

# Provisional report on diving-related fatalities in Australian waters 2002

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## Key words

Diving deaths, scuba, breath-hold diving, surface-supply breathing apparatus (SSBA), diving accidents, case reports

## Abstract

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This report covers a total of 33 deaths, of which 17 were in people using a snorkel (three breath-hold diving), 13 in those using scuba, and three in those using surface-supply (hookah) breathing apparatus. There was a wide range of causes of death among the snorkel users, the most unusual being two cases of 'stroke' due to acute, severe hypertensive responses to box jellyfish envenomation. Cardiovascular factors were implicated in nine cases, including a significant history of cardiac disease in three, and single cases of 'silent' cardiomyopathy, 'stroke' in association with hypertension, and obesity. Two cases occurred during the victims' probable first use of a snorkel. In the scuba group, cardiac factors were implicated in 10 of the 13 fatalities, though other factors were also present. Inexperience was critical in at least two cases, and one died when an unsuspected congenital bronchogenic cyst ruptured during an apparently normal ascent. These reports are based on presently available coronial or published reports.

## Introduction

Project Stickybeak has identified and reported on deaths associated with diving in Australia on an annual basis since 1972.<sup>1-5</sup> The deaths identified from official sources in 2002 are reported here. Summaries of the data for each case were made, and these form the basis of this review. Ethical approval was given to the author by the State Coroners for Queensland and New South Wales, and through the Divers Alert Network Asia-Pacific Research Group by the coroners of the remaining Australian states. The general methodology for searching for and reviewing the documentary evidence associated with fatalities has been described previously.<sup>4</sup> These case reports are based largely on the information obtained by the police and others on behalf of the coroner. As there is inevitably variance in the way those present recall events, on occasion a choice has to be made as to which details most probably reflect the actual facts. Where such differences appear to be important, this is noted. The details frequently involved opinions on the experience of the deceased, the water conditions, depths, distances, and passage of time. The purpose of these reports is to assist the identification, and therefore avoidance, of factors predisposing to a serious or fatal outcome to a potentially safe activity.

## Snorkelling and breath-hold diving fatalities

Seventeen snorkelling and breath-hold diving deaths were identified in Australian waters during 2002. The basic data are summarised in Table 1.

### CASE BH 02/01

Four friends decided to go spear fishing, two of whom had

frequently dived in the same area. The victim, a fit 24-year-old man, was reported to be an experienced diver before he came to Australia from his homeland. The chosen locality was too rough, but a calmer area was found on the other side of a rocky headland. Access was from a rock platform and the two most experienced divers entered the water first to check the conditions. The sea was choppy but the visibility was good, and the remaining two entered the water. The victim speared an octopus, then handed the spear to one of the others and swam back towards the rock wall behind a protruding rock. One of his friends swam after him and saw him as he stood on a rock ledge with his upper body out of the water. He was seen to signal he was 'OK' and then indicated his friend should continue diving on the reef, which he did. When the victim failed to rejoin him, his friend swam back to where he had last seen him but found no sign of him. He swam out to the other two, which took about 10 minutes, to ask whether they had seen him. Becoming worried by his absence, they came ashore, but the check from land was unsuccessful so they all re-entered the water to check among the rocks. Finally accepting that he was missing they notified the Park Rangers' office and a police search was organised. The body was not found until it washed ashore three days later.

*Autopsy:* The autopsy report is limited, stating that "there was green/black discolouration of the skin, mild atherosclerosis of the right coronary artery, and decomposition", and made no report of evidence of trauma. The cause of death was given as drowning.

*Comment:* No information is available concerning his experience in rough water, but even an experienced swimmer could be temporarily impaired if rough water caused contact with a rock.

**Summary:** BREATH-HOLD DIVING; REPUTEDLY EXPERIENCED; BUDDY SEPARATION IN ROUGH WATER AMONG ROCKS; BODY NOT RECOVERED FOR 3 DAYS; DROWNING.

#### CASE BH 02/02

This fatality was the first recorded in Australia as following a sting from a small carybdeid (box jellyfish) thought to be *Carukia barnesi*, causing the Irukandji syndrome, and has been reported in detail previously.<sup>6</sup> The victim was a 58-year-old male overseas visitor who was stung on his chest and face while in shallow water close to the beach on a resort island. Although he was aware of something stinging him, he did not see the creature. Within about 20 minutes he became distressed, a delay typical of the toxins from box jellyfish, with generalised muscular cramping pains, sweating, anxiety and nausea. His blood pressure was 260/160 and heart rate 142 beats per minute. He was given pethidine, morphine, metoclopramide, promethazine, and diazepam, but 10 minutes later his condition suddenly deteriorated and he became unresponsive, with stertorous breathing. A provisional diagnosis of cerebrovascular accident was made. He was air evacuated to a mainland hospital, where brain CT showed an extensive intracerebral haemorrhage effacing the right ventricle. Death occurred the next day, about 18 hours from the time he left the water.

**Autopsy:** No autopsy was done as the CT had demonstrated the presence of the large intracerebral haemorrhage.

**Comment:** Until this fatality, the danger from these small box jellyfish had been little recognised, though they were first identified in 1963. The dramatic response to the toxin may have been increased by the fact that he was on warfarin prophylaxis as he had a prosthetic aortic valve replacement.

**Summary:** SNORKELLING; CLOSE TO BEACH; MILD STING FELT; ACUTE COLLAPSE WITHIN 30 MINUTES; AORTIC VALVE REPLACEMENT; ON WARFARIN; IRUKANDJI SYNDROME; CEREBRAL HAEMORRHAGE.

#### CASE BH 02/03

This 44-year-old man was the second victim of the Irukandji syndrome on the Great Barrier Reef (GBR). Details of the incident are sketchy, but it is known that he died in hospital from a cardiac event, a consequence of the severe hypertension caused by the toxin. It was reported he had a medical history of a previous 'stroke'. No autopsy results are available. Scrapings from his clothing showed the culprit was not one of the usual *Irukandji* species but one of the *Malo* genus.

**Comment:** Only limited information is available about this incident, the medical history of the victim, or the medical management.

**Summary:** SNORKELLING; STING FROM BOX JELLYFISH OF *MALO* GENUS; ACUTE HYPERTENSION; POSSIBLE HISTORY PREVIOUS CEREBROVASCULAR EPISODE; CEREBROVASCULAR ACCIDENT.

#### CASE BH 02/04

This 82-year-old man, on a round-the-world holiday with his wife, visited one of the resort islands on the GBR. He had undergone a right hip replacement in March 2000 and had been given a clean bill of health a couple of months before starting the trip. He was booked on a guided snorkel tour while his wife had joined a hike on the island. The boat carried a skipper, a crewman who was to be the lookout, one instructor with a resort diver, and an instructor to lead the eight making the snorkel tour. They were given a safety briefing and asked whether they had any health problems or were using medications, and about their competence in the water. He said he had not been in the water "for a while" but was fine in the water. He declined the offered wetsuit and fins, saying he felt the latter weighed him down. The details are unclear but it appears that some accompanied the instructor while others were swimming independently but under the supervision of the safety lookout. There was minimal current and the island sheltered this area from the wind. The vessel was a 'live boat' and acting as the safety boat, rather than mooring, so not needing to put its rescue tender in the water. One of the group noticed the victim floating face up, his snorkel pointing underwater, so made a 'help me' signal. The instructor was about five metres away and rapidly swam to him. This was also seen by the lookout, the boat reaching the victim shortly after the instructor. The victim was unconscious and not breathing, so resuscitation was started as soon as he was pulled into the boat. The other passengers were recalled and a rapid trip was made back to the island's medical centre. There, the nurse hooked up a defibrillator while awaiting the arrival of paramedics. Resuscitation efforts were ceased after 50 minutes with no response.

**Autopsy:** The autopsy revealed no evidence of drowning. The heart appeared normal, but a few minute areas of subendocardial fibrosis were visible in the antero-septal wall of the left ventricle. The descending branch of the left coronary artery near its origin was almost completely occluded, but its more distal branches appeared widely patent as was the circumflex artery; the right coronary artery had segmental narrowing of about 20 to 30%. Within the aorta there was significant atherosclerosis, particularly in the abdomen, with a number of ulcerating plaques. Histology of the myocardium was essentially normal. It was thought that the most likely cause of death was an acute arrhythmia.

**Table 1. Summary of diving-related fatalities  
(BNS – buddy not separated, BSB – buddy separation before incident,**

Case	Age	Sex	Training	Experience	Dive group	Dive purpose
02/01	24	Male	Nil	Experienced	GSB	Spear fishing
02/02	58	Male	Nil	Not stated	BNS	Recreation
02/03	44	Male	Nil	Not stated	BNS	Recreation
02/04	82	Male	Not stated	Not stated	GNS	Recreation
02/05	68	Female	Nil	Nil	BSB	Recreation
02/06	66	Female	Nil	Nil	GNS	Recreation
02/07	66	Male	Nil	Nil	BSB	Recreation
02/08	53	Female	Nil	Nil	Solo	Recreation
02/09	61	Male	Nil	Nil	Solo	Recreation
02/10	19	Male	Nil	Some	GSB	Recreation
02/11	28	Male	Some	Experienced	BSB	Recreation
02/12	72	Male	Nil	Nil	GSB	Recreation
02/13	61	Male	Not stated	Not stated	Solo	Recreation
02/14	56	Male	Not stated	Not stated	BSB	Recreation
02/15	46	Male	Not stated	Some	BSB	Recreation
02/16	48	Male	Trained	Not stated	BSB	Spear fishing
02/17	52	Male	Not stated	Some	BSB	Abalone fishing

*Comment:* This incident occurred among a group swimming freely under the supervision of two safety watchers on the boat and a crew member in the water. None of these people or any of the snorkellers noticed anything untoward to alert them that the victim was in trouble.

*Summary:* SNORKELLING; SILENT DEATH CLOSE TO OTHERS; CORONARY ATHEROMA; PRESUMED CARDIAC DEATH FROM ACUTE ARRHYTHMIA.

#### CASE BH 02/05

This 68-year-old lady was on holiday from overseas with her daughter and taking a day trip to the GBR. They were issued with snorkelling equipment and, though this is not recorded, probably heard a safety talk on snorkelling. On

the island, they hired a buoyancy vest for the mother, and booked a supervised snorkel tour for later that morning. To pass the time they decided to practise snorkelling around the jetty area. The daughter entered the water first; her mother followed shortly after and was seen to start swimming. A few minutes later, the daughter looked round and could not see her mother. Although the life jacket could be seen floating at the surface about five metres away, she could not see her mother's snorkel and there was no movement apparent. She started to swim to her mother, but before she got there a stranger swam out and started towing her mother to the beach. There, he started CPR, soon joined by others, two of whom were doctors. They successfully maintained the victim's circulation until the emergency helicopter arrived and transferred her to hospital. She died later that afternoon.

**in Australian waters in 2002, snorkel and breath-hold incidents**  
**BSD – buddy separation during incident, GSB – group separation before incident)**

Depth (msw) Dive	Incident	Weight belt	Comment
Not stated	Surface	No	Buddy separation, ? trauma/heart
Not stated	Surface	No	Jellyfish sting/CVA
Not stated	Surface	No	Jellyfish sting/cardiac
Not stated	Surface	No	Cardiac
0.5	Surface	No	Drowned in knee-deep water, wearing buoyancy vest
Not stated	Surface	No	Cardiac, wearing buoyancy vest
Not stated	Surface	No	Cardiac
Not stated	Surface	No	Cardiac
Not stated	Surface	No	Cardiac
Not stated	Surface	No	Cardiac
Not stated	Surface	No	Drowned
30	2.7	No	Hyperventilation, ascent hypoxia, rescued from 47.2 msw
1	Surface	No	Cardiac, wearing buoyancy vest
Not stated	Surface	No	Cardiac
Not stated	Surface	No	Cardiac
Not stated	Surface	No	CVA
Not stated	Not stated	Yes	Trauma?
Not stated	Not stated	Yes	Drowned? GIT history

*Autopsy:* At autopsy her coronary arteries were widely patent. There was focal myocardial fibrosis noted on histology. No other diseases were identified. The cause of death was given as drowning.

*Comment:* Although not specifically noted, she had almost certainly never used snorkel equipment previously, and the hiring of a buoyancy vest suggests a great lack of confidence in her swimming ability. Her daughter said the water was only knee-deep where the incident occurred, so this appears to be another example of the inescapable tunneling of thought induced by panic. In this case, simply standing up in the shallow water at any time would have led to a favourable outcome.

*Summary:* SNORKELLING; PROBABLE FIRST USE; WEARING LIFE JACKET; BUDDY ONLY 5 METRES

AWAY IN KNEE-DEEP WATER; SILENT DROWNING.

CASE BH 02/06

This healthy, 66-year-old woman and her husband, who was a doctor, took a trip to a GBR island with their overseas group. Her only medication was 'Lipitor' for cholesterol control. They had viewed a video on safe snorkelling on the trip out and in the afternoon were provided with mask, snorkel, fins and buoyancy vests before they were taken in a tender to a larger, moored boat for a guided snorkel. There were eight in the group, plus an instructor and a divemaster. The water was choppy, and she, her husband, and a friend were to hold on to a rubber ring and be towed by the instructor, the divemaster also towing a ring. She appeared to have no problems, hooking her arm over the ring to hold on. While they were being towed back to the

boat her mask was seen to be dislodged and the instructor replaced it, and replaced the snorkel in her mouth. Soon after this she was seen to be face up, though she turned back to face down when given a small push by her husband. It is possible the end of her snorkel had been underwater. The snorkel was still in her mouth at this time. A short time later the instructor noticed she was in trouble, took hold of her, and removed her mask and snorkel. She was foaming at the mouth. He rapidly brought her back to the moored boat and resuscitation was started as she was brought back to shore, where oxygen and a defibrillator were employed. Spontaneous breathing returned briefly and her eyes opened but she became unresponsive again and resuscitation was reinstated. She was evacuated by helicopter to hospital, but was declared dead on arrival.

*Autopsy:* The autopsy showed there were only mild coronary changes, maximal narrowing of 40%, and no evidence of myocardial ischaemia. The cause of death was given as drowning, which may have followed salt-water aspiration causing a cardiac inhibition response.

*Comment:* This incident occurred in between the frequent occasions when the instructor stopped and raised his head to check on those he was towing. It underlines the rapidity with which a critical situation can occur in the water.

*Summary:* SNORKELLING; POSSIBLE FIRST USE; WEARING BUOYANCY VEST; BEING TOWED ON A BUOYANCY RING BY AN INSTRUCTOR; SILENT LOSS OF CONSCIOUSNESS; DROWNING.

#### CASE BH 02/07

During their holiday to Australia, two brothers took a day trip to a pontoon on the GBR. A snorkelling safety talk was given on the way out. After they arrived at the pontoon they were given mask, fins and snorkel. Passengers with medical or other problems were asked to tell the staff, but neither brother declared any illness. However, the victim, aged 66 years, had a past history of deep vein thrombosis and was on warfarin whilst his elder brother had asthma, although he had apparently not brought his 'ventolin' inhaler on the trip.

The designated swimming area was monitored by a lookout with a rescuer ready to enter the water if needed, and a crew change every half hour to avoid any loss of vigilance. The lookout, who wore an orange safety vest, had a list of those who had notified a medical problem so as to watch them particularly; these individuals were identifiable by a pink ribbon tied to their snorkel. There were about 25 to 40 others in the water when the brothers entered the water together. They found there was a strong current they had not been warned to expect, and after a short time the elder brother became anxious he would have an asthma attack. He waved for assistance as they had been instructed to do, but there was no response. With some difficulty, he managed to get himself back to the pontoon, exhausted. He had not told his brother

he was making a return to the pontoon, being too interested in his personal survival. He went and lay down to recover and slept for about 45 minutes. When he awoke, he was unable to find his brother upon searching the pontoon. He became increasingly worried and reported this to the captain. All snorkellers were recalled and a count confirmed that one person was missing. A boat search found the victim's body near one of the adjacent reefs. Despite the presence of rigor mortis, one crewman attempted resuscitation. It was now about three hours since his brother had last seen him. The safety lookouts reported having seen none of those in the water make a signal for assistance in contrast to the elder brother's account.

*Autopsy:* At autopsy, the heart appeared healthy, with no significant coronary disease. Histology showed no evidence of past or recent infarcts, but had occasional areas of relatively diffuse fibrosis or scarring. The pathologist suggested that myocarditis, sarcoid, vascular spasm, or undetected significant atherosclerotic narrowing was the probable cause of death. He noted that he had discussed the findings with other forensic pathologists and their view was that the changes were essentially those of a cardiomyopathy and the actual cause of death was probably a cardiac arrhythmia. The cause of death was given as drowning.

*Comment:* The victim was reportedly an average swimmer but fully capable of getting himself out of trouble, which makes a sudden cardiac factor a reasonable explanation for his drowning. The failure of the lookout to see either his brother's signal or the floating body indicates the difficulty in watching such a large group of snorkellers.

*Summary:* SNORKELLING; EXPERIENCE UNKNOWN; HISTORY OF DEEP VEIN THROMBOSIS ON WARFARIN; SUPERVISED AREA WITH LARGE NUMBER OF SNORKELLERS; BUDDY SEPARATION; UNEXPECTED CURRENT; SILENT DEATH; POSSIBLE CARDIOMYOPATHY; DROWNING.

#### CASE BH 02/08

A couple joined a day trip to the GBR. A snorkelling safety talk was given on the outward trip. The wife, aged 53 years, suffered from foot problems, requiring 'Panadeine forte', though she had taken none that day. She also revealed that she suffered some type of cardiac arrhythmia especially if she was stressed, and this required her to use 'Anginine'. The crew member who took her medical form noticed there was evidence of a past thyroid operation she had failed to mention. On being told she would not be allowed to undertake a 'resort dive experience' she retrieved her form, tore it up, and said she would go to another operator next day and not be so honest in giving her health history! This crew member thought the woman looked much older than her stated age. It was suggested that the couple snorkel, but first they were asked how they were feeling as it had been a rough trip out and both had been seasick. She swam and



they took a glass-bottom boat trip before lunch. After a heavy lunch, she decided to go for another snorkel whilst her husband rested. After a while, he thought his wife was likely to be tired of snorkelling and went to see if she had returned but was unable to find her anywhere, then met a crew member who told him his wife was probably dead. The designated safety lookout had been alerted to an incident by a call from a crewman in a nearby glass-bottomed boat concerning a person in the water who was not moving. He took a dinghy and found the person unconscious with an arm over the snorkel line of one of the 'rope trails' (these were buoyed at intervals and were all connected to the pontoon). The victim was quickly dragged from the water and brought back to the pontoon where resuscitation efforts were unavailing and a formal declaration of death was made by the Medivac team after it arrived.

*Autopsy:* At autopsy, mild hypertrophy of the left ventricle was noted, the histology showing areas of fibrosis but no evidence of recent infarction or myocarditis. The left coronary artery had about 60% narrowing from an atheromatous plaque about 20 mm from its origin, the right vessel being about 50% narrowed 30 mm from its origin by atheroma. The official cause of death was given as myocardial ischaemia resulting from atherosclerotic coronary artery disease.

*Comment:* The victim had been correctly refused a 'resort dive' but was permitted to snorkel without a buddy in a supervised area. Supervision of individual snorkellers in a crowd can never be perfect, particularly when no indication is given by a swimmer that they are experiencing a problem. No practical and acceptable solution appears likely to be found for the sudden death risk that is a feature of many of the fatalities in this age group of visitors to the GBR.

*Summary:* SNORKELLING; SOLO BUT IN SUPERVISED AREA; HISTORY OF PAROXYSMAL ARRHYTHMIA WITH ANGINA; PAINFUL FEET SO UNABLE TO WEAR FINS; SEASICKNESS EN ROUTE; SILENT DEATH; CORONARY ATHEROMA; CARDIAC DEATH.

#### CASE BH 02/09

Although travelling together, this couple had met whilst overseas solely to have a companion during their holidays. Neither understood English beyond that essential for basic needs, which limited their understanding of the safety talk given in English over the public address system during the boat trip out to the reef. It is not known whether the 61-year-old victim had ever snorkelled previously. After the incident, his companion stated through an interpreter her ignorance of what medications the victim took, but knew he had had a heart operation 12 to 13 years ago and possibly a heart attack seven years earlier. The boat was anchored in the shelter close to a cay but not on the more commonly utilised permanent mooring as there was a 1.4 metre swell there. Masks, snorkels and fins were supplied and the victim

hired a 'shorty' wetsuit. While his travelling companion was still getting ready to snorkel, he jumped into the water without putting his mask on. She heard him say "*I am having difficulties putting the mask on and I believe I had enough already*" then saw him swim towards the platform at the stern of the boat. She found a piece of rope for him to hang onto before herself jumping into the water. About 10 to 15 minutes later, a tender took her back to the main boat, where she found her travelling companion on the platform receiving resuscitation.

In the interim a lookout was watching the swimmers from the boat, changing his position as the boat swung at its mooring. However, the alarm was raised by the boat's hostess who happened to look down and saw a man sitting on the stern duck board. He seemed to be having trouble breathing and did not answer when she asked if he was all right. She told the skipper, who immediately went down to him. The victim was struggling to breathe and not responding to questions. About 30 seconds after being reached, he fell backwards into the skipper's arms. He was lowered onto the deck and resuscitation commenced as he had stopped breathing. Oxygen was soon provided and an airway inserted. Resuscitation efforts were unavailing and a formal declaration of death was made by the Medivac team after it arrived.

*Autopsy:* There was a vertical central chest scar from his cardiac surgery, cardiac tamponade from blood in the pericardial sack due to a ruptured right ventricle (2.5 x 2.5 cm hole), thin-walled right and left ventricles, and a moderately enlarged heart, with severe proximal atherosclerosis in the major coronary arteries. Cause of death was cardiac rupture.

*Comment:* The victim had appeared to be in good health and been swimming on a number of previous occasions with his travelling companion without apparent symptoms.

*Summary:* SNORKELLING; HISTORY OF OPEN HEART SURGERY AND MYOCARDIAL INFARCT; LANGUAGE PROBLEM; SUDDEN ONSET OF BREATHLESSNESS AFTER WATER ENTRY; CARDIAC TAMPONADE FROM RIGHT VENTRICULAR RUPTURE.

#### CASE BH 02/10

A family and friends drove to a headland for lunch, intending to swim afterwards. An elder brother warned the 19-year-old victim not to go too far out because he was not a good swimmer. The three, identical triplets, and a friend entered the sea from the beach wearing fins, mask and snorkel. They were in and out of the water repeatedly, and then two of the triplets left the water without noticing that the third was not following them. A witness sitting on the headland described hearing a faint cry for help and then saw the victim about 15 metres from the rocks panicking in a rip and being pounded by breaking waves. He courageously

jumped into the sea after judging the correct moment to do so, his intention being to pull the person away from the rough water and avoid endangering himself in the process. When reached, the victim was unconscious and had vomit in his mask, which the rescuer removed before attempting to use the rip to keep away from the rocks. They were both repeatedly submerged by the turbulent water. After about 12 minutes, two more people reached them with a body board and pulled the victim onto it just before two lifesavers arrived in their inflatable rescue boat. He died in hospital two days later having failed to regain consciousness.

*Autopsy:* No adverse health factors were noted. The cause of death was given as drowning.

*Comment:* The opinion of the rescuer was that if the victim had not panicked and tried to fight the rip, but let it take him away from the rocks, he would probably have survived. A young boy in the family group told one of the brothers afterwards that he thought the victim had not been wearing fins when found but this was never formally recorded.

*Summary:* SNORKELLING; NOT STRONG SWIMMER; BUDDY SEPARATION; CAUGHT IN RIP CLOSE TO ROCKS; PANIC; BRAVE RESCUE ATTEMPT BY WITNESS; DROWNING.

#### CASE BH 02/11

The 28-year-old victim was described by his sister and co-workers as being extremely fit and healthy; a diving instructor able to breath-hold dive to 40 metres' sea water (msw) and stay underwater for one and a half minutes. He was employed on a live-aboard dive boat on a six-day GBR trip. On the fourth day, he was without dive-guide duties for the day. The dive site was a coral bommie rising to about 14 metres below the surface, famous for its schools of pelagic fish. There was a sheer drop to approximately 40 metres at its edge. The sea was described as calm with a minimal current, good visibility and water temperature 28°C. Once all the passengers had entered the water, the victim did a breath-hold dive to about 10 msw near the stern of the boat. Then he made a second dive, to 30 msw (recorded on a dive computer set in 'free dive' mode). There were two crew members in addition to the designated lookout watching as he started his dive and the time was noted. Alarm was voiced when two minutes had passed without him resurfacing. One of the observers entered the water and saw a lot of bubbles about 30 metres below, and a diver rapidly ascending holding a body. He freedived to assist in bringing the victim to the surface, aware that the scuba diver would need to make a decompression safety stop. At about 6 msw depth he ran out of air and had to let the body go. When he surfaced he called for assistance and oxygen. The victim was taken onto the boat and an emergency radio call made.

An instructor was taking a group of divers for a nitrox dive on the bommie and one of this class, who was an underwater

photographer, took a photo of the freediver at about 30 msw. He appeared calm and smiled as his photo was taken. Another pupil also saw him as he descended towards the school of barracuda they were watching at 27 msw and watched him look at the dive computer on his wrist, turn and wave and start to ascend. A witness saw him make a short stop before starting his return to the surface and confirmed that this had been his usual freediving practice. Another witness, scuba diving with a buddy at 10–15 msw, saw him as he was ascending, slowly kicking with his fins, but then lost sight of him to watch some fish. The instructor was unaware there was anything wrong until one of the divers pointed animatedly towards the bottom where he saw the victim about 15 metres below him, so immediately dived to reach him. There was blood coming from his mouth, his eyes were closed, there was blood and water in his mask, and he was unconscious. His hands were locked with his fists twisted in towards his chest. The instructor immediately started to bring him rapidly to the surface, in his account making no mention of the intervention of the breath-hold diver from the boat above. At the surface, resuscitation with supplemental oxygen was initiated and this continued as the victim was airlifted to hospital, where death was formally declared. His computer showed he had dived to 30 metres, waited a few seconds, then ascended to 2.7 msw (now 2 minutes from leaving the surface) before sinking to a maximum depth of 47.2 msw. His dive computer showed that he was submerged for a total of 7 minutes and 40 seconds.

*Autopsy:* The autopsy confirmed he had been in excellent health, although mild fatty changes were noted on liver histology. Pulmonary oedema was the only pathology. Blood alcohol nil, urine alcohol 16 mg.100 ml<sup>-1</sup>. The cause of death was drowning following a post-hyperventilation anoxic blackout.

*Comment:* This appears to have been a drowning following a post-hyperventilation blackout (ascent hypoxia). Unfortunately it appears to be an innate characteristic in those who attempt to push their underwater breath-hold ability to believe they are immune from the risks of hypoxia.

*Summary:* BREATH-HOLD DIVING; HEALTHY DIVING INSTRUCTOR; EXPERIENCED BREATH-HOLD DIVER; REACHED 3 MSW ON ASCENT FROM 30 MSW THEN SANK TO 47.2 MSW; POST-HYPERVENTILATION ASCENT HYPOXIA; DROWNING.

#### CASE BH 02/12

This 72-year-old, heavy-smoking male attended his doctor for two-monthly health checks, but was taking no medication, and had not reported any symptoms. He and his two daughters were overseas visitors taking a trip to an island. They went to the main snorkelling area of the beach and hired masks, fins, and snorkels but declined the offer of instruction on the grounds that they had all snorkelled

before, the father at least three times, though he had not been in the water for a while. Because he had trouble the last time he had snorkelled he had hired a life vest as well. The duty lifesaver “observed the elderly man in front of the beach hire hut. He was moving his arms and swimming about slowly” and thought he needed watching as he did not appear to be a competent swimmer. He was swimming in waist-deep water. One daughter saw her father nearby, face down and snorkel sticking up like it should, and thought he was watching the fish. She put her head underwater and saw his arms were hanging down and not moving. She called to him, then pulled on his life jacket, but obtained no response, so she rolled him over and saw his eyes were closed and bubbles were coming from his mouth. She turned him on his side and started to tow him to shore, helped by another person who was swimming nearby. A lifeguard was quickly in attendance and started resuscitation. The victim was intubated by a lifeguard, but the tube was removed when he started breathing and bringing up a lot of water. Whilst being moved on a trolley, he again ceased breathing. An oxygen unit and defibrillator were obtained from the nearby dive shop and his heart and breathing were restarted, but he remained unconscious. He required continued rescue breathing as he was not breathing adequately for himself. On their arrival, paramedics found him in cardiac arrest and worked on him for about 10 minutes before pronouncing him dead.

*Autopsy:* There was an 85–90% stenosis of the proximal right coronary artery. Histology showed moderate interstitial fibrosis in the myocardium and the epicardial arteries showed severe calcific atherosclerosis. Moderate to severe atherosclerosis was present in the aorta with ulceration in the abdominal portion. There was a midline upper abdominal scar from a past gastrectomy with gastro-jejunal anastomosis. The cause of death was given as drowning.

*Comment:* The history of a silent death in close proximity to others makes it probable that a sudden cardiac event led to his inhaling water. It is possible that he panicked and drowned despite the life jacket and shallowness of the water. The life jacket failed to keep his face out of the water.

*Summary:* SNORKELLING; REGULAR HEALTH CHECKS; HEAVY SMOKER; SHALLOW, CALM WATER; SILENT DEATH CLOSE TO OTHERS; CORONARY ATHEROMA; CRITICAL FACTOR POSSIBLY CARDIAC AND/OR INEXPERIENCE; DROWNING.

#### CASE BH 02/13

A 61-year-old man from overseas and his companion visited the GBR on a day trip. While the boat was anchored at the reef he went for a snorkel, but returned after 10 minutes and went to rest on a sun bed. Although he claimed he was feeling fine, he looked pale and was breathless. During the short time taken for his companion to fetch his heart tablets he became pulseless and apnoeic. Resuscitation efforts including oxygen were continued until paramedics arrived

by helicopter at which time he was pronounced dead. He had a history of myocardial infarcts in 1982 and 1991, and triple bypass surgery in 1992. A cardiac catheterisation in 2001 showed that two grafts were occluded and the third partially obstructed. He was taking digoxin, sotalone hydrochloride, enalapril maleate, atorvastatin, aspirin, and a diuretic.

*Autopsy:* There was cardiomegaly (weight 650 g, twice normal), evidence of old posteroseptal and inferior infarcts with borderline left ventricular aneurism formation at the apex, and the aortic valve cusps were sclerotic, but without significant stenosis. There was severe atherosclerosis of the coronary arteries, the ascending and transverse aorta and its major vessels. A graft leading from the aorta appeared occluded. There was fibrosis of the left ventricle wall, in some areas full thickness. Cause of death was given as arrhythmia and asystole due to coronary vascular insufficiency and myocardial ischaemic damage.

*Comment:* There is no record of the victim’s apparent health prior to his death but this degree of coronary arterial disease would be likely to produce symptoms. His decision to swim was the trigger for a fatal cardiac episode which was likely to occur whatever life decisions he made.

*Summary:* SNORKELLING; HISTORY TWO MYOCARDIAL INFARCTS; TRIPLE BYPASS WHICH LATER STENOSED; ON MEDICATION; CALM WATER; FELT ILL; RETURNED TO BOAT; CARDIAC ARREST; ACUTE CARDIAC FAILURE.

#### CASE BH 02/14

This incident occurred during a four-day cruise by a commercial charter fishing boat which carried a crew of two and six passengers. Four of the passengers were related, a man with his twin sons and brother (the victim). The victim, aged 56 years, was described as appearing to be in good health, a non-smoker and non-drinker. On a calm, sunny day while the boat was anchored, the passengers had a swim before lunch. There was a coral bommie about 10 metres from the boat and the victim decided to snorkel to it accompanied by one of the twins. One of the crew was keeping a watch while filleting fish on the aft deck. After a short time the twin returned leaving the victim on the far side of the bommie. As this broke the ‘stay in pairs’ safety rule, the skipper ordered him to return, though in fact it was the other twin who swam back to the bommie. He found his uncle floating face down as if he were looking at the corals below and then noticed that his legs were dangling under him, so yelled out and immediately turned him face up. He pulled the mask off and noticed froth coming from the victim’s mouth; then he started towing him towards the boat. The crewman soon reached him with a life ring on a line and the skipper also entered the water to assist the recovery. Resuscitation continued for about 25 minutes, at which point an emergency doctor contacted by phone advised them to cease their efforts.



*Autopsy:* The autopsy revealed extensive coronary atherosclerosis, with 90% obstruction of the anterior descending artery 3 cm from its origin, and a 70% stenosis of the right coronary artery 5 cm from its origin. The heart showed no gross evidence of scarring or previous myocardial infarction. Histology of the myocardium showed numerous small areas of scarring typical of ischaemic damage but there was no evidence of recent infarction or myocarditis. The cause of death was given as myocardial ischaemia due to coronary stenosis due to atherosclerosis.

*Comment:* The victim's brother later recalled his mentioning some recent pain in his left arm, but as his work involved installation of suspended ceilings this was believed, possibly correctly, to be a musculo-skeletal injury. It is unlikely the outcome would have been different even had there been no buddy separation, but the skipper should be commended for his insistence on the buddy protocol. This is a further illustration of the fact that, in this age group, silent death can occur in the apparently healthy.

*Summary:* SNORKELLING; APPARENTLY HEALTHY; CALM WATER; BUDDY SEPARATION; ATHEROSCLEROTIC STENOSIS, TWO MAJOR CORONARIES; CARDIAC ISCHAEMIA.

#### CASE BH 02/15

An eleven-strong group from overseas had joined other holidaymakers to make the trip to a popular island and view the coral reef. The victim, a 46-year-old man, was described as an overweight, pack-a-day smoker who was also a heavy drinker. He had hypertension and was taking unspecified medication for this. On the trip to the island he mentioned that he felt unwell in the chest and nauseated. The group chose to swim or snorkel off a beach using hired equipment. The victim explained to the others how to snorkel as they entered the water. There is no mention of conditions but it is probable the sea was calm. After about 45 minutes of snorkelling they all left the water. The victim had a cigarette and a can of beer before returning to the water. About 30 minutes later, he was noticed floating face down and two lifeguards were alerted. They quickly brought him ashore and started resuscitation. Paramedics arrived about 50 minutes later; there was no response to resuscitation.

*Autopsy:* The autopsy revealed an obese man with a well-defined area of haemorrhagic disruption within the mid-right cerebral hemisphere extending into the thalamic region. The major vessels of the Circle of Willis were patent although mildly atherosclerotic. The coronary arteries were widely patent, but there was thickening of the walls of the more distal branches. The left ventricle myocardium was thickened (up to 33 mm) and the heart was enlarged. The liver appeared significantly enlarged, and histology confirmed the presence of severe fatty degeneration. Serum alcohol level of 50 mmol.L<sup>-1</sup> was from blood taken at the autopsy two days after death and of uncertain significance.

There was no evidence of drowning. The cause of death was given as a right-sided cerebral haemorrhage.

*Comment:* He was unfit, but not to a degree that either he or his friends thought it unwise for him to snorkel. There is nothing to suggest that he unduly exerted himself. It is likely this death was not preventable and not a consequence of his in-water activity.

*Summary:* SNORKELLING; HISTORY HYPERTENSION, HEAVY ALCOHOL AND SMOKING; OVERWEIGHT; IN GROUP; SILENT DEATH; RIGHT CEREBRAL HAEMORRHAGE.

#### CASE BH 02/16

Two married couples, one from overseas, were friends of long standing. The victim, a 48-year-old man, was described by his wife as a very competent diver, such that she never had any fears for his safety; however, no details of his experience are recorded and he had only a basic scuba diving certificate. No details are supplied concerning his friend's training, but it is apparent the friend believed himself to be the more experienced spear fisherman. The two men entered the sea off rocks, the buddy leading. Each wore a wetsuit, weight belt, fins, mask, and snorkel, and both carried spear guns. The buddy saw a fish and dived, surfacing occasionally for air as he pursued it for about five minutes. When he gave up the chase and looked around he could not see his friend so thought he must have returned to the beach. Water depth was about 3 msw in an area close to a rocky reef. When the buddy reached an area where he could stand up, he indicated to those on the shore that his friend was missing, then started to swim back to where he had last seen him. He saw him floating face down and as soon as he reached him started to pull him towards the beach. Soon, others entered the water and helped bring him ashore. There is no mention concerning the management of his weight belt. Resuscitation was commenced while help was summoned. The rescue helicopter and an ambulance came but the victim showed no response to resuscitation efforts.

*Autopsy:* The autopsy showed only minimal coronary atheroma and no medical factors to explain the victim's death. A 60 mm diameter bruise was noted on the inner surface of his scalp in the central forehead area but did not appear to be regarded as significant by the pathologist. The cause of death was given as drowning.

*Comment:* The investigation of this death was sufficient to exclude suspicious circumstances but omitted serious consideration of why it occurred. No reason can be suggested for his death except the possibility that his swimming ability and water confidence level were overstated; the fact that the buddy had decided to lead may indicate that he regarded his friend as lacking experience, though this is not stated. There is no description of the sea conditions so it is probable they were not adverse. The suggestion was made that he may

have hit his head on a rock because of the forehead bruise and proximity to the rocky reef. Whether the equipment was borrowed, his own or a combination was not noted.

*Summary:* SPEARFISHING; APPARENTLY COMPETENT, SCUBA TRAINED; BUDDY SEPARATION; SILENT SURFACE DEATH; NO DISEASE FACTORS; POSSIBILITY OF HEAD TRAUMA; DROWNING.

#### CASE BH 02/17

The 52-year-old male victim was with others hunting for abalone both on a reef and in the water close to the reef over which waves were breaking. The top of the reef was jagged and slippery. He was described as a good swimmer, and his only known medical history was medication for a gastric ulcer. His son saw him from time to time walking on the reef or swimming close to it, but was concentrating on his own hunting and only became anxious about his father some 90 minutes later. The body was found three weeks later.

*Autopsy:* The body was too decomposed for more than a finding that the victim's death was 'consistent with immersion'.

*Comment:* It is not known whether this fatality occurred in the water or on the reef, but as it was a location containing a potentially dangerous mix of insecure, sharp surfaces and wave action, a fall could easily have occurred and drowning happened before the victim could regain command of his situation.

*Summary:* SNORKELLING; CLOSE TO/ON REEF HUNTING ABALONE; HISTORY OF GASTRIC ULCER; ROUGH SEA; REEF JAGGED AND SLIPPERY; BUDDY SEPARATION; BODY NOT FOUND FOR 3 WEEKS; DROWNED.

#### Scuba and surface-supply (hookah) fatalities

Table 2 provides additional data not included in the case summaries below but derived from the same sources.

#### CASE SC 02/01

Four friends were diving on a wreck, depth about 37 msw, intending to salvage an anchor and a dinghy they had found previously close to the wreck. The victim, a 55-year-old man, was regarded as a very experienced diver, but he had stated his intention to limit his dive to seven to nine minutes "because his doctor had advised him not to dive, as he had a viral heart condition". This case has been reported previously by Acott,<sup>7</sup> but some additional details are provided here.

He and his buddy were the first to enter the water and performed their task of attaching the boat's anchor line to the anchor to be salvaged. While doing this the sand was

stirred up and visibility lost, a 'silt out' situation resulting in separation. The buddy, knowing they had completed their job, decided to ascend. After boarding the boat, he decided to re-enter the water to make a decompression stop. As he was descending the line, he saw the victim, motionless, eyes closed, unresponsive but with the regulator in his mouth, so he grabbed him and brought him to the surface. The two other divers described later how they had entered the water 10 minutes or so after the first couple. They were met by the victim when they reached the anchor chain, about 1.5 metres above the sea bed. He made a quick 'out of air' signal and snatched the regulator from the mouth of one of the other divers, who in turn grabbed the regulator from his buddy's mouth. Fortunately the buddy was able to quickly reach her 'octopus' secondary regulator. They then commenced a rapid ascent up the anchor line, connected in a 'daisy chain' with the victim leading. At about 30 msw, the diver whose regulator the victim had been using noticed that the victim's regulator was now hanging by his side, minus its mouthpiece. They continued their ascent, omitting planned decompression. Once at the surface, they required ropes to get him into the boat. His BCD was noted to be inflated. There was no report of any resuscitation efforts. Examination of his equipment showed that the wetsuit jacket was too small, there was a small leak from the BCD supply, and the mouthpiece of the regulator was missing, but there was no functional fault. A dive computer showed his last dive as 22 minutes, maximum depth 38 msw.

*Autopsy:* A pre-autopsy X-ray showed the presence of air within the heart, confirmed at autopsy. There was marked cardiomegaly, patchy interstitial fibrosis, but no significant atherosclerosis. This supported the diagnosis of viral myocarditis. There was no other underlying organic disease. The tongue had been bitten. Medical history included hypertensive cardiomyopathy with previous heart failure, described by the victim's cardiologist as stable. Cause of death was given as cerebral arterial gas embolism (CAGE) and drowning.

*Comment:* The victim had told his buddies about medical advice not to dive, then failed to follow his dive plan. His failure to ascend when he became separated from his buddy was the first step in a fatal cascade of mistakes. It is possible that nitrogen narcosis affected his behaviour.

*Summary:* EXPERIENCED; 37 MSW DIVE; BUDDY SEPARATION AT DEPTH IN SILT OUT; OUT OF AIR; RAPID ASCENT WITH INFLATED BCD; TIGHT WETSUIT JACKET; OBESITY; HISTORY OF HYPERTENSIVE CARDIOMYOPATHY; NITROGEN NARCOSIS POSSIBLE FACTOR; CAGE.

#### CASE SC 02/02

This case of a 42-year-old woman was also described previously by Acott.<sup>7</sup> In summary, she was obese, with limited mobility from a previous back injury. She was diving

**Table 2. Summary of diving-related fatalities in Australian waters in 2002, scuba and surface-supply incidents  
BSD – buddy separation during incident, CAGE – cerebral arterial gas embolism, GSB – group**

Case	Age	Sex	Training	Experience	Dive group	Dive purpose	Depth (msw)* Dive
<b>Scuba</b>							
02/01	55	Male	Trained	Experienced	BSB	Wreck	38
02/02	42	Female	Trained	Some	BNS	Recreation	3
02/03	52	Female	Trained	Nil	BSD	Recreation	11
02/04	56	Male	Trained	Not stated	BSD	Recreation	20
02/05	37	Female	Trained	Nil	BSB	Recreation	3
02/06	51	Female	Trained	Some	BNS	Recreation	11
02/07	44	Male	Trained	Experienced	GSB	Recreation	3
02/08	44	Male	Trained	Experienced	BSB	Crayfishing	21
02/09	17	Male	Trained	Some	BSB	Crayfishing	7†
02/10	56	Male	Trained	Experienced	GSB	Recreation	18
02/11	63	Male	Trained	Some	GSB	Recreation	13
02/12	64	Male	Trained	Experienced	BNS	Recreation	13
02/13	20	Female	Trained	Some	BSD	Recreation	10
<b>Hookah</b>							
02/01	52	Male	Trained	Experienced	BSB	Crayfishing	8
02/02	23	Male	Not stated	Experienced	Solo	Scallops	10
02/03	43	Male	Not stated	Experienced	Solo	Crayfishing	Not stated

with an inexperienced buddy in a relatively sheltered bay in calm sea with a slight swell. They snorkelled out to a rock about 250 metres off shore, making a couple of rest stops on the way, and there began diving. The victim found she was too buoyant and so her buddy put another weight on her belt, giving her a total of about 18 kg. After about 10 minutes at 3–4 msw, she indicated she wished to rest, so they surfaced and swam to some rocks intending to climb out. Wave action pushed them into the rocks, repeatedly submerging the victim. It is uncertain whether she retained the regulator in her mouth properly, and she seemed to be having difficulty with her buoyancy. Despite her buddy's attempts at rescue and the arrival of assistance, resuscitation was unsuccessful. Examination of her equipment showed there was adequate remaining air and the regulator and BCD functioned correctly.

*Autopsy:* The autopsy showed marked pulmonary oedema and bilateral pleural effusions. No underlying disease was found and a drug screen was negative. The cause of death was given as salt-water drowning.

*Comment:* This lady appeared to be obese and unfit. The outcome was due to fatigue, and panic when repeated waves submerged her on the rocks. Whether her back pain was a factor is not clear, but she was definitely diving overweighted and never released her weight belt.

*Summary:* TRAINED BUT INEXPERIENCED; PHYSICALLY UNFIT; OBESE; HISTORY OF BACK INJURY; FATIGUED BY SURFACE SWIM; WAVE ACTION ON SURFACE; FAILED TO INFLATE BCD OR DITCH WEIGHT BELT; EXCESS WEIGHTS;

(BCD – buoyancy compensation device, BNS – buddy not separated, BSB – buddy separation before incident, separation before incident; \*depths and weights rounded; †witness statements range from 5–10 msw)

Depth (msw)*	Weight belt	Weight belt kg*	BCD	Air left	Equip test	Comment
38	On	Not stated	Infl	Nil	Slight fault	CAGE
Surface	Buddy	18	Not infl	++	NAD	Drowned
11	On	10	Infl	Low	NAD	CAGE?
Surface	On	9	Not stated	+++	NAD	Cardiac
Surface	On	12	Infl	+++	Some adverse	Drowned
11	On	Not stated	Buddy	++	NAD	Pulmonary oedema
Not stated	On	Not stated	Not infl	++	NAD	Drowned
8	On	9	Infl	+++	Some adverse	Cardiac
7†	On	Not stated	Not infl	++	NAD	Drowned/Cardiac?
18	Not stated	Not stated	Not infl	++	NAD	Cardiac
13	On	Not stated	Infl	++	NAD	CAGE/Cardiac
13	On	Not stated	Not infl	Not stated	Not stated	Cardiac
3	On	Not stated	Not infl	Not stated	NAD	CAGE; ruptured bronchogenic cyst
Surface	On	22	Not infl	n/a	Some adverse	Cardiac
Surface	On	Not stated	Not infl	n/a	Some adverse	Shark attack
Surface	On	Not stated	Not stated	n/a	Not checked	Motor boat propeller; major head injury

#### INEXPERIENCED BUDDY; DROWNING.

##### CASE SC 02/03

The victim was a 52-year-old woman from overseas, with a history of hypertension and asthma, but who undertook regular daily exercise including cycling up to 50 km. According to her friend she had not taken any asthma medication for many months, but had been medically retired from her teaching position some unknown time previously. She joined a trip to the GBR, her first open-water dive since her basic training 13 months previously. The boat moored sheltered from the waves by an islet. She had appeared anxious during the outward trip and had asked the instructor to check the assembly of her equipment on the boat, and admitted to feeling quite nervous as it was so

long since she had last dived. All her equipment was hired and she was wearing a 5 mm wetsuit, over which she had a thermal short-sleeve vest with a hood. After a buoyancy check, she dived with 10.5 kg of weights, one being placed in her BCD pocket.

The incident dive was her second dive of the trip; no details of the first are recorded. Water temperature was 22°C. It was planned that they would make a 40 minute dive to a maximum depth of 12 metres. She was to dive with two others (one of whom was a 'resort diver') in a group led by an instructor. During the descent she left the group and headed back to the surface. This was noticed by the instructor, who indicated to the others to remain where they were whilst he ascended, meeting her descending again. She indicated that she was okay. After an uncertain time, she indicated she



was low on air, but the instructor assured her she still had plenty. There was a strong current into which the instructor indicated they should swim following him. Because of the strong current, the group became separated and the victim was seen swimming away from the other three. She made a solo ascent. When he surfaced, the instructor saw her floating upright with her BCD fully inflated, about 15 metres away, mask in position and regulator out of her mouth. He swam back to the boat and asked for it to be taken to pick up her and the other divers. As the boat was approaching her he saw that she was now lying face up and not reacting as water washed over her face. He jumped into the water and swam to her to start rescue breathing. Her lips were cyanosed and she was unresponsive. On board, resuscitation was commenced, supplemental oxygen given, and the Coast Guard advised. On shore, advanced life support was unsuccessful. Examination of her equipment showed that it was functioning correctly, and the contents gauge showed 20 bar remaining air.

*Autopsy:* At autopsy, the pleural cavities were opened under water; there was no evidence of pneumothorax. The left lung had a 4 cm lobulated tumour at its hilum, a small cell carcinoma. There was concentric left ventricular hypertrophy consistent with the history of hypertension; petechial haemorrhages were present over the great cardiac vein and on the posterior wall of the heart. The coronary arteries were widely patent. Histology of the lungs showed a slight increase in mucus glands in some bronchi 'consistent with the history of asthma'. In view of the incident history and absence of barotraumas, the pathologist's opinion was that death resulted from a sudden cardiac episode.

*Comment:* Despite her exercise history, she may not have been particularly fit, and she was clearly anxious because this was her first dive since her course 13 months before. The dive leader was aware of her anxiety but had responsibility for a 'resort diver'. The strong current was a factor in her separation from the group during ascent. An alternative cause of her sudden death was CAGE on clinical grounds despite absence of direct evidence. The medical reason for her retirement is unknown.

*Summary:* TRAINED; INEXPERIENCED; HYPERTENSION ON MEDICATION; ASTHMA HISTORY; ANXIETY; STRONG CURRENT; BUDDY SEPARATION; SOLO ASCENT; LOSS OF CONSCIOUSNESS AT SURFACE WITH FULLY INFLATED BCD; NO EVIDENCE PULMONARY BAROTRAUMA; SMALL LUNG CANCER TUMOUR; CAUSE OF DEATH UNCERTAIN; POSSIBLE CARDIAC EVENT OR CAGE.

#### CASE SC 02/04

This 56-year-old man was on a wreck dive trip through a dive shop with four other customers. He was described as short to medium height and slightly overweight. His diving

experience and medical history were not recorded. The dive boat was moored to the buoy line on the wreck and a full dive briefing was given. The water conditions were described as a bit choppy, with a one metre swell, sea breeze of 13–15 knots and an incoming tide of about one knot. The victim was the first to enter the water, from the bow. He was seen to give the 'OK' signal then swim to the line, holding on to it with both hands, regulator in his mouth and mask in position.

A short time later the boatman heard a commotion "like anxious voices" at the bow of the boat and saw the victim gripping the line, with the regulator out of his mouth, rising out of the water when the bow rose with the waves. He did not respond when the boatman yelled to him to put the regulator back in his mouth, and when his buddy replaced it he soon spat it out again yelling out in a panicked voice. The boatman shouted several times telling him to make his way to the stern of the boat where there was a mermaid line. He was seen to swim past the starboard side of the boat, about two metres from it, and showed no response when the mermaid line, which had been pulled in, was thrown to him. He drifted beyond the end of the rope so a longer one was let out, but he made no effort to take hold of it even when it touched him. Whether he dropped his weights is not stated. Two of the other divers reached him about 40 metres beyond the boat and they stayed, one on each side of him, while the boat was brought to pick them up, helping to pull him aboard. There was some delay in recalling the other two as they had dived, unaware of the developing drama, and one of those on board had to dive to bring them back. Resuscitation was commenced, and this was continued by two ambulance officers who came out on a surf life-saving boat, but without response. Examination of the equipment found no faults.

*Autopsy:* Autopsy was reported as showing a right coronary artery occlusion; no additional details are available.

*Comment:* It is possible that panic was a critical factor in triggering the cardiac event. There were no signs of distress or ill health before the victim entered the water, but it is apparent that he found his situation holding on to the line between the dive boat and the buoy stressful as the line lifted and dipped in response to the boat's rise and fall.

*Summary:* EXPERIENCED; APPARENTLY FIT, MILDLY OVERWEIGHT; PROBABLE PANIC RESPONSE AT SURFACE AFTER ENTRY INTO ROUGH WATER; RIGHT CORONARY ARTERY OCCLUSION; SUDDEN CARDIAC DEATH.

#### CASE SC 02/05

For this 37-year-old overseas woman and her husband this was their last opportunity for a scuba dive before returning home. They had taken their basic course about 6 years previously, but she had probably made only seven dives since then. Her husband said she was very fit because she

was an aerobics instructor, but was liable to panic if she got into difficulty, and apparently she was not a good swimmer. Her husband claimed he had dived in all types of water conditions. They hired tanks, weight belts and hoods, the remaining equipment being their own including the semi-drysuit the victim was wearing. Her experience of diving wearing this type of suit is unknown. She was carrying 12 kg of weight, and using a 55 cu ft cylinder and a regulator with no contents gauge as it was at a dive shop for repair.

Her husband experienced problems in assembling the equipment on the beach, so he asked for advice from both a diving instructor and a newly trained diver. When the instructor returned from taking his group for a dive, 45 minutes later, they were still there on the beach. Both these witnesses concluded that he was seriously inexperienced and in need of revision of the basic skills. However, the instructor thought this area was so safe that he was not overly concerned about them. He later saw them snorkelling in shallow water about five metres from the shore. They probably entered the water from a boat ramp, though this is not clearly stated, and swam out with their BCDs inflated. Their dive plan was to watch sharks. About 35 m off the boat ramp, she said “something doesn’t feel right”. They agreed she should return to shore and he would continue with his dive. When he surfaced from his dive 15–20 minutes later he called out to ask where his wife was. Learning she was not ashore he descended and started a search for her but the current, surge, poor visibility, and a looming low-air situation limited his search and he contacted the police after coming ashore. He then learned from his children that she had earlier experienced a problem with her mask leaking, that “*something had broken off but she had been able to put it back together*”. Her body was found that evening by police divers 40 m offshore, her fins, mask, weight belt and tank still in their correct positions.

Examination of the equipment revealed tears in the silicon mouthpieces of both the main and secondary regulators, which allowed a spray of water when the user inhaled. There was no contents gauge but the tank was full. The semi-drysuit had a tight neck seal. However, her husband reported that she was floating high in the water while swimming when they separated and there is no evidence that she ever changed from snorkel to scuba use.

*Autopsy:* A pre-autopsy X-ray was negative. There was no evidence of coronary atheroma, but perivascular and subendocardial fibrosis and thickened myocardial vessels, and the cellular changes of hypertrophy were seen on histology. There were other findings not relevant to this accident. The cause of death was given as drowning.

*Comment:* Gross inexperience and a liability to panic, compounded by a lack of awareness of the significance of these factors for safe diving, were the critical elements in this tragedy, combined with a poor decision to do a solo return swim to the beach. It is difficult to reconcile the husband’s

description of his wife floating high in the water as she began her surface swim back to the beach, her BCD inflated, with the experience of a police diver using the same equipment during a test dive. He stated he felt too heavy when he entered the water and had to fin hard to remain at the surface, this requiring so much effort he became out of breath. It is not stated whether his build was similar to the victim’s and there is no statement that he wore a drysuit for the test. The tight neck seal and the water spray from the split in the regulator mouthpiece may have contributed to panic.

*Summary:* TRAINED BUT INEXPERIENCED; LIABLE TO PANIC; NEW SEMI-DRYSUIT WITH TIGHT NECK SEAL; BUDDY SEPARATION ON SURFACE BEFORE DIVE; MASK LEAK; BCD INFLATED; FAILED TO DROP WEIGHTS; DROWNED.

#### CASE SC 02/06

This 51-year-old woman was described as a bright person and extremely health conscious. She had made 20 dives since her basic course 18 months previously. One of her buddies (Buddy 1) on this dive, who had trained with her, reported a previous incident where she appeared to have an episode of impaired consciousness while trying to exit onto rocks. Another friend reported occasions where the victim had complained of trouble breathing, blaming her regulator for ‘playing up’, and aborting one dive even before descending, citing this as the reason. This dive was arranged as a threesome, a commercial diver friend (Buddy 2) of Buddy 1 joining them, at a sheltered harbour with a reef in 10–15 metres’ water. There were several fishermen on the breakwater and the divers were aware of the need to keep well clear of their lines. They entered the water from a sloping flat rock close to the breakwater, Buddy 1 towing an inflated inner tube with a dive flag attached. He soon became separated from the others as he became tangled in one of the fishing lines and had to surface to get free. After regrouping on the surface, the three of them descended again.

The victim was noted by Buddy 1 to make a rapid, vertical, head-down descent. He then noticed the weight on the line from the inner tube was suspended above the sea bed so returned to the surface where he let down more line before rejoining the other two. It was at this time that the victim signaled to Buddy 2 that she wished to surface and they made a slow ascent at a controlled rate facing each other. Buddy 1 described following them, but stopping at 4–5 msw as he expected them to return after correcting some equipment problem. When they remained absent, he surfaced and saw them swimming towards a moored boat about 20 metres away, Buddy 2 appearing to assist the victim. While resting against a large tractor tyre attached to the mooring, she said “*I’m feeling dizzy and going downhill*”. Her voice sounded weak, and she appeared to be short of breath and tired, and Buddy 2 had inflated her BCD. At this time the regulator was in her mouth, which was well above the water. As there was nobody nearby to provide help, and the moored boat was too

high to climb into, they decided to swim her to shore.

Buddy 2 described how the victim ascended far faster and descended more rapidly than he did on each occasion and that he had held her arm to control her final ascent while maintaining eye contact to keep her calm. She was breathing quickly as they ascended. At the surface she started using her snorkel but soon panicked so he helped her reach her regulator whilst supporting her with his other arm. She was finning weakly and unable to grasp the boat's anchor chain when they reached it so he put her arms over the tractor tyre and supported her till Buddy 1 reached them. Initially they finned each side of her holding her under the armpits with her on her back. Within two minutes of leaving the mooring the regulator fell from her mouth and she was unable to retain it when replaced. They maintained her face above the water during the swim back to the breakwater area against a current. She lost consciousness before reaching the shore. The swell breaking on the rocks created some difficulty getting her on shore. Assistance arrived but resuscitation was unsuccessful.

Examination of the equipment showed about 85 bar of air; unexpectedly low as they had been diving for only 10 minutes and she started with 210 bar. The BCD functioned correctly and the equipment was in good condition except for incorrect seating of the second (octopus) regulator's diaphragm; this regulator was not used during the incident. There was an excessive water content in her cylinder ( $>160 \text{ mg.m}^{-3}$ ; the recommended upper limit  $<100 \text{ mg.m}^{-3}$ ) of uncertain significance.

*Autopsy:* The autopsy report noted cerebral oedema, frothy fluid in the lower airways, degeneration of the mitral and tricuspid valves, with early ballooning of the tricuspid, sarcoidosis in the hilar lymph nodes, microcalcification of the bundle of His, and fractured ribs consistent with vigorous resuscitation efforts. The Coroner gave the cause of death as 'more consistent with pulmonary oedema than drowning', but the pathologist gave drowning as cause of death, with sarcoidosis, tricuspid valve degeneration, and unacceptable water in the air tank as contributing factors, in summarising his autopsy findings. However, a year later in a written presentation to the Coroner he gave his opinion that the diver's pulmonary oedema syndrome might be the reason for this fatality.<sup>9</sup> He also suggested there be early involvement of medical specialists in diving and hyperbaric medicine in the investigation of diving deaths in this State.

*Comment:* There were several strange incidents in the victim's diving history as mentioned above, including an episode of cyanosis and semiconsciousness after a dive, exhaustion, disorientation and breathlessness. It is unfortunate these previous episodes were not investigated medically. No definite conclusion was reached as to why she drowned, possibilities including a cardiac conduction defect causing arrhythmia. The cardiac valve degeneration may also have been clinically significant.

*Summary:* TRAINED; LIMITED EXPERIENCE; HISTORY OF BREATHLESS EPISODES AND EXCESSIVE FATIGUE; FAILURE TO INVESTIGATE PREVIOUS DIVING INCIDENTS; OVERCONFIDENT; EXCESSIVE USE OF AIR; MITRAL AND TRICUSPID VALVE DISEASE; DROWNED.

#### CASE SC 02/07

A 44-year-old scientist, who was an experienced diver, was visiting from overseas. He was tired after the flight, and had slept poorly the first night after he arrived. The opportunity to dive arose on the second evening. Wetsuits, weight belts and tanks were hired, but he and a colleague had brought the rest of their equipment with them. They were guided by two experienced local divers. The victim's experience had been in tropical waters but his colleague was a qualified diving instructor with cold-water dive experience. They entered the water off a boat ramp close to a shallow rock wall where sea dragons are commonly found. Conditions were described as being calm, but cold.

The dive leader had a video camera and asked another colleague who was to remain ashore to record their water entry. When this was viewed later, it showed the victim's gear was not properly adjusted – the tank strap could be seen hanging down in a loop so the tank was able to slip out as the BCD was lifted off the ground. Also the 'octopus' regulator was not secured so that it was readily available and the BCD inflator hose was also not secured. Just before the victim entered the water, his BCD feed and depth gauge could be seen almost off his left shoulder, which would result in them floating behind him and being extremely difficult to reach. His buddy reported checking him before the victim entered the water. They each had a torch, and a 'cyalume' stick attached to their tank.

The group submerged when in chest-deep water and swam to the rock wall, about nine metres away. One of them found a sea dragon in about 3 msw depth. It was then noticed that one diver was missing so they immediately surfaced. The victim's light was seen on the seabed almost at the end of the launching ramp in a depth of about 2 msw. His colleague reached him, inflated his BCD and easily brought him to the surface and towed him to shore where the other two divers helped to pull him out of the water and start resuscitation, continuing till the ambulance arrived: there was no response.

Examination of the equipment showed that the venturi of the second-stage regulator was set in pre-dive rather than dive mode, which would have restricted air flow. Otherwise the equipment functioned satisfactorily. Excessive water and  $\text{CO}_2$  content was noted in the air in the cylinder.

*Autopsy:* Pre-autopsy CT showed a small amount of gas in the liver, a large air bubble in the stomach, probably due to the resuscitation efforts, and a small amount of air in the

heart. The left coronary arteries showed up to 30% narrowing by atherosclerosis with a 60% narrowing of the distal right coronary artery. These stenoses were not considered clinically significant by the pathologist. The cause of death was given as drowning.

*Comment:* The critical factors were thought to have been the cold water, to which he was unused, fatigue and anxiety as he was inexperienced in night diving, and became separated from the others. His snorkel was missing but the significance of this is unknown. His death occurred very shortly after entering relatively shallow water. He was apparently healthy, though with a history of asthma, and had passed a pre-employment medical check some six months before this dive.

*Summary:* EXPERIENCED BUT POSSIBLY FIRST COLD-WATER NIGHT DIVE; ASTHMA HISTORY; BUDDY SEPARATION SOON AFTER WATER ENTRY IN SHALLOW WATER; FAILED TO INFLATE BCD OR DROP WEIGHT BELT; CORONARY ARTERY ATHEROMA; DROWNING.

#### CASE SC 02/08

This 44-year-old experienced male diver was on medication for IgA nephritis. A dive for crayfish was planned with two friends, involving a climb down a rocky cliff to reach a suitable water entry site. The water was described as calm with no swell. The victim had been diving regularly for years; the experience of his buddy reportedly was less than his. They separated after entering the water and it was only when the other two surfaced after 45 minutes that they saw the victim floating face upwards at the surface. At first they thought he was resting, then they saw a wave wash over his face without him showing any reaction, so realised something was wrong. His weight belt was on, BCD inflated. They towed him to a rock platform and commenced resuscitation, this being continued till paramedics arrived: there was no response.

Examination of the equipment showed 150 bar in the cylinder, indicating death had occurred soon after entry into the water. The equipment was described as being quite old, but well maintained. The tank contained a small quantity of water and the second stage had a slight problem with the diaphragm that made it difficult to breathe under stressful conditions.

*Autopsy:* A pre-autopsy X-ray of the chest revealed no gas in the mediastinum or pleural cavities, and the heart contained no air when opened underwater. The proximal segment of the left anterior descending coronary artery had an 80–90% occlusion and the right coronary artery showed approximately 70% stenosis by eccentric atheroma. No thrombi were present in the coronary arteries. Histology of the kidney showed scattered hyalinised glomeruli. Cause of

death was given as spontaneous lethal arrhythmia in a man with significant double-vessel coronary artery disease.

*Comment:* The inflated BCD indicates that the victim had enough time to react to the onset of a problem. He had reportedly aborted his previous dive because of chest pain but had not sought medical advice. It is apparent that he managed the difficult access to the water down the cliff path without obvious symptoms, but this may have expended his cardiac reserve and left no margin to meet the demands of the dive itself.

*Summary:* EXPERIENCED; BUDDY SEPARATION; HISTORY OF ABORTING PREVIOUS DIVE DUE TO CHEST PAIN; NEPHRITIS; INFLATED BCD; WEIGHT BELT NOT RELEASED; CORONARY ARTERY DISEASE; SUDDEN CARDIAC DEATH.

#### CASE SC 02/09

A family group and friends were visiting a relatively sheltered, shallow, sandy bay to catch crayfish. Approximately 100 metres offshore there is a rocky outcrop, and there are numerous reefs that conceal crayfish. The sea was calm with only a slight swell, excellent visibility, and a slight surge around the reef opening. The victim, a 17-year-old male, had trained several years before but had dived infrequently since. He was apparently fit and well, apart from a history of a 'drop attack' some two years previously. He and his father undertook a 45 minute boat dive, then returned to shore for a rest. As the victim and his father had about 100 bar of air remaining, they decided to make a second dive in the same area and were taken out in one of the boats. After about 10–15 minutes the father caught a large crayfish under a ledge while the victim held the torch, but it was soft-shelled and he let it go. When he looked around again he did not immediately see his son, but then saw him lying motionless under a ledge, apparently trapped. He attempted to pull him free but quickly abandoned this when, he said, his mouth suddenly filled with water and he made a rapid ascent to the surface, there yelling out to the man in the boat. He was pulled into the boat and this man, realising the situation was urgent, put on scuba gear and jumped into the water. He saw the fins sticking out under a ledge in about 5 msw. Swimming round to the other side, he saw the victim was unconscious, the regulator out of his mouth, and his arms in front of him. After unbuckling the victim's backpack unit, he pulled him free and brought him to the surface. Resuscitation was initially successful but he died later in hospital without regaining consciousness. The electrocardiogram showed a long QT interval. Inspection of the equipment showed it to be in good condition, and the tank still contained 90 bar.

*Autopsy:* No autopsy was performed. The cause of death was certified by the hospital doctor as cerebral anoxic damage, a 'delayed-drowning' death, with the victim's long QT syndrome a possible critical factor.



*Comment:* This case has been reported previously by Acott in a review of the long QT syndrome.<sup>8</sup> The fatal progression of events was initiated by the victim's decision to leave his buddy, despite their agreement to stay together, then he became wedged under a ledge. The two divers were separated for possibly a minute or so. Whether the victim was actually trapped is uncertain, it being possible he was merely difficult to extricate after losing consciousness, or he may have felt trapped and lost the regulator from his mouth as the critical sequence of events.

*Summary:* TRAINED BUT INEXPERIENCED; CRAYFISHING; BRIEF BUDDY SEPARATION; FOUND CAUGHT UNDER A LEDGE; PREVIOUS BLACKOUT; LONG QT SYNDROME; ACUTE CARDIAC DEATH.

#### CASE SC 02/10

Prior to a family trip to Australia this 56-year-old man underwent a 'full medical check' at his own request, including a cardiac stress test. This indicated 'a slight abnormality' so he had a cardiac catheterisation and blood tests. An elevated blood sugar was noted and he received dietary advice. He was assured he was fit to continue the type of diving to which he was accustomed. He was accompanied by his wife and their two sons, one of whom had been diving for 10 years and was now a divemaster. The victim had trained in 1997 and made about 80 dives around the world with his wife as his usual buddy. They walked in the Blue Mountains and climbed the Sydney Harbour Bridge before staying at a GBR island resort, and booking a diving trip. On the dive charter boat, a routine safety talk was given to the mixture of scuba divers and snorkellers, and he was cleared to dive after showing the recent medical certificate from his physician.

The family members were using their own equipment except for hired tanks. Another safety talk was given to the scuba group, all equipment was checked, and they were divided into two groups of three buddy pairs with an instructor as guide. The victim was buddied with his wife and their two sons were paired together, all being in the same group. During the descent, his wife experienced some ear equalisation problems and they ended up on the seabed close to the other group of six divers. Meanwhile their two sons had returned to the surface along with their dive guide because the less experienced one was unable to effectively clear his mask. He decided he would rather join the snorkellers than dive again, while his brother chose to buddy with their guide. There was a slight current but the sea was calm and visibility about 9 metres. Meanwhile, the victim and his wife saw the other group move off and followed them, holding hands, but its guide noticed and signaled to them to go with their own guide, who was now close behind them.

They followed her till the victim's wife pointed out some coral for the victim to photograph. While he was trying to focus his camera, his wife saw that their guide was swimming

away and noticed that there was a slight current against them. She signalled to the victim what she intended, then followed their guide. They had swum about 3–5 metres before the guide turned round and queried where her buddy was. It was only then she realised her husband was not close behind her. She could see the coral he had been photographing but he was no longer there. At this time they heard a dinghy moving above them. The group now ascended, making a safety stop together, and surfaced close to the dive boat. It was only then that she learned her husband was ill and receiving emergency resuscitation. Prolonged resuscitation efforts were unsuccessful. The safety lookouts had seen the victim surface about 10–15 metres from the boat. He was waving his arms and definitely conscious at this time, but was not heard to shout or make any noise. He was reached by the dive tender within a minute or two, by which time he was unconscious, floating on his back, mask on his face and BCD not inflated. The regulator was held tightly by his clenched teeth.

Examination of the equipment showed no faults and ample remaining air, but there is no description of whether the integrated weights were still present in the BCD pouches or had been dropped. His gauge showed maximum depth to be 18.5 msw.

*Autopsy:* The autopsy revealed evidence of an old anterior myocardial infarct near the coronary ostia. The remaining cardiac tissue appeared normal macroscopically, but histology showed extensive areas of interstitial fibrosis in the anterior left ventricle. The coronary arteries were patent and showed only moderate atheroma, while the abdominal aorta also showed moderate atheroma. There was no indication of arterial gas embolism; nothing in the reported findings suggests this diagnosis. The cause of death was given as probable ventricular arrhythmia due to myocardial ischaemia due to coronary atheroma.

*Comment:* As there was no reason to suspect dive stress, there is no suggestion that the fatal event could or should have been predicted. This case is an unfortunate demonstration of the limitations in predicting life expectation even after thorough medical investigations.

*Summary:* TRAINED; EXPERIENCED; RECENT CARDIOLOGICAL ASSESSMENT WITH MINOR PROBLEM NOTED AND ELEVATED BLOOD SUGAR; BUDDY SEPARATION; SOLO ASCENT; LOSS OF CONSCIOUSNESS ON SURFACE; EVIDENCE OLD MYOCARDIAL SCAR; ACUTE CARDIAC DEATH.

#### CASE SC 02/11

Travelling alone from overseas, this 63-year-old man was trained but 'a bit rusty' having not dived for two years. However, he made two dives without incident following his arrival and he reported this when he signed up for a live-aboard dive cruise. It was noted he had some difficulty

controlling his buoyancy, this tending to cause separation from his buddy. At the dive briefing, it is thought he indicated he had made a night dive the previous night, but this is uncertain. There was a slight current and clear visibility when he and his two buddies descended to 13 msw. He wore a lycra suit under a wetsuit and hired scuba equipment. After about 25 minutes, they passed another group and soon after this his buddies noticed his absence. They assumed he had joined this other group so were not worried.

The surface safety watch saw a light come to the surface about 70 metres away and called out, receiving a reply from the diver indicating he was okay but wished for assistance back to the dive boat; he gave no appearance of any distress. The water was too shallow for the tender to reach him but he said he was not able to swim to it, so a rope was thrown to him and he held onto it while he was dragged clear of the coral. As he raised his hand to be helped into the tender he went slack so the crewman removed his weight belt and other equipment and tried to pull him into the tender, but when he found he could not do so he entered the water to keep the diver's head above the surface and to give in-water rescue breathing. With others to help he was brought to the dive vessel where resuscitation was started, but to no avail. Examination of the equipment found it to be in good condition and there was about 90 bar in the cylinder.

*Autopsy:* A pre-autopsy X-ray showed no evidence of abnormal tissue air, and no evidence was found during physical examination of the body. The myocardium of the left ventricle appeared slightly thickened (28–33 mm). The left anterior descending (LAD) coronary artery had an area of over 80% stenosis 8 mm from its origin and 9 mm in length, but was patent further on. The right coronary artery was widely patent throughout its length. There was no evidence of past or recent myocardial infarction. Lung histology showed possible signs of an intercurrent infection. The cause of death was given as cardiac failure.

*Comment:* The reason for the victim's separation and solo unobserved ascent is unknown as he had adequate remaining air. It is possible he experienced some panic when he lost contact with his buddies. Whether this resulted in a cardiac arrhythmia or an air embolism cannot be known. Although a diagnosis of CAGE may be sustainable on clinical grounds, the severity of the LAD stenosis makes a cardiac cause of death a more probable diagnosis. Pharmacological evidence of the use of nasal decongestants supports the possibility of a respiratory tract infection, though this had no apparent part in the course of events.

*Summary:* TRAINED; NIGHT DIVE; BUDDY SEPARATION; LOSS OF CONSCIOUSNESS AT SURFACE; POSSIBLE RESPIRATORY TRACT INFECTION; CORONARY ARTERY DISEASE; NO EVIDENCE OF CAGE; SUDDEN CARDIAC DEATH.

#### CASE SC 02/12

The victim was a 64-year-old, apparently fit man with an active lifestyle, whose occasional symptoms from a hiatus hernia were his only medical problem. He had mentioned taking an antacid "for an upset stomach" on the morning of this dive. He was a very experienced and active diver, and had dived on the two days prior to this boat dive. His first dive was incident free and, after an appropriate surface interval, he made a second dive with his buddy. The water conditions were good, no significant current or wave action. After about 20 minutes his buddy looked back, as he was following close behind, and they exchanged 'OK' signals, but when the buddy turned round five minutes later he saw the victim stationary in the water with the regulator out of his mouth. When he tried to replace it he was unsuccessful as the victim was unresponsive. Rescue breathing was started as soon as he was brought to the surface, and resuscitation in the dive boat, but without success.

*Autopsy:* At autopsy he had an enlarged heart and significant coronary artery disease. Acute cardiac death.

*Comment:* This death appears to have been completely unpredictable. It is possible that the victim's 'indigestion' had, in part, been anginal pains.

*Summary:* EXPERIENCED; APPARENTLY FIT MAN; SUDDEN LOSS OF CONSCIOUSNESS UNDERWATER; CORONARY DISEASE; ENLARGED HEART; SUDDEN CARDIAC DEATH.

#### CASE SC 02/13

The victim was a 20-year-old, apparently fit woman, trained but inexperienced. At the end of an uneventful dive lasting 40 minutes to a maximum depth of 10 msw she and her buddy had ascended to 3 msw. There, without warning, she began to descend head first, apparently unconscious. Her buddy brought her to the surface but she showed no response to resuscitation efforts.

*Autopsy:* The autopsy revealed the presence of a congenital bronchogenic cyst in the right upper lobe, which had partially ruptured, probably due to the air expanding during ascent, resulting in an arterial gas embolus. There was haemorrhage within the centre of the cyst.

*Comment:* No other details are available about the victim's medical history, the diving incident and the autopsy findings. It is possible that a chest X-ray as part of a diving medical assessment might have demonstrated the cyst's presence.

*Summary:* TRAINED BUT INEXPERIENCED; NORMAL ASCENT; RUPTURE OF UNDIAGNOSED CONGENITAL BRONCHOGENIC CYST; CAGE.

## CASE HH 02/01

A 52-year-old man, who had been diving for 18 years, was described by his son as “*fit and healthy, been diving most of his life and never had any problems*”. He took out two friends for a day’s diving. This case has been reported previously by Acott.<sup>7</sup>

It was an excellent day for diving, a calm sea with visibility of 6–9 metres, water temperature 22°C and a slight breeze. The boat and hookah equipment, which was owned by the victim, was thoroughly checked by him before the dives. His wetsuit was very tight, and he required considerable assistance to put it on. While one of his friends remained in the boat as an observer, the other two dived twice to hunt crayfish. After about 15 minutes into the second dive, the buddy experienced some pain in his ears and temple, and felt it was time to end the dive. They ascended slowly and at the surface swam side by side towards the boat, three to four metres away. When the buddy reached the boat he looked round but could not see his friend, then looked down and saw him lying on the sea floor with no bubbles coming from his regulator. The buddy, who had experienced no problem with his air supply, immediately swam down and with difficulty removed and ditched the victim’s harness and vest before bringing him to the surface. He was pulled into the boat and resuscitation started but there was no response. They returned to land, which took about half an hour. There, the non-diver of the trio landed and went for assistance, but after walking a short distance he began to have breathing difficulty, collapsed and also died despite resuscitation attempts by off-duty ambulance officers.

*Autopsy:* The victim was obese (132 kg; BMI 38 kg.m<sup>-2</sup>) and had emphysema with at least one large bulla and others at the apex of his left lung, but there was no evidence of pulmonary barotrauma. A carboxyhaemoglobin level was 2%. There were severe fatty changes in his liver, moderate coronary atheroma, and minor ischaemic cardiac fibrosis. The cause of death was given as drowning.

*Comment:* The tight wetsuit may have increased the effort expended during the dives and with his other medical problems have contributed to impaired pulmonary gas exchange. His buddy cannot have been unaware of the victim’s lack of fitness but obviously was not concerned by this. It is possible that he suffered a fatal cardiac arrhythmia as he swam towards the boat, becoming rapidly incapacitated and incapable of calling for help before drowning. There is no evidence of any equipment factor, and the water conditions did not cause any problems for either diver.

*Summary:* SURFACE-SUPPLY BREATHING APPARATUS; EXPERIENCED; OBESITY; EMPHYSEMA WITH BULLAE AT APEX LEFT LUNG; MINOR MYOCARDIAL ISCHAEMIC CHANGES; TIGHT WETSUIT; POSSIBLE ACUTE CARDIAC DEATH; COLLATERAL DEATH NON-DIVER CREWMAN; DROWNING.

## CASE HH 02/02

This 23-year-old professional scallop fisherman was diving turn-and-turn-about with his assistant, in about 10 msw. About five to ten minutes into the dive, whilst he was sorting the catch on board the boat, the assistant heard the victim yelling. He had not seen him surface, but “*knew something was wrong so kicked the motors over and put it in gear*” and started to motor to him, 50–100 metres away. He then saw a white pointer shark, “*it was enormous, the size of the boat [6.5 metres]*”, and witnessed its attack almost immediately, taking the unfortunate diver in its jaws, shaking its head and thrashing him around. He hit the shark with the side of the boat and managed to pull his friend into the boat, receiving electric shocks from a ‘shark pod’ carried by the diver as he did so. The victim died soon after. The boat’s VHF radio was defective and their mobile phone had a flat battery, so the assistant had to ask some fishermen he met as he was returning to port to radio ahead to warn others of the danger.

*Autopsy:* The autopsy detailed the amputation of the victim’s right lower limb at the hip joint and the multiple irregular incised bite marks on the buttocks and upper left leg.

*Comment:* Blood loss and shock from massive trauma made this an inevitable fatality. Examination of the victim’s ‘shark pod’ showed that it had been incorrectly applied, though in a manner probably common amongst users. The apparatus produces an electrical field that impacts on the shark’s receptors, the Ampullae of Lorenzi, causing it discomfort, then muscle spasm if it comes too close. The pod has three components – a battery with an electrode worn on the air cylinder or back of the buoyancy vest, a second electrode worn on one fin, and a hand switch which comes over the diver’s shoulder and is attached to the front of the buoyancy vest. For maximum protection it should be switched on whilst in the water, but as the perceived risk is minimal while the diver is working close to the sea bed, only arising as the diver is ascending and while at the surface, it is common practice for divers to switch it off while on the sea bed, avoiding electrical shocks to the wearer. However, on this occasion the fin electrode had been placed on the air hose attached by a float and as the hose is flexible the two electrodes can become too close to exert an effective deterrent field when the diver is at the surface – the time this shark attacked. Police examination showed the ‘pod’ to work well if correctly worn. It is probable the shark became interested in the diver while he worked with the pod turned off. This may have resulted in him switching it back on and then starting to ascend, the field deterring the shark till he reached the surface and one electrode rose out of the water. Electrodes should be at least 1.5 metres apart.

*Summary:* SURFACE SUPPLY BREATHING APPARATUS; PROFESSIONAL DIVER; ‘SHARK POD’ INCORRECTLY POSITIONED; WHITE POINTER SHARK ATTACK; MASSIVE TRAUMA.

### CASE HH 02/03

This 43-year-old diver was surfacing from a crayfishing dive with his buddy when he was hit by the propeller of a boat and suffered severe head trauma. The injury left him in a vegetative state from which he never recovered, and he died 11 months later. A 'diver down' flag was displayed on the dive boat, but it is unclear whether the hookah hose extended beyond the 50 m (in Western Australia) 'no go' zone. Despite an intensive search, the boat involved was not located. However, it is unlikely the boat's occupants remained unaware of the event as details were widely publicised. Due to the long interval between the incident and the diver's death, the normal coronial investigation for a diving-related fatality was not instituted. Details of the incident are still lacking but continue to be sought.

*Summary:* SURFACE-SUPPLY BREATHING APPARATUS; MAJOR HEAD TRAUMA FROM BOAT PROPELLER; BOAT NOT IDENTIFIED; COMA FOR ELEVEN MONTHS BEFORE DEATH.

### Discussion

The safest way to learn about dangerous situations and their avoidance is through an examination and understanding of what has befallen others, death being the worst endpoint of any misadventure. Despite the unsuitability of the underwater environment for any air-breathing creature, it can be successfully entered if the necessary conditions are met. It is the purpose of training, the development and correct use of appropriate, well-designed equipment, and an adequate understanding of potential medical problems and their management to reduce the risks of diving to acceptable levels. It is only through constant measurement of reality against theory and assumptions that we can improve safety.

Understanding of complex problems is a dynamic process that challenges accepted beliefs with the evidence of new data. However, there are particular problems in the matter of diver safety in accessing the validity and weight of data offered by persons involved in a serious incident, such as a fatality. There will inevitably be a tendency on the part of witnesses to present a simple and 'clean' report on the events, one limited to satisfying the investigator's area of interest. This may leave unexplored matters that appear peripheral to the main focus of the coronial investigation – for example, the medical history of the victim – often as a consequence of the difficulty in obtaining this information from the family. The clinical significance of a medical condition may be overlooked, or the absence of a 'medical history' may not be an accurate representation of the facts.

### SNORKELLERS

Though buddy separation frequently occurred before the fatal cascade of events, this may not have been the critical

element in most of the snorkelling incidents. Water power was a probable factor in three cases, either close to rocks or, as in the case of BH 02/10, in the form of a rip current. Only one case of ascent hypoxia from a deep breath-hold dive was reported (BH 02/11). In the two snorkellers who died from box jellyfish envenomation, it is possible that there might have been a better outcome but for their underlying medical conditions. As a result of these and other such incidents, the Queensland Irukandji Taskforce has recently developed guidelines for the emergency management of the Irukandji syndrome.<sup>10</sup>

As in previous years, cardiovascular factors were common, though sometimes these were accepted as the likely cause of death rather than being proven to be so. This may be a reflection of the age range of the majority of those who died. Of the 17 cases, 14 were over 40 years of age, the eldest being 82 years old. Of special interest to those running commercial trips to the Great Barrier Reef is that 12 of the 17 snorkellers who died were middle-aged or elderly overseas visitors (average age 69 years), and unsuspected cardiac factors are believed to have been critical in seven of these, with a CVA consequent to hypertension in another. It is difficult to see how anyone could give an accurate prediction of the safety of swimming to someone with a cardiac problem but who has no known symptoms, except by unjustifiably restricting the activities of the many who are now correctly advised to undertake exercise. The continued occurrence of unobserved deaths in supervised swimming areas appears to confirm the silent nature of many such deaths but remains a potential concern regarding the techniques of supervision adopted in this industry. Unfortunately the wearing of a life vest does not prevent drowning, as cases BH 02/05, BH 02/06 and BH 02/12 demonstrate.

### SCUBA DIVERS

One unexpected finding has been the frequency of health problems (10 out of 13 divers), often unsuspected, in this group of apparently healthy people undertaking scuba diving, an activity with energy demands that may be severe in an emergency situation. This is consistent with the recent report on New Zealand diving fatalities.<sup>11</sup> However, in only one instance (SC 02/1) had the person disregarded a specific warning from a cardiologist not to dive. There were three instances (SC 02/2, SC 02/06, SC 02/09) in which symptoms worth further investigation were, unfortunately, not reported to a doctor, but in the remainder the health problems appear to have remained occult. In one case (SC 02/10) a specialist had legitimately made the decision that diving was allowable, illustrating the problem of predicting the future. Whether a person liable to panic (SC 02/05) should dive is another area problematic to enforcement.

Although two had a history of asthma there is nothing to suggest that this played any part in their deaths. It is difficult to see how fatalities can be reduced other than by a strict adherence to generally promoted safe diving protocols



and an increased awareness among the diving community of the value in seeking informed medical advice on any health problems they may experience. A bronchogenic cyst constitutes a 'classic' but a rare risk factor – one insufficiently common to justify a return to routine chest X-ray as a requisite to medical clearance for dive training.

#### HOOKAH DIVERS

These three cases illustrate different, potentially dangerous situations. In two, the critical factors implicated were known and accepted by the victims, though they both failed to recognise their significance. In the first case it is likely that the victim was undoubtedly aware of his lack of physical fitness, but both he and his buddy failed to recognise the serious health risk this factor constituted. In the second case the shark attack might not have occurred had the deterrent equipment been worn as advised by the manufacturer. This diver was unfortunate that an apparently common practice in how the 'shark pod' was worn and used left him exposed to risk at the surface. The manufacturers of such equipment should consider how to address the problem wearers experience from shocks at the surface. The third death indicated that it is not always possible to escape the actions of others who ignore safety rules.

#### Conclusions

It is difficult to see how the occurrence of deaths among visitors swimming with snorkels on the GBR could be reduced. There is now a real awareness among the commercial firms providing this service of the need to provide safety advice, a watch over those in the water, and offer buoyancy aids. However, a significant proportion of their clients are carrying cardiovascular risk factors and it would appear unacceptable to have a compulsory age cut-off for allowing them to snorkel swim. Water power is more likely to be a factor in non-commercial diving situations. Reiteration of the potential dangers of breath-hold diving can be difficult in the special breed of divers seeking to set greater depth records.

Although only one scuba diver received, and ignored, medical advice not to dive, two others unfortunately failed to attend a doctor to discuss their symptoms. The incidence of cardiovascular factors is likely to remain a problem as they are often unrecognised by the victim, and the value of regular age-related medical fitness checks is debatable. A continued emphasis on training, experience, and awareness of the need to dive within one's ability, remains a necessity.

#### Acknowledgements

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