then unable to cope with the problems of surviving at the surface.

In summary, unsuspected health factors, cold water and inexperience continue to be significant factors adverse to survival of divers. It will be noted that this investigation details not only cases in which the diving activity was directly responsible for the death, but cases where health factors were critical and the diving itself was not necessarily the significant critical factor other than in respect to the

factors of physical exertion by the victim and the in water location of the problem.

Acknowledgment

This report could not have been prepared without the generous help and forbearance of those charged with the management of the documentation concerning such fatalities. This is true of every State and includes the Police service in some States in reference to cases where no inquest was considered necessary. Others who supplied identification of cases or supplied information are also thanked. It is hoped that one day there will be a wider involvement in this project by members of the diving community.

PROJECT STICKYBEAK DATABANK

The objective of this on-going project is to identify factors which influence the safety of divers. Reports are requested concerning incidents of all types and severity, particularly where there has been a successful outcome. **MEDICAL CONFIDENTIALITY** is given to every communication received.

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THE WORLD AS IT IS

SHRINKING DIVING RESEARCH DOLLARS

John Williamson

The following Editorial by Dr. Peter Bennett appeared in the November/December, 1992 issue of *Alert Diver*, the magazine in the USA's Divers Alert Network (DAN). The message has direct relevance to Australian and New Zealand diving medicine.

"DAN (Divers Alert Network, Inc.) research in the last few years, with support by NOAA (National Oceanic and Atmospheric Administration) and DEMA (Divers Equipment Manufacturers Association), has primarily been concerned with the epidemiology of diving accidents and has focussed on factors which could be modified to help reduce such accidents and deaths or to help in treatment.

However, there was and is a greater concern. I have been in diving medical research since 1953 and have worked in four countries. Thus, I was in the middle of the tremendous growth and worldwide interest in diving medicine following World War II. The US and British navies spearheaded this uniquely productive research effort and supplied considerable financial support. The growth of deep commercial diving in support of the offshore oil industry in the 1960's stimulated additional interest and finance too in exploring oxygen-helium and trimix (oxygen-helium-nitrogen) deep diving. Other Navies and governments around the world also initiated similar diving research laboratories, and the National Institutes of Health (NIH) in the United States supported major multi-chamber research laboratories at Duke University Medical Center, the University of Pennsylvania and at the University of Buffalo.

However since 1972, when I became Director of the Duke University Hyperbaric Program, research funds have been steadily shrinking. But none of the major diving problems of decompression illness, nitrogen narcosis, or oxygen toxicity, are solved, nor do we know very much about their mechanisms. Today, for example, there are more dive algorithms for tables and computers to bring a diver safely back to the surface than you can count on your fingers. We obviously have much to learn since they cannot all be right! The nitrox controversy will renew interest in oxygen toxicity information and so on. Recreational diving must therefore find its own research funds if it wishes to move forward. There will be little help from the government!

Some time ago, I reported to you of the formation of the Recreational Diving Research Foundation by DAN, PADI (Professional Association of Diving Instructors) and DEMA with a view to promote research dollars for needed research. In the last few years we were able to accumulate only some $67,000, about one third what one normal NIH research grant would cost today! With the advent of a new research granting organisation by PADI in 1991, it became clear that the RDRF could not compete for the same few dollars from the same few divers. So we decided to close the RDRF and after peer review, to disperse several one year grants to the following researchers: George Meyer, an engineer, and Mark Perry, Executive Director of the Florida Oceanographic Society, to Study the "Practical Limitations of miniature scuba cylinder alternatives"; Jolie Bookspan PhD, of the University of Pennsylvania, to study the "Detection of endogenous gas phase formation in humans at altitude"; Wayne Gerth, PhD, of Duke University Medical Center, to study "Quasi-physiological models for calculating flying after diving guidelines"; and Judy Lasher DPsych, with help from Mercy Hospital, in Miami, to