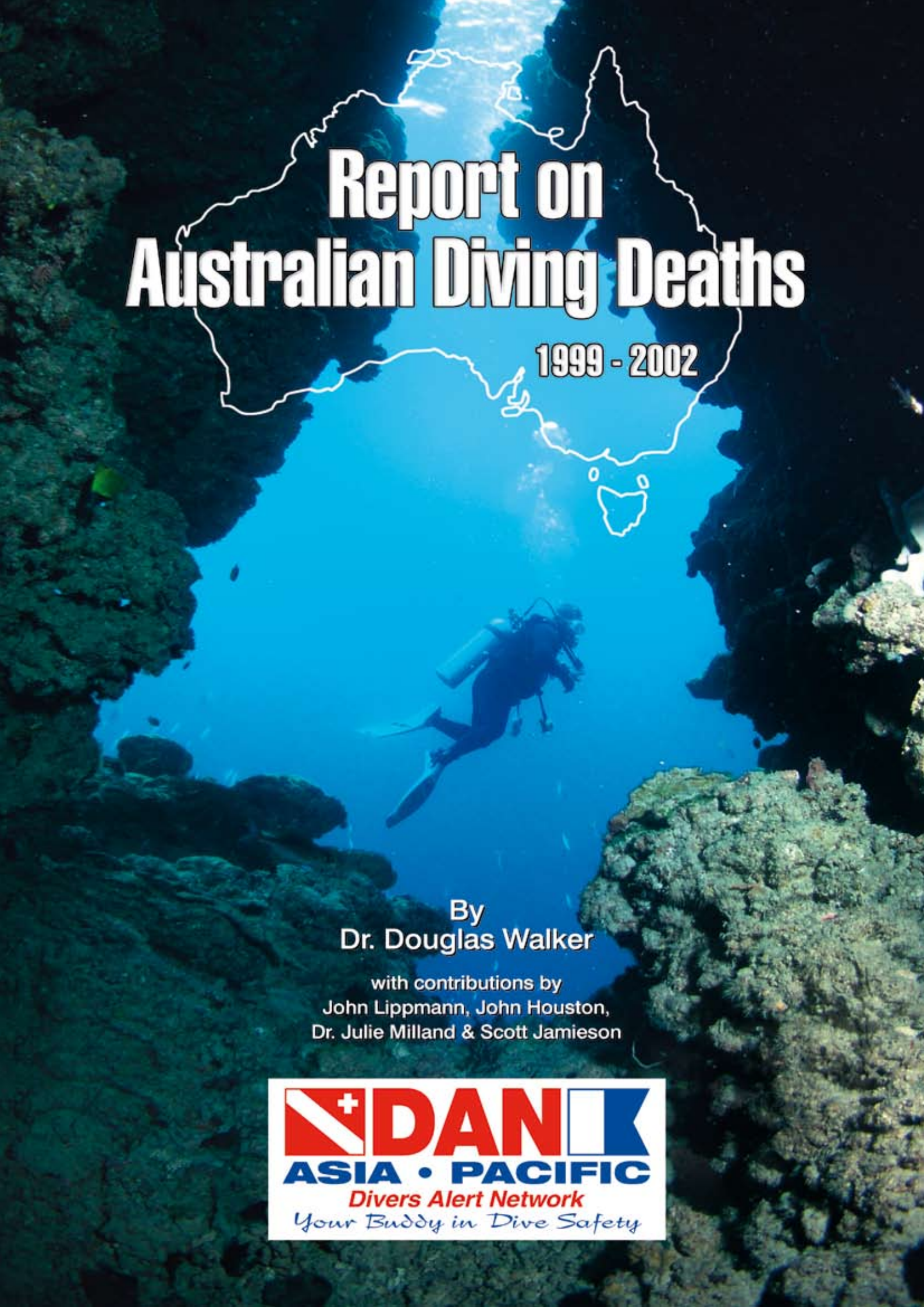

Report on Australian Diving Deaths

1999 - 2002

By
Dr. Douglas Walker

with contributions by
John Lippmann, John Houston,
Dr. Julie Milland & Scott Jamieson

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Walker D. Provisional report on diving-related fatalities in Australian waters 2001. Diving and Hyperbaric Medicine. 2006; 36: 122-138.
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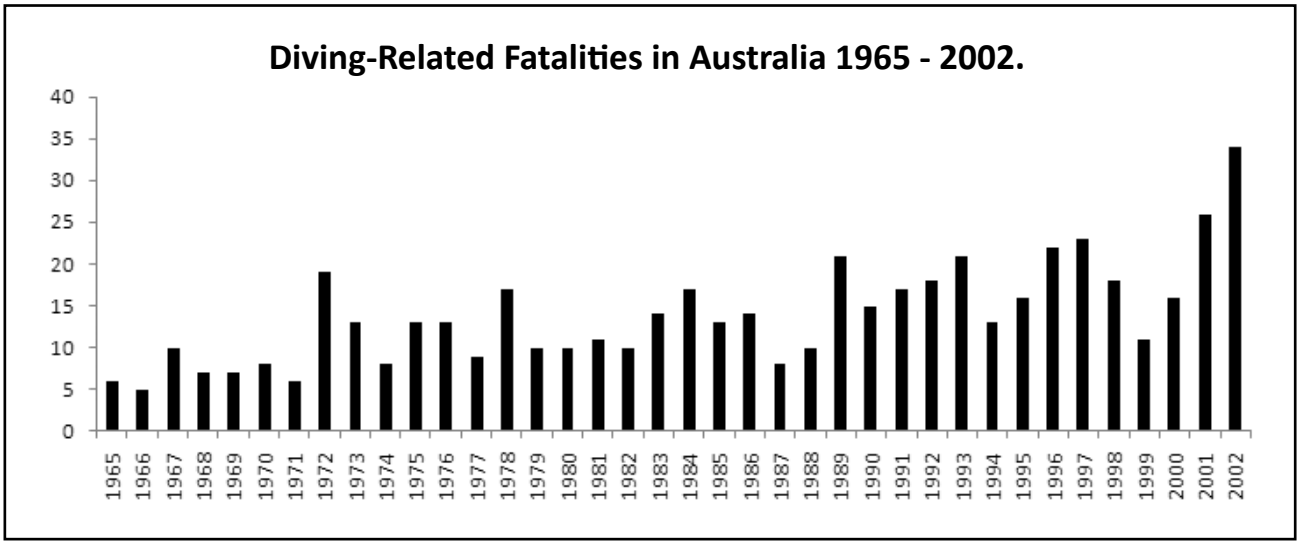


PREFACE

The Divers Alert Network (DAN) is an international group of autonomous non-profit scuba diving safety associations with branches in throughout the world. These are DAN America, DAN Europe, DAN Japan, DAN Southern Africa and DAN Asia-Pacific.

DAN's overall mission is to improve the safety of recreational scuba diving. It works towards this by a variety of means that include: the provision or sponsorship of diving emergency hotlines, the provision of evacuation and insurance services for injured divers, accident management training programs, the conduct of educational seminars, the publication of regular *Alert Diver* dive safety journals, research into diving medicine and accident prevention, and the reporting of dive accidents.

DAN Asia-Pacific (AP), established in 1994, provides services to most countries within the Asia-Pacific Region. DAN AP is committed to improving the collection of and reporting on dive accidents, throughout this region. This is a very difficult task due to the size and diversity of the region and the lack of effective reporting and diving accident investigation protocols in many of the countries within the Asia-Pacific. DAN AP is working closely with various key organisations and individuals to obtain accident data from countries throughout this region. We hope to continue to improve the collection, collation and reporting of these accidents and to provide regular reports of regional diving accidents. To this end, we implore divers who become aware of a serious diving accident to contact DAN AP to ensure that we are aware of the accident and can follow it up. This can be done by emailing us at info@danasiapacific.org, or by downloading an Accident Report Form from the Research Section of www.danasiapacific.org or copying it from the end of this publication.

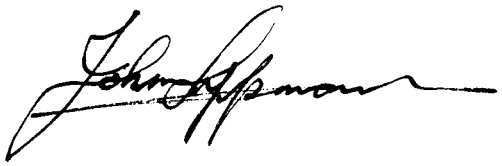
In 1998, DAN AP published the *Report on Australian Diving Deaths: 1972-1993* which detailed the 301 diving and snorkelling-related deaths that were known to have occurred in Australia during that period. In 2002, we published the *Report on Australian Diving Deaths: 1994-1998*, relating to the 92 diving and snorkelling-related deaths reported during that time.

This current report provides details of the 86 victims of diving and snorkelling-related accidents that occurred between 1999 and 2002 inclusive. These reports were again written by Dr. Douglas Walker and were published year by year in the South Pacific Underwater Medical Society Journal.

We hope that this document will be a valuable resource to divers and others who are interested to learn from the mistakes or misadventures of others and so reduce the likelihood of similar accidents occurring in the future.

We look forward to your help in preventing future diving accidents.

Safe diving,



John Lippmann OAM
EXECUTIVE DIRECTOR
Divers Alert Network Asia - Pacific

1999: Australian Diving-Related Fatalities

Overview

In 1999 there were eleven diving associated deaths in Australia for which data, sometimes incomplete, are available. Five deaths were associated with scuba diving and six with use of snorkels. Four scuba divers died from cerebral arterial gas embolism (CAGE) and one from running out of air. Four of the snorkellers were over 65 and three of these died from cardiac causes. One snorkeller was attempting to reach a deeper depth than he had previously achieved and hyperventilated before the dive. The sixth snorkeller was found floating just under the surface in shallow water. Unrecognised health problems in older tourists were an important factor in the deaths of four snorkellers. The facts are summarised in Table 1 and the case reports appear below.

CASE REPORTS

Breath-Hold and Snorkel-Using Swimmers

CASE BH 99/1

This woman, her husband and their six-year-old child were day-trip visitors to an island. It is thought they did not attend the talk about the safe use of a snorkel provided on the trip out. After disembarking they went to the beach near the landing jetty. Here there was a notice stating that swimming was prohibited in this area. All three entered the water. The victim had used a snorkel only once before, seven years earlier.

After about 15 minutes of snorkelling alone, the husband returned to his wife and child, who were standing in shallow water about 15 metres from the shore. He suggested that she remain there until he returned from taking his daughter back to the beach. Because the mask he had been using had leaked, he changed his mask before returning to where he had left his wife. He was unable to see her among the others in the water so he quickly returned to the shore and ran down the jetty to ask for help from the crew of the boat which had brought them. A surface check using binoculars was unsuccessful, then he saw her lying in a small boat moored at the jetty with people attempting to resuscitate her.

Some men had seen her floating in the water beneath the jetty. At first they had thought it was a mannequin which someone had thrown into the water as a joke, then realised it was a real woman. There was a slight delay before they noticed that, although she had a snorkel, she was not coming up for air. One of them walked to a nearby bar and asked the barman to look at her, saying “She doesn’t look too healthy”. The barman responded quickly, yelling for assistance before jumping in the water. She was pulled into a boat and CPR was immediately instituted. This succeeded in maintaining her alive and she was transferred to the local hospital. She died the next day from near-drowning cerebral anoxic damage.

Comment

It is probable that this woman would have survived had she stood up. A possible reason for her failure to do so may have been the shock and surprise of breathing in water through her snorkel. Although she was not wearing fins, this need not have necessarily compromised her safety in the shallow water close to the beach. The notice prohibiting swimming near the jetty was probably designed to keep swimmers out of the path of boats approaching the jetty.

A strange feature of this case was the action of the vessel’s owners, who instructed their solicitor to prevent the police from taking statements from the crew. Equally strange is the fact that this was legally permissible. As there is no reason to suppose the incident was in any way due to any act or omission of the crew this ‘pre-emptive strike’ appears to have been the result of a fear lest some error be alleged in their management.

Summary

SNORKELLING; FIRST USE FOR 7 YEARS; DID NOT ATTEND INSTRUCTION SESSION; NOT WEARING FINS; SHORT TIME OF SEPARATION; SILENT DEATH BY DROWNING IN CALM SHALLOW WATER CLOSE TO OTHERS; NO KNOWN HEALTH.

CASE BH 99/2

This man and his wife were making a day trip to the Barrier Reef. During the outward journey there was a talk on snorkelling techniques and the passengers were required to complete a medical questionnaire. On this form he declared himself as having none of the listed conditions as he had been in good health since

two "minor heart attacks" in 1982. During the morning snorkelling, wearing a wetsuit and fins supplied by the company, and using his own mask and snorkel, he had no problems. After lunch the vessel moved to another location, and while his wife watched he snorkelled in the prescribed area. She saw him rest at a float station to adjust his mask, then swim back to the vessel and cling onto the bottom step of the snorkelling platform. He spoke to his wife, who noticed that he had a "ghastly pallor", then he lost consciousness and floated away. She screamed for help and a diving instructor quickly entered the water and brought him to the dive platform at the vessel's stern, as this was at water level. The crew gave CPR and only ceased after medical advice by radio to do so.

Autopsy

At the autopsy there was noted to be emphysema involving the outer two thirds of both lungs, and carbon deposits on their surfaces. There were pericardial adhesions and proximal blockage of the inter-ventricular coronary artery. The lower abdominal aorta and the iliac arteries were described as "egg shell" calcified. Death was ascribed to a myocardial infarction.

Comment

This myocardial infarction could have occurred anytime, anywhere, and was not predictable from his health history.

Summary

CONSIDERED HIMSELF HEALTHY; SNORKELLING IN CALM WATER BEFORE LUNCH; AFTER LUNCH SUDDEN CARDIAC DEATH IN CALM WATER; HISTORY OF TWO "MINOR" HEART ATTACKS 17 YEARS EARLIER; ACUTE MYOCARDIAL INFARCTION.

CASE BH 99/3

This youth was the son of one of the crew of the dive boat, and a guest rather than a paying passenger. There were two groups of scuba divers aboard, under the supervision of two divemasters, and a crew of three. The club divers managed their own affairs, with one divemaster organising the scuba divers, the other divemaster and the skipper keeping a surface lookout watch on the divers. In response to his mother's request they also maintained a watch on the youth as he snorkelled. He appeared to be making 'duck dives'. At one time the skipper judged that the youth was getting too distant from the boat for safe observation and asked his mother to tell him to come closer, which he did. He was seen to be wearing board shorts and a T-shirt, a mask and snorkel, with strap-on fins, borrowed from his mother, on his bare feet.

After some time spent making shallow dives he apparently told his mother that he intended to try to dive deeper, to beat his previous best of 17 metres' sea water (msw), and donned one of the weight belts lying on the deck close to the stern boarding board. His mother instructed him in how to release the belt. He asked about the depth and was told it was 22 msw. The skipper denied having any knowledge that he had donned a weight belt but had noticed that he hyperventilated to some degree before his descent. He had suggested that it was safer to have a buddy, and also that he had one arm raised as he ascended so as to know when to blow the water from his snorkel as he broke the surface. This advice was not followed.

The alarm was raised when a single fin floated to the surface close to the dive boat. One of the scuba divers, having a post-dive swim, looked down and saw a body lying face up on the sea bed 22 metres below. The divemaster who had been acting as safety lookout immediately donned the scuba set kept ready for any emergency and jumped into the water. He noted that the mask was in position, some 'facial squeeze' was present and the snorkel was out of his mouth. He released the weight belt, said to be five kilograms or less, and carefully brought him back to the surface. Once back on board the boat, CPR was commenced.

Autopsy

The autopsy confirmed that drowning was the cause of death, and a post-hyperventilation dilution hypoxia blackout was given as the reason. In the autopsy report it was mentioned that the brain was retained and not returned with the body, a procedural matter the subject of recent intense public interest following a New South Wales investigation into the management of bodies and body parts by forensic departments.

Inquest statements

At the subsequent inquest the divemaster stated he had initially thought the victim was one of the crew and was unaware anyone would be snorkelling. He also said that he had directly asked to be informed whenever the youth entered the water so as to know to look for him and that this was not done. There was some criticism concerning the absence of a reservoir bag on the OxyViva resuscitation equipment but this would not have affected the outcome as he was

Table 1. Summary of Diving-Related Fatalities in Australian Waters

CASE	AGE	TRAINING & EXPERIENCE	DIVE GROUP	DIVE PURPOSE	DEPTH (METRES) DIVE	DEPTH (METRES) INCIDENT	WEIGHT BELT ON	WEIGHT BELT KG
BH 99/1	35	None	Buddy separation before incident	Recreation	< 2 m	< 2 m	None	-
BH 99/2	71	Some experience	Solo	Recreation	?	Surface	None	-
BH 99/3	24	Some experience	Solo	Recreation	22 m	Ascent	On	5
BH 99/4	75	Some experience	Solo	Recreation	2 m	Surface	On	?
BH 99/5	68	None	Buddy separation before incident	Recreation	?	Surface	None	-
BH 99/6	70	Some experience	Buddy separation before incident	Recreation	2 m	Surface	None	-
SC 99/1	31	Some training No experience	Group separation before incident	Class	2 m	2 m	On	?
SC 99/2	29	Trained No experience	Group separation before incident	Recreation	10 m	10 m	On	?
SC 99/3	65	Trained Experienced	Buddy separation before incident	Recreation	15 m	Ascent	On	?
SC 99/4	60	Trained Experienced	Buddy separation during incident	Recreation	?	Ascent	?	?
SC 99/5	31	Trained Some experience	Buddy separation during incident	Recreation	?	18 m	On	6

certainly dead when found. Although there was a statement in the government regulations that the emergency equipment should deliver 100% oxygen, expert opinion was presented that this was an impossible requirement.

There was much discussion concerning whether the dive-boat owner or the hirer was responsible for checking the safety equipment before a chartered dive boat left harbour. It was decided that the dive-group organiser was probably the one to have this legal responsibility. As the victim was a guest of a crew member it was decided, after some discussion, that this was not a 'workplace' death so did not require an official investigation. If he had been a member of the scuba diver group or had performed any crew duties this would have been required.

Comment

That his mother had to show him how to release the weight belt suggests that he had no experience of diving with one. Although there was no direct description of the sea conditions, the fact that he was diving without a wetsuit and could be seen from the surface 22 metres above would imply water conditions were good. It is evident that he was far from being an experienced breath-hold diver.

The loss of one fin, possibly because of a slack strap, would have compromised his ability to swim to the surface had he become aware of an urgent need to do so before blacking out. The fins were intended to be worn over bootees, and were not his own but

in 1999 (BH – Breath-Hold, SC – Scuba, ? – Unknown)

BOUYANCY VEST	CONTENTS GAUGE	REMAINING AIR	EQUIPMENT TESTED	EQUIPMENT WHOSE	COMMENTS
No	n/a	n/a	n/a	Own	Second use of snorkel. Solo. Shallow water. Drowned.
No	n/a	n/a	n/a	Hired	Mild myocardial infarct 17 years ago. Appeared healthy. Acute myocardial infarction.
No Unused	n/a	n/a	n/a	Borrowed weights and fins	Attempting deep dive. Hyperventilated. Not used to diving with weight belt. Lost fin.
No	n/a	n/a	n/a	Hired	Childhood polio. Hypertension. Recent medical check. Acute myocardial infarction.
No	n/a	n/a	n/a	Hired	Last snorkelled four years before. Aortic valve replaced two years before. Surface swim separation. Probably acute cardiac arrhythmia.
No	n/a	n/a	n/a	Hired	Silent death in calm water. Hypertensive myocardial changes. Cardiac death.
Not stated	Not stated	Adequate	No fault	Hired	First open water dive with class. Rapid ascent after separation. CAGE.
Not stated	Not stated	None	No fault	Hired	Separation underwater. Drowned.
Partly inflated	Not stated	Adequate	No fault	Hired	No dives for four years. Recent refresher dive. Separation underwater. CAGE
Not stated	Not stated	Not stated	Not checked	Own	Possible underwater avalanche panic caused ascent. CAGE. Delayed death.
Not stated	Not stated	Adequate	Not stated	Hired	Sudden panic ascent. CAGE. Brain dead next day.

borrowed from his mother. His clothing would produce drag and prevent his achieving a rapid descent or ascent, and therefore could have had some effect on the tragic course of events.

After this episode his mother could never bear to sail on the boat. She considered that she had a degree of responsibility for his death because she had failed to warn him of the risks of post-hyperventilation blackouts. However, her past scuba training had not left her with any awareness of this risk.

Summary

EXPERIENCED SNORKELLER; NOT USED TO DIVING WITH WEIGHT BELT; HYPERVENTILATED BEFORE DIVE; ATTEMPT TO EXCEED HIS PREVIOUS BEST DEPTH; BARE FEET; LOST STRAP-ON FIN; FAILED TO DITCH WEIGHTS; PROBABLE POST-HYPERVENTILATION BLACKOUT; DROWNING.

CASE BH 99/4

This man was a member of a group of 'senior citizens' from overseas taking a trip with the intention of making a reef walk. However, on their arrival it was decided that the tide was too high for this and they were offered the option of snorkelling as an alternative. They had previously been given advice regarding snorkelling. Six of them decided to snorkel. Like all of the other members of the group, he had

completed a medical questionnaire. In this he stated there were no medical restrictions to his fitness to undertake the trip and noted that he was taking some medication for hypertension.

The snorkel group was taken in a rubber dinghy to a small lagoon about two metres deep, about 150 metres from the vessel. After snorkelling for about 15 minutes they were all called back to the dinghy and it was then noticed that one person, the deceased, was floating face down about 100 metres from the dinghy. The dinghy stopped a short distance away from him as it was returning to the cruise boat, and when its presence evoked no response a crew member jumped into the water and turned him face up. His mask and snorkel were noted to be correctly in position. He was quickly pulled into the dinghy and brought back to the cruise boat where it was decided there would be no purpose in attempting CPR as he was obviously dead.

Autopsy

At the autopsy a scar was noted over and anterior to his left shoulder and that there was some atrophy of the left arm muscles, findings relating to childhood polio. The left ventricular wall was hypertrophied and the mitral valve showed moderate deformity, while there was moderate coronary artery disease. The cause of death was acute myocardial infarction in association with hypertension.

Comment

The fact that he was found in the water between the dinghy and the cruise boat may indicate that he felt unwell and was swimming back to it for this reason. The post-polio atrophy of one arm would not have influenced this outcome.

Summary

APPEARED TO BE HEALTHY; TAKING MEDICATION FOR HYPERTENSION; SNORKELLING IN CALM WATER NEAR OTHERS; MODERATE CORONARY ATHEROMA; ACUTE MYOCARDIAL INFARCTION.

CASE BH 99/5

This man and his wife were staying at an island on the Barrier Reef when they saw a snorkel dive advertised as "being for those with snorkelling experience". Their actual experience was not stated but it was probably rather less than was intended in the notice, as the man had not snorkelled since 1995. He had had an aortic valve replaced in 1997. Since then he had undergone cardiac checks every five months. These had apparently been satisfactory and his wife was unaware of any recent ill health. Although she judged the water conditions to be too rough for them she said nothing as she knew that he would have gone without her if she had refused to go and she believed he would be safer if she came to buddy him. Otherwise, she knew, he would be a solo swimmer in a crowd of other snorkellers.

There were 20 people on the 11-metre dive boat, both snorkel and scuba divers. The snorkel divers had a safety lecture during the trip out to the anchorage at a 'bommie'. The skipper and deckhand remained on board as surface safety cover for the snorkellers, while another staff member accompanied the scuba group. After swimming for a time the wife touched her husband and indicated it was too rough and they should return to the boat. Their normal practice was to swim side by side but after they turned to start their return she lost sight of him because of the waves. She decided it was wiser to continue her return swim alone rather than try to locate him. The skipper observed him lagging behind her as they swam along the reef edge 50–60 metres from the boat as they began their return. They would have the advantage of the wind during their return. He noticed the man stop swimming and shout to his wife, who did not hear him and continued swimming. He therefore signalled to him 'Are you all right?' and received an 'OK' signal in return. The skipper was still not satisfied "as he did not seem comfortable" although showed no signs of distress or of struggling. He ordered the mooring to be cast off and motored to make a close check of his condition. The boat passed close to the victim's wife, although she did not notice it, and when they reached him they found he was now face down and unresponsive.

He was quickly brought aboard and expired air resuscitation commenced after checking his carotid pulse was present. His mask was in position, the snorkel attached but not in his mouth. The recall horn was sounded, a radio call was made for the resort's medical assistance to meet them on their return, and CPR was instituted.

Autopsy

The autopsy showed only minimal atherosclerotic changes in the major vessels, the prosthetic aortic valve in situ, apical adhesions to the right parietal pleura, and a 1 cm bulla on the postero-apical surface of the left lung. Vomit was present in the oesophagus and both lungs. There were also fractured ribs

– parasternal right 2nd and 3rd, left 2nd to 5th, and left mid-clavicular 4th and 5th ribs. These resulted from the very desperate and vigorous resuscitation attempts. Both kidneys showed signs of infection, with pus present on the cut surfaces, and cortical scarring especially of the right kidney. The weight of the heart was 548 gm. Cardiac arrhythmia was given as cause of death.

Comment

Another senior citizen, this time with a mistaken belief that he was fit for anything. Just because ordinary exercise is within a person's effort tolerance it does not mean that harder work can be tolerated without problems. Buddies who are out of sight or who cannot see you are no help in an emergency.

Summary

LAST SNORKELLED IN 1995; AORTIC PROSTHESIS INSERTED 1997; EXCESS BELIEF IN HIS ABILITY TO COPE WITH THE WATER CONDITIONS; SURFACE SEPARATION FROM BUDDY IN ROUGH SEA; RENAL INFECTION; PATENT CORONARY ARTERIES; DEATH PROBABLY DUE TO ACUTE CARDIAC ARRHYTHMIA.

CASE BH 99/6

This man and his wife were members of a group travelling to visit the Barrier Reef. They received a talk on snorkelling and general safety matters translated into their language by their tour guide during their outward trip. This included a requirement to report any medical problems. On arrival at the cay the passengers were transferred to the beach and snorkelling equipment was distributed, with buoyancy vests offered to anyone who wished for one. The victim had brought his own gear as he was concerned about the hygiene of company equipment. However, he was reassured as to this company's practices and used the offered equipment. There was a designated snorkelling area watched over both from the vessel and by a crew member on the beach, who could radio for a replacement if he had to enter the water to assist a swimmer. The sea was calm and the weather fine.

The victim had swimming and snorkelling experience and no significant medical history, so while four passengers were receiving instruction in snorkel use and others waded in the water, he was among the three or four experienced snorkellers who headed off to view the highlights of the safety zone. His wife remained on the beach. He returned to her after a short time to leave his fins as they were annoying him and he usually wore none, then he returned to the water. She later noticed he was stationary, floating face down. She was not initially concerned as she assumed he was taking photos. He was about 20 metres from the beach, not swimming, and then started to float away from the shore. Next there was a shout from some people in another boat who were pointing to a floating body. The shore safety watcher immediately informed the dive boat and then took his tender to give assistance.

First to reach the victim were two people who had swum out from the beach. They rolled him face up and noted that his face was cyanosed and he was unconscious and not breathing. They were towed back to the beach holding onto the tender and there CPR was commenced after removing his false teeth. However, the facial change this created resulted in the pocket mask not sealing properly. They continued CPR, changing places, until the oxygen respirator arrived from the boat. They initially experienced problems from regurgitation of food and water after nearly every breath they gave him. He was transported back to the boat on a stretcher and resuscitation efforts were continued until advised to cease by an emergency doctor by radio from a hospital.

Autopsy

The autopsy showed the heart weighed 529 gms and there was up to 40% narrowing within the left anterior descending coronary artery. The left ventricle was 2.1 cm in thickness. The diagnosis was death due to hypertensive heart disease and coronary heart disease. His only medication was "Xatral" (alfuzosin hydrochloride) for his prostate.

Comment

Again the victim was a senior citizen. Many elderly people live unaware of their hypertension until they see the doctor about something else, such as prostate problems. Many over the age of 65 have difficulty accepting that their effort tolerance is no longer that of a fit 40-year-old.

Summary

APPARENTLY FIT AND ACTIVE MAN ON PROSTATE MEDICATION; SILENT DEATH SNORKELLING IN CALM WATER; UNDIAGNOSED HYPERTENSIVE MYOCARDIAL CHANGES; CARDIAC DEATH.

Scuba Fatalities

CASE SC 99/1

This death occurred during the first open water dive of a basic scuba course. The sea was calm, with only a slight swell and tidal current. The visibility was 5 to 8 metres. The dive boat landed the class on a beach then took some scuba divers to another location. The instructor chose to lead his class of four in a 'V' formation from the beach. The victim was the second student on the instructor's left. The party descended slowly and after 1 to 2 minutes, at about 2.5 to 3 msw, the victim was missing. The instructor immediately brought the three other divers to the surface and told them to look around for bubbles coming to the surface. The dive boat returned at this time and a surface search was made from it and another nearby boat.

The body was found sitting on the sea bed by the instructor during his underwater search, less than 20 metres from the shore, depth two metres, about 25 minutes after his absence was noticed. CPR was unavailing.

During the inquest the victim's sister, who was in the same scuba class, said that both of them had experienced problems with the class work because of language difficulties. They had required the instructor's help to pass the second exam of the course.

A child witness described seeing a distressed diver come to the surface, then rapidly submerge. The witness also mentioned seeing the "whole top part" of the diver's body, that he probably did not have the regulator in his mouth, and that there was a "pretty loud noise like he was taking a very big breath, like gasping" before he went straight back under the water.

Comment

The child witness's statement is very suggestive of cerebral arterial gas embolism (CAGE) but the autopsy report is not yet available (July 2005). Panic induced by losing sight of the other divers may have precipitated a dash for the surface and breath-holding made this dash fatal. Buddies, or instructors, who are out of sight or who cannot see you are no help in an emergency. Unfortunately to lead a dive an instructor needs to be in front and to watch over a group he needs to be behind it. As long as instructors take more than two students with them underwater, separation of the group can occur and separation may lead to incidents and death.

This death occurred during the first open water dive of a basic scuba course; it demonstrates the narrow safety margin between a safe or a fatal course of events.

Summary

LANGUAGE PROBLEM IMPAIRED TRAINING; FIRST OPEN WATER DIVE OF COURSE; ENTRY FROM BEACH; SHALLOW CALM WATER; SCUBA INSTRUCTOR LEADING FOUR STUDENTS; SEPARATION; WITNESS SAW DIVER COME TO SURFACE "LIKE A ROCKET"; CLINICAL VERDICT WAS PROBABLE CAGE.

CASE SC 99/2

This overseas visitor had been trained to dive 21 months earlier. Apparently the course provided only four dives in an indoor pool. She had not dived since then. She signed up at a dive shop for some guided dives under the direction of an instructor who was a compatriot of hers. There was to be a third member of the dive group, another compatriot of similarly limited diving experience (nine dives). She, however, had taken a short 'refresher' dive with the instructor a few days before this dive so was better prepared to make the open water dive. The victim's first open water experience was an uneventful morning dive in a small sheltered bay with good visibility and a variety of marine life. This bay was considered so safe that it was used for training by local dive schools.

The instructor said that he showed the area to them and described the dive plan before they kitted up. He stated he checked that they had correct weights, and assisted the victim to assemble her gear as she had largely forgotten what her course should have taught her. He included instruction on how to inflate the BCD. It is uncertain whether he reminded them of the buddy system or of the rule to ascend to the surface if separation occurred. It is clear that he was treating her like a pupil rather than a certified diver. They moved slowly to enable him to assess their skill levels during the first dive, with a maximum depth of 10 msw.

For the surface swim out from the beach, they were told to partly inflate their BCDs. During their first dive she experienced some problems equalising her ears so before their second dive the instructor made her practise equalising them five times. Their second dive was to be a little longer and deeper than the first. The plan was for him to lead, the other two to follow, but it is thought that the buddy was alongside him and

the victim was behind them. On the first dive she had used less air than her more practised buddy.

Fresh cylinders were used for the second dive. She had no equalising problems on this dive. The instructor pointed out marine life on the reef, looked without success for a Weedy Sea Dragon, then checked their air. The victim still had 130–140 bar but the buddy was down to 100 bar, so the instructor decided to start their return to the beach. He believed that he had signalled his intent but the victim evidently failed to see it and separation occurred, though he claimed they had made eye contact. Visibility was 10 metres but when he looked back "in 30 seconds" she was not in sight. He brought the buddy to the surface and then searched the surface for signs of bubbles but saw none, so dived again to make an underwater search. This proved unsuccessful so he surfaced and brought the buddy back to the beach. He then made a further 30–40 minute underwater search till his air supply was exhausted. It was his hope that she had joined some other divers, but this was not the case.

An intensive search was instituted but was unsuccessful. This was concentrated on the area where the separation had occurred. She was found three days later by local divers who used two underwater scooters and a careful search pattern in an area further from the shore than the original search area. All her equipment was in place and her air cylinder was empty. She was said to be short-sighted but did not wear glasses for everyday activities so this was not considered to be a factor significant in her death.

Comment

What occurred can never be known but it is probable that when the victim found herself alone she panicked and did not think about such basic actions as ascending to the surface or dropping her weight belt, and then drowned when she ran out of air, still focused on trying to find the other two. It was only her second open water dive. As the coroner said, it is one thing to listen to what may have been spoken about in general terms 21 months before, but quite another to know what to do when panic comes after finding oneself alone underwater. Indeed, the instructor himself stated about his compatriots, "they are more used to being guided underwater rather than diving by themselves". Unfortunately he did not let this acute observation govern his actions in the management of these two divers. Overseas-trained divers have not necessarily been trained in, let alone have experienced, diving conditions similar to those they find in Australia, but this may not be taken into account when they present a certificate of training. Such was the situation here.

Summary

OVERSEAS TRAINED; SECOND OPEN WATER DIVE; TRIO GROUP LED BY INSTRUCTOR; SEPARATION; CALM WATER; FAILED TO DITCH WEIGHTS OR INFLATE BCD OR ASCEND TO SURFACE; MILD SHORT-SIGHTEDNESS; CULTURAL FACTORS SIGNIFICANT; DROWNED.

CASE SC 99/3

The victim and her husband had dived for many years in a range of locations. However, because they had not dived for about four years before this incident they took a refresher dive before coming to the resort island. Although she suffered some mild seasickness on the trip out to the island this had resolved by the next day when they joined 18 others for a guided dive. The instructor gave them a talk on the trip to the mooring. Here the four photographers in the group chose to dive independently while the remaining 14 divers continued with the instructor, who was acting as a divemaster.

This couple were aware they were likely to have ear equalisation problems so they spoke to the instructor and they were among the first to enter the water and descend. On the seabed, 10 to 15 metres down, they adjusted their buoyancy and joined the group around the instructor. After a short time the husband found he was experiencing a problem with water in his mask and turned away from his wife while clearing it. When he turned back he was unable to see her but presumed she was among the other divers. When the instructor next checked the group he noticed that one diver was missing and followed protocol by looking around for about two minutes, then rounded up the group and brought them slowly up the mooring line, making a safety stop for three minutes at five msw. Earlier in the dive one buddy pair had left the group after notifying him. When they reached the surface he saw another dive boat was now alongside his dive boat. When he came aboard he saw that CPR was being given to a diver. During the dive he had kept all of the group within about 10 metres of himself, visibility being about 15 metres.

The skipper of the other dive boat reported how they had seen a diver at the surface close to the reef edge, who had descended again. They later saw the deceased come to the surface gently, apparently face up. There was no movement and their first impression

was that this was a turtle. There was no response to an 'Are you OK' signal so the decision was taken to go and investigate. She was about 40 metres off the reef edge, unresponsive, mask on, regulator floating free, with blue lips and dilated pupils, and her eyes looking cloudy or foggy. Her BCD had a little air in it but was not full. The weight belt was in place and one fin was off. CPR was commenced as soon as her backpack was taken off. Oxygen was given and a radio call made to alert the resort nurse. A trauma physician who was staying at the resort assisted the resuscitation efforts. Radio contact was made with a mainland medical emergency service before CPR was discontinued. A check of the contents gauge showed 120 bar pressure remained – the initial pressure had been 200–210 bar.

Autopsy

A CT scan was performed of the head, neck, chest and abdomen before the autopsy was commenced. This showed extensive intra-arterial gas throughout the cranium, neck, thorax, abdomen and pelvis. Pockets of gas were seen anteriorly within the chambers of the heart but there is no description of which chambers were involved. There was a moderate-sized left pneumothorax, and there was some calcification in the right lobe of the liver that may indicate a history of previous granuloma. The coronary vessels were widely patent and showed only mild atheroma, while histology of the lung showed alveolar spaces apparently distended, with occasional alveolar haemorrhage. Some alveolar spaces contained a small amount of gastric contents. Also mild nephrosclerosis and nephrocalcinosis were noted.

Her health history was of a mild, non-medicated hypertension, hormone replacement therapy, and vitamins. She had an annual health check and, like her husband, took regular exercise. The equipment check, which did not record the weight of the belt, revealed no significant faults. The regulator mouthpiece had excessive perishing and a hole, but there was no water entry when it was tested. The air contained no contamination. There was a comment that the equipment required some maintenance but was functional. She was wearing a prescription mask.

Comment

It is difficult to imagine a reason for this experienced, though 'rusty', diver to leave her buddy without warning, particularly as there were others close by, the visibility was good, water calm, she had plenty of air remaining, and her equipment was working correctly. No reason for her to have been 'spooked' has been identified, and even had she experienced a spray of water through the regulator this should not have caused her to panic. The skipper's report suggests she did not surface violently, and the BCD was apparently only partially inflated, which suggests she made a swimming ascent but omitted to breath regularly, or exhale adequately, during her ascent. The severity of the pulmonary barotraumas and of the CAGE was remarkable. The missing fin probably came off during her recovery. Once again, separation was the first step on the path to disaster.

Summary

TRAINED, EXPERIENCED DIVER; NO DIVES FOR FOUR YEARS; RECENT REFRESHER DIVE; WELL-ORGANISED DIVE; GOOD WATER CONDITIONS; UNEXPLAINED SUDDEN SEPARATION FROM BUDDY; SOME AIR IN BCD; PRESCRIPTION MASK; SOME HYPERTENSION; MASSIVE CAGE.

CASE SC 99/4

Although this incident occurred outside Australian territorial waters it is included as the victim was evacuated by air and died in Australia, so was investigated on behalf of the local coroner. He was an experienced diver who was making his 23rd annual live-aboard trip with friends of long standing. He and his buddy were at an unstated depth when they were enveloped in material from either an underwater avalanche or the collapse of the rock shelf above them. They apparently made an ascent together until about three metres from the surface, at which time the victim reportedly removed his mask and made a rapid ascent to the surface. He was unconscious when reached. CPR was quickly initiated aboard the yacht and this was continued until he was evacuated by air to Australia for specialist treatment. He died in hospital from a cardiac arrest.

Autopsy

The autopsy showed minimal atherosclerosis in his heart. He had had a left-sided thoracotomy some years before for a "non-malignant condition" and a few pleural adhesions were noted. Inflation of the lungs was performed and an air leak was demonstrated into the pulmonary circulation from the posterior aspect of the left lung. This led to the pathologist's diagnosis of CAGE, which was supported by the typical history of a CAGE diving incident, though the period of treatment since the accident had removed the possibility of gross intravascular air being found.

Comment

Unfortunately there is no record of any examination of his equipment being performed, so there are no details as to whether he had adequate remaining air, inflated his BCD, dropped his weight belt, or was using his regulator during the final stage of his ascent.

The diver fitted the definition of a senior citizen in the State of Victoria, being over 60 years old. There was no evidence that he had been diving since his last annual diving holiday. Being involved in a rock fall could well have overwhelmed his years of experience.

Summary

EXPERIENCED DIVER; ENGULFED BY UNDERWATER AVALANCHE; ASCENT WITH BUDDY; SEPARATION; RAPID MASK-OFF ASCENT LAST THREE METRES; UNCONSCIOUS AT SURFACE; DIED IN HOSPITAL AFTER AIR EVACUATION; CAGE; TERMINAL ACUTE CARDIAC FAILURE.

CASE SC 99/5

The victim was an overseas visitor of limited experience who joined a three-day live-aboard trip to dive on the Barrier Reef. He had been trained two years previously. The boat carried a group of dive pupils with their two instructors, and another diver who had an Advanced Diver certificate. This man's experience was about 30 dives greater than the victim's. One of the instructors got them to fill out a form to detail their dive experience, and a liability-release form, then issued them their equipment. This instructor also gave them a talk covering good diving practices. Although the company manual stated that all divers should be taken on an assessment dive before they were allowed to dive unaccompanied by an instructor, this was not thought necessary as he had recently made a dive with the company and performed in a correct manner.

Their first dive was rapidly aborted when the victim's personal mask leaked due to separation of the face plate. An instructor assisted their return. Following the return of the trainee divers the boat was driven to another area close to a reef wall and the skipper took the two trained divers in the outboard tender to a place where they could descend and drift back to the dive boat along the wall. The skipper noticed that the victim was having great difficulty in descending headfirst, so advised him to descend upright and hold the deflator hose above his head. He appeared to be normal in his demeanour and followed the advice successfully. The skipper told them he would remain and drift around as their surface supervisor. The visibility was good, 20 metres or so, and he remained still and watched their bubbles ascending. Then he noticed there were a lot more bubbles, rather like shaken soda water, and the victim shot up through the surface right to his waist. His mask was off his face and he made a sound like a shout, then flopped face down in the water. He was only about 10 metres from the tender so was rapidly reached and taken aboard. The buddy surfaced very soon afterwards.

The buddy first met the victim on the dive boat when the equipment was being handed out. He thought the victim appeared to be anxious about his mask, taking a second one as a spare. They were briefed by one of the diving instructors to follow behind the students for their first dive of the trip and reminded of the good diving practices they should follow. He thought the victim was still anxious as they started their first dive, as shown by his quick movements, heavy breathing, and difficulty at the surface until the instructor ascended and took him back to the dive tender because of the separation of the mask's skirt from the face-plate frame. The buddy joined the instructor and continued with the dive.

After this dive, the boat was moved to another location and the next dive was arranged after checking that a sufficient surface interval had elapsed. The buddy was surprised that when he suggested they prepare for this dive the victim asked for time to have a few minutes' sleep, which he took to indicate nervousness, a need to collect himself. After they had checked each other's equipment they got into the tender with the skipper. The victim was slow to descend but did so after advice from the skipper of making a feet-first descent. The buddy kept a close watch on him as they descended and they exchanged frequent OK signals. They descended quickly to 18 msw then gradually swam back up to 14 msw, their planned dive depth. The victim showed his inexperience by jerky movements "like a diver in training". They swam along the reef wall for a few minutes, the buddy keeping him in constant view, though unable to establish eye contact. The victim continued to give the impression to his buddy that he was anxious, then he suddenly began to swim horizontally away from his buddy very fast. There was no apparent reason for his action. His buddy followed, assuming that he would look round and accept a 'slow down' signal. Suddenly he became vertical, began to fiddle with his mask, his rapid movements indicating extreme anxiety and his breathing rapid and heavy. He then started kicking hard towards the surface holding his mask. The buddy was able to watch his ascent, which was faster than his bubbles, and his recovery by the skipper. He was

not able to see whether he breathed out during his ascent but saw him go limp before he reached the surface. He then made his own ascent. Frothy blood was coming from the victim's mouth, his eyes were open, and "he looked bad".

Once back on the dive boat, CPR was commenced. CAGE was diagnosed and a radio call for assistance was made. Instructions were received to go to a helicopter pontoon 13 miles away, which they did at maximum speed, and from there he was taken to a hospital that had a recompression chamber. At the hospital, bilateral intercostal catheters were inserted and a chest X-ray showed gas in the mediastinal, pericardial, and subcutaneous tissues across his chest. CT scan of his brain showed gross oedema and presence of some cerebral perfusion. Hyperbaric treatment to 18 metres with 100% oxygen proved unavailing and he remained deeply unconscious. He developed high-output renal failure, a suspected centrally mediated diabetes insipidus, and other metabolic derangements. Brain death was confirmed by two independent specialists the next day.

Autopsy

At autopsy pin-point air leaks were noted on inflation of the lungs and multiple scattered air blebs were present over the surfaces of both lungs. The diagnosis of CAGE was confirmed. Examination of the equipment showed it functioned adequately in a static situation and met the manufacturers' performance specifications. However, the regulator was noted to be in poor mechanical condition from lack of regular maintenance, and unhygienic due to the lack of, or poor, cleaning. It was not tested to establish how it would satisfy the demands of a panicking diver. The mask had some splits and holes in the skirt that allowed ingress of a small amount of water initially but more when the mask was moved or pressure was reduced by the wearer inhaling from it. Although the remaining air was not recorded there is every reason to believe the tank contained more than sufficient air had the victim remained still and regained his composure.

Comments

While the matter is not noted, it is probable the BCD was not inflated. Water inflow into the mask may have exacerbated the victim's anxiety level during the dive. Once panic occurs the diver is at extreme risk of dying even though well supplied with air and close to his buddy. Such was the case here.

Summary

TRAINED BUT INEXPERIENCED; LACKED CONFIDENCE; PROBABLE MASK PROBLEM WITH WATER ENTRY; POSSIBLY INADEQUATE AIR SUPPLY FOR A PANIC BREATHING SITUATION; PANIC ASCENT; FAILED TO DROP WEIGHT BELT; CLASSIC CAGE SYMPTOMS; BUDDY ACTIONS COMMENDABLE.

DISCUSSION

The rationale for the existence of the medical sub-specialty of diving medicine is to reduce to a minimum morbidity and mortality among those who 'dive' or enter an environment of significantly changed ambient pressure or breathing medium. The basis of advice is theory soundly based on case studies and experiments. In the case of diving-related fatalities, the most complete and comprehensive body of information is the investigations into such fatalities made on behalf of coroners. This is particularly so in Australia where such data are available far more readily than in other countries. Such form the basis of this and previous reports.[1,2] However, one of the difficulties in properly assessing diving-related deaths is the time it takes to obtain all the various reports.

Examination of the data from cases in which a snorkel was being used confirms yet again the findings of previous reports that show clearly that hyperventilation to increase depth and duration of a dive can be fatal (BH 99/3). This is a lesson that appears to require successive generations of divers to learn anew. Case BH 99/1 is a reminder that a person inexperienced in the use of a snorkel can drown in water so shallow that they would have saved themselves by placing their feet on the sea bed and standing up. It possibly demonstrates the fatal 'tunnel vision' effect on the thought processes of a person faced with an unexpected problem while in the process of concentrating on trying to perform a new skill.

Four of the dead snorkellers were over 65 years old. Health problems are more frequent in older people. In the four senior citizens, a cardiac factor was the most probable critical factor. None of these persons regarded themselves as being unhealthy, and it is unlikely a routine medical check would have raised warnings of their risk of death. It may be necessary to regard such deaths as an unavoidable fact of life, though asking about health histories is

certainly appropriate and of potential value. However, determination to snorkel or scuba dive has long been known to lead to suppression of the answers that would bar the person from such activities.

There are significant lessons to be learnt from the cases reviewed here for those who organise scuba dives involving inexperienced divers from overseas, or who teach persons in other than their first language. There is also the confirmation of the fact that an instructor leading others cannot perfectly monitor them constantly. This is sadly demonstrated in cases SC 99/1 and SC 99/2. It is of particular importance to be aware of the different expectations vested in the dive leader by some overseas cultures. Instructors have great responsibilities and it is difficult for them to adequately cover every eventuality, particularly where a dependent diver fails to follow reasonably expected responses to becoming separated. Perhaps it is time to encourage groups to have two safety divers, one the dive leader and the other the rearguard. Self-interest should ensure all those involved with inexperienced scuba divers are aware that proof of training is no guarantee of a diver's competence in an open water environment.

Conclusions

Once again, the 1999 fatalities in Australia highlight both the avoidable risks of snorkelling and the risks to elderly, apparently fit, people in the age group where sudden death is an unavoidable reality. The efforts made by watchers and others to resuscitate the victims are commendable.

Four of the scuba divers died from CAGE. Only one of these was an inexperienced diver. One diver, in a class doing its first sea dive, died with an empty tank after losing the group.

A constant problem for dive-group leaders is having to both lead a group and simultaneously closely watch over its members. Leading requires being in front and watching over a group requires being behind it.

When welcoming visitors to the Great Barrier Reef there is the problem of adequately imparting vital safety information to those for whom English is not their first language. Some of the scuba divers have little, if any, experience and may expect to be nannied by their dive leaders. When planning dives these facts should be considered in order to increase the safety of those involved.

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2000: Australian Diving-Related Fatalities

Overview

A total of 16 fatalities were identified from official sources as having occurred during 2000. Nine deaths were in association with freediving or snorkelling and five with scuba. There was also one death where surface-supply air was involved, and one where the equipment used was not clearly identified. The investigation of many of the first group did not, in fact, proceed to a coroner's inquest but the investigation documentation is available. The case summaries are presented with attention to the diver performance, equipment and medical factors. Important adverse factors are identified and discussed for each of these groups, with comments on possibilities for reducing the number of fatalities that occur. Many of the factors involved in these tragedies have recurred time and time again in the case histories reported over many years from Project Stickybeak.

Introduction

Project Stickybeak is an ongoing investigation into Australian deaths associated with freediving, snorkelling and diving using scuba or surface-supply equipment, and has been running since 1972.[1–3] The case histories of 16 deaths associated with freediving, snorkelling, scuba and hookah diving in the year 2000 are reported here and summarised in Table 1.

The National Coroners Information System (NCIS) was searched and details of identified cases made available for this investigation by the State Coroners and NCIS. Not all deaths associated with snorkelling are notified to coroners for investigation by the Police. Therefore, several additional sources of information needed to be interrogated, including the media. Fortunately the Queensland Workplace Health and Safety (diving) department provides information on such events in the Great Barrier Reef area even when they do not fall within its area of responsibility. A few cases are known only through notification by the Police, private investigators, the Divers Alert Network Asia-Pacific (DAN AP), or through the media.

The basic purpose of coroners' enquiries is to determine who died and why, and to make comment on the lessons to be drawn from such tragedies. Access to the information resulting from police investigations on behalf of the local coroner is an essential element of investigations such as Project Stickybeak. This documentation often contains the only reliable information, as police 'incident' investigations now elicit most of the details needed to understand the factors involved in diving-related deaths. Despite this, data are frequently missing and autopsy reports are not always as detailed as would be expected. The evidence often contains a range of estimates on depths, distances, and the experience of those involved, while the available health history of the deceased is usually minimal at best. However, Australia is fortunate in having this official support for diving fatalities research. Therefore, Project Stickybeak reports inevitably contain an element of bias in determining the most likely course of events in an accident where the documentary data reflect variation in witness recall.

CASE REPORTS

Breath-hold and Snorkel Using Swimmers

CASE BH 00/1

This 80-year-old lady, described as mentally alert and active despite some pain from past right hip and bilateral knee replacements, was with a group of retirees from overseas. She had met none of them previously. They were on a day trip to view the Barrier Reef and received the regular talk on snorkelling during the trip out to their destination, a pontoon at a reef. She wore a buoyancy vest for her first snorkel swim but, after making a trip in the glass-bottomed boat, did not wear one for her second swim. Although there were sometimes up to 200 people in the water under the watch of a crew member in a high chair, at this time there were only about 20 in the water. Her absence was not noticed till a count was taken before the boat left the pontoon. A determined search did not find her body. There is no information concerning her past health or whether she had ever previously used a snorkel, but she was said to have been a good swimmer. The safety watcher had not observed any unusual behaviour in any of those in the water and it is unknown whether she silently sank or drifted away. The cause of death is unknown.

Summary

ELDERLY; APPARENTLY FIT; HISTORY PAIN FOLLOWING BILATERAL KNEE REPLACEMENTS AND RIGHT HIP REPLACEMENT; SNORKELLING; NO BUOYANCY VEST; SILENT DEATH IN WATCHED, CALM SEA; BODY NEVER RECOVERED.

CASE BH 00/2

This 79-year-old man was also an overseas visitor making a day trip to the Barrier Reef. He appeared to be fit and after the instruction talk on snorkelling he did not declare any medical conditions. There was no indication that anything was wrong till the safety lookout saw a group of three snorkellers waving to catch his attention. When he reached them he found two were supporting the third, who was now unconscious. Attempts to resuscitate him were unsuccessful.

Autopsy

The autopsy showed an acute myocardial infarction.

Summary

APPARENTLY FIT; SNORKELLING IN CALM SEA NEAR OTHERS; SUDDEN DEATH; ACUTE MYOCARDIAL INFARCTION.

CASE BH 00/3

This 30-year-old man had been spearfishing for 15 years and was known to be capable of diving to a depth of 30 metres' sea water (msw). He was with a friend but they were about 60 metres apart to avoid interfering with each other's hunting. The buddy became cold and left the water after a time to sit on the beach. Although he could not see his friend this did not worry him, as the latter was wearing a black wetsuit and his float was black. It was only after about three hours that he became concerned and persuaded a man to take him out in a boat to search, which was not successful so the police were notified. The float was found but the line could not be pulled up as it was entangled in the kelp. It was now getting dark so it was not until the next day that the police divers could search for the body. The spear gun was recovered but the spear was not found. The body was never recovered.

Comment

This is a typical scenario for a post-hyperventilation ascent hypoxia drowning. There was a history of him having survived such an episode in the past, being fortunate to regain consciousness on the surface on that occasion.

Summary

BREATH-HOLD, EXPERIENCED SPEAR FISHERMAN; SOLO; PROBABLE POST-HYPERVENTILATION ASCENT HYPOXIA; BODY NEVER RECOVERED.

CASE BH 00/4

This 31-year-old man had no admitted ill health and, like his friend, was an overseas visitor. While the friend was an experienced breath-hold spear fisherman, he himself was described as 'not confident enough to [scuba] dive'. Indeed, his friend checked his ability to swim using a snorkel for about two hours before feeling satisfied it was safe to leave him and go ashore for a shower. When he returned an hour later he could not see his friend, then he was alerted to a dive boat which had found him floating unconscious. The victim failed to respond to resuscitation efforts.

Autopsy

The autopsy revealed the presence of significant coronary atheroma with vessel narrowing, the left anterior descending showing 80% narrowing at one place, which may have been a significant factor leading to his drowning. There was no evidence of a myocardial infarction.

Summary

INEXPERIENCED SNORKELLER; APPARENTLY FIT; SOLO; CALM SEA; SILENT DEATH; SIGNIFICANT CORONARY ATHEROMA; PROBABLE CARDIAC DEATH.

CASE BH 00/5

A 75-year-old woman and her husband were amongst the passengers on a day trip to view the Barrier Reef. There was a talk on safe snorkelling during the outward trip and there was a request for anyone with a health problem to discuss the matter with a crew member. Neither reported a health problem and the available records fail to provide any details. On arrival at the cay there was a further briefing and instruction in

Table 1. Summary of diving-related fatalities

(BH – breath-hold, BSB – buddy separation before incident, GNS – group not separated,

CASE	AGE	TRAINING	EXPERIENCE	Dive GROUP	DIVE PURPOSE	DEPTH (METRES) DIVE	DEPTH (METRES) INCIDENT	WEIGHT BELT ON	WEIGHT BELT KG
BH 00/1	80	Nil	Some	Solo	Recreation	Not stated	Surface	None	n/a
BH 00/2	79	Not stated	Not stated	GNS	Recreation	Not stated	Surface	None	n/a
BH 00/3	30	Not stated	Experienced +	BSB	Spearfishing	25	Ascent	On	6
BH 00/4	31	Nil	Some	BSB	Recreation	9	Surface	None	n/a
BH 00/5	75	Not stated	Not stated	GSB	Recreation	Not stated	Surface	None	n/a
BH 00/6	27	Nil	Not stated	Solo	Recreation	Not stated	Surface	None	n/a
BH 00/7	60	Not stated	Not stated	GNS	Recreation	Not stated	Surface	None	n/a
BH 00/8	28	Not stated	Not stated	GSB	Recreation	Not stated	Surface	None	n/a
BH 00/9	55	Not stated	Not stated	Solo	Recreation	Not stated	Surface	None	n/a
SC 00/1	24	Trained	Nil	BSB	Recreation	21	17	Ditched by buddy	7
SC 00/2	30	Trained	Experienced	BSB	Cray fishing	20	Not stated	Not stated	?
SC 00/3	27	Trained	Experienced	Solo	Work	9	9	On	6
SC 00/4	30	Trained	Experienced	GNS	Recreation	54	54	Ditched by buddy	?
SC 00/5	29	Trained	Experienced	BSB	Recreation	10	10	On	10
H 00/1	20	Scuba	Experienced	Solo	Work	9	12	On	?
X 00/1	31	Scuba	Nil	Sepn	Work	Not stated	Not stated	On	Not stated

snorkelling offered, but it is not known whether this couple accepted this instruction. There were two safety lookouts watching over the 40 persons in the water off the beach, one on the boat and the other on the beach. When the latter decided to take the small tender out to assist some swimmers he first arranged for another to replace him on the beach. The water was calm but there was some current. He noticed one person, who was wearing a buoyancy vest, drifting face down among the other swimmers and snorkellers and went to investigate. The unconscious woman was quickly brought to shore but could not be resuscitated. It was suggested that she may have been floating unconscious for 15 minutes before this was noticed.

Autopsy

Unfortunately no autopsy report is available. However, the pathologist decided this was a case of drowning but offered no reason for it to have occurred in calm water in a person wearing a buoyancy vest and close to others, so it is not possible to evaluate whether there was a cardiac cause for her death.

Summary

SNORKELLING; NO HEALTH HISTORY; POSSIBLY NIL SNORKEL EXPERIENCE; WEARING BUOYANCY VEST; SILENT DEATH CLOSE TO OTHERS IN CALM

In Australian Waters in 2000

GSB – Group Separation Before Incident, H – hookah, SC – scuba, ? – unknown)

BOUYANCY VEST	REMAINING AIR	EQUIPMENT TESTED	EQUIPMENT WHOSE	COMMENTS
Off	n/a	n/a	Dive boat	Possible cardiac death. Body never recovered.
Nil	n/a	n/a	Dive boat	Cardiac death.
Nil	n/a	n/a	Own	Probable post-hyperventilation blackout. Body never recovered.
Nil	n/a	n/a	Hired	Cardiac death.
On	n/a	n/a	Dive boat	Drowned. Possible cardiac death.
Nil	n/a	n/a	Hired	Drowned.
Nil	n/a	n/a	Dive boat	Acute heart failure.
Off	n/a	n/a	Dive boat	Drowned. Epilepsy.
Nil	n/a	n/a	Not stated	Drowned. Possible cardiac death.
Not stated	Nil	Fault	Dive shop	Drowned. Inexperienced. Fatigue. Cold. Buddy breathing failed. Out of air.
Not stated	Not stated	Fault	Own	Body never recovered.
Nil	Not stated	Nil to test	Employer	Drowned. Commercial diver. No wetsuit. No lifeline. Fatigue. Body never recovered.
Not stated	++	NAD	Borrowed twin set	Cerebral arterial gas embolism (CAGE).
Not stated	+	NAD	Hired	Drowned. Aborted dive as “felt uncomfortable”. Health?
Nil	n/a	Fault	Employer	Drowned. Wave swamped boat. Regulator separated from hose.
Not stated	n/a	Fault	Employer	Possible seizure condition.

SEA; GOOD LOOKOUTS SAW NO DISTURBANCE TO SUGGEST ANYONE IN TROUBLE; NO AUTOPSY REPORT BUT REPORTED AS DROWNING; POSSIBLE CARDIAC DEATH.

CASE BH 00/6

This 27-year-old man was a member of an overseas group of employees visiting Australia. The record is very limited concerning the lead-up to this fatality beyond the statement that he was snorkelling off a beach when he cried out for assistance. He was apparently alone at the time. His cry was heard by a witness who was mooring an empty dive tender 30 to 50 metres from him. She saw someone waving their arms and initially thought it was to people on the beach, then realised he might be in trouble and alerted the lifeguard on the beach. Each then swam out to him to give assistance. As he was swimming out, the lifeguard observed the person appear to have a convulsion and his body come half out of the water. When reached, the person was unconscious, cyanosed, and floating face down. They placed him on a surf ski and brought him back to the beach. He failed to respond to resuscitation.

Autopsy

At autopsy, his heart and coronaries were healthy, and the cause of death was given as drowning. The pathologist offered no comment concerning the cause of the 'convulsion'.

Comment

There is a total absence of any information concerning his swimming and snorkelling experience or where the other members of his group were at this time. The sea conditions were described as far from inviting as it was raining, overcast, windy, with a 0.8 metre swell, so his decision to enter the water alone is strange.

Summary

SNORKELLING; UNKNOWN HEALTH AND SNORKEL HISTORY; SOLO; ADVERSE SEA CONDITIONS; SUDDEN CRY FOR HELP; CONVULSION THEN UNCONSCIOUS; DROWNED.

CASE BH 00/7

While visiting a Great Barrier Reef island with her daughter, this 60-year-old lady joined a snorkelling trip to a reef pontoon. There was no history of ill health according to her daughter and she appeared to be behaving in a normal manner till she stood up on some coral and said she was feeling short of breath. She was noticed to have lost most of her normal colour so those nearby called the glass-bottomed boat to collect her. Arrangements were made to transport her by a float plane to the nearby resort island but during transfer she stopped breathing and expired-air breathing was started. Circulatory arrest ensued and cardio-pulmonary resuscitation was commenced, but she failed to respond. There is an alternative report of the incident which describes the onset of her symptoms being as she rested on the pontoon after her swim.

Autopsy

The autopsy showed there was 60% narrowing of the left anterior descending coronary artery but no evidence of thrombus. There was histological evidence suggestive of chronic myocardial ischaemia. There was marked thickening of both cusps of the mitral valve with ballooning of the anterior cusp. The lungs were moderately congested and oedematous.

Comment

This being regarded as a 'death from natural causes' there was no coronial involvement, and no further investigation took place. Death appears to have been due to acute cardiac failure. It is possible that immersion pulmonary oedema was a factor, initiating the fatal conclusion, but this was not recorded as having been considered.

Summary

SNORKELLING; APPARENTLY HEALTHY WOMAN; ONSET BREATHLESSNESS LEADING TO CARDIAC ARREST; ACUTE CARDIAC FAILURE; CORONARY ATHEROMA AND MYOCARDIAL ISCHAEMIA.

CASE BH 00/8

This 28-year-old man had a history of epilepsy, which he claimed was well controlled by his medication. He had declared this condition when booking his 'adventure holiday' trip. He was in a group which had gone white-water rafting, mountain biking, and backpacking before commencing this 'scuba and snorkel' trip to visit the Great Barrier Reef. They were on a motor schooner and received the regular safety talks. The diving instructor on the boat refused his request to undertake a 'resort dive' but found nothing in the rules which required him to be prohibited from snorkelling. He claimed to have made a number of scuba dives previously, but this did not dissuade the instructor from his decision concerning the 'resort dive'. He was not wearing a buoyancy vest, a decision permitted because it would have prevented him from leaving the surface. Although all had been told to dive or swim with a buddy he had separated from his. He had been in a group of others but none had noticed any disturbance, though one noticed his stillness 'but was reassured when he saw him start kicking'. There was a safety watch of those swimming near the boat and when he was first noticed to be too still in the water it was thought he was taking underwater photographs. Then he was seen to be drifting with his arms and legs hanging down. The instructor quickly entered the water to check the situation and the skipper brought the safety tender. They found he was unconscious, face down, with his snorkel still in his mouth. It was difficult to get him into the tender as he was described as 'a large man' and it was necessary for them to use a harness to pull him into the tender. Resuscitation attempts were unsuccessful.

Autopsy

The autopsy showed drowning in a healthy person, assumed to be as a result of an epileptic episode.

Comment

Wearing a buoyancy vest would not have prevented him from drowning as it would have floated him face down. The safety watchers cannot be faulted as there was no disturbance apparent to draw attention to him. Although his full medical history is not known there was a holiday history of recent strenuous physical exertion without problems so his acceptance as a snorkeller can be defended.

Summary

SNORKELLING; EPILEPTIC WELL CONTROLLED ON MEDICATIONS; KNOWN GOOD EXERCISE TOLERANCE; SILENT DROWNING AMONG OTHERS DESPITE GOOD SAFETY WATCHERS; PROBABLE EPILEPTIC FIT.

CASE BH 00/9

This 55-year-old man had an unfortunate family medical history, his father and brother having both died from heart disease. He had recently been started on anticoagulants for his hypertension but he appeared to be healthy. No details are available about his experience or ability as a swimmer or snorkeller. His family were sitting on the beach watching him snorkel round a wreck and occasionally waving to them. Then they noticed he was floating without moving and became alarmed. His son paddled out on an inflatable raft but was unable to drag him onto it. The police were notified and the rescue helicopter arrived about 35 minutes later and dropped a diver who brought him back to the beach. Resuscitation efforts were unsuccessful. His mask was up on his forehead when he was reached.

Autopsy

The autopsy showed mild atheroma in the right coronary artery but 70–80% narrowing in the left, with patchy myocardial fibrosis lesions. However, there was no evidence of acute myocardial infarction so his death was attributed to drowning, although possibly from an initial cardiac factor.

Comment

The fact that his mask was on his forehead when first found is a possible marker for a panic reaction or awareness that he was in some kind of trouble.

Summary

SNORKELLING; SOLO; SUDDEN SILENT DEATH; SIGNIFICANT CORONARY ARTERY NARROWING; DROWNING; POSSIBLE CARDIAC FACTOR.

Scuba Fatalities

CASE SC 00/1

It is particularly tragic and ironic that this 24-year-old woman was making an escorted dive intended to help her improve her confidence and ability, a present from her boyfriend. She had trained overseas in warm waters and made two subsequent dives, during one of which she had experienced problems. The dive leader was a divemaster and was aware of her inexperience. Her assigned buddy was a slightly more experienced diver, a person who had taken an advanced diver course. The dive shop supplied all their equipment and they were told about the proposed dive, water entry to be from a rock ledge followed by a snorkel out with inflated BCDs before descending. The area was described as being shallow and protected. This would be her first 'rock entry' dive. The weight on the belt was an estimate made in the shop and no buoyancy check was made. They were told to indicate when their contents gauge reading fell to 100 bar pressure.

There were nine customers with a divemaster as dive leader, and a trainee divemaster as support. The dive leader, who was buddying a diver known to be liable to stray, was in the lead and the others followed in buddy pairs in line behind him, with the trainee divemaster acting as a back marker. The water was described as rough at the entry point, visibility 'not good', and cold. A police witness later said he believed the water conditions were too rough for snorkel swimming. There was a current against them during their outward underwater swim and this, in combination with her inexperience, led her to use her air faster than her buddy and most of the other divers. The dive leader split the group when she showed him that her remaining air was down to 100 bar. She and one other were to return to shore with the 'back marker', then her buddy decided it was the

correct thing for him to remain with her although still having about 160 bar. They were slowly ascending on their return swim and were at about 12–13 msw when her 'low air' situation became acute. Her buddy offered his 'octopus' regulator to her and they began to buddy breathe, sinking down to the sea bed at 21 msw as they did so.

After a short time the buddy's contents gauge bleeped, warning of a critically low state. They were holding onto each other while he was attempting to drop her weight belt when his contents gauge bleeped a warning he was about to run out of air. He dropped his own weights and started a low air/out-of-air ascent, the two becoming separated at this time. His ascent technique was fortunately successful and he suffered no serious ill effects, though required treatment for salt-water aspiration. His friend failed to surface and her body was not found for three days. The weight belt was off when she was found. It is apparent that he had managed to ditch her weight belt, but her wetsuit was older than the one he was wearing and provided less buoyancy so she remained on the sea bed. The reason he had not recognised his seriously low air situation was because his gauge was reading 25 bar too high, a fact only discovered later.

Autopsy

The cause of death was given as drowning. It should be noted that the body was not recovered for three days.

Summary

SCUBA DIVING; TRAINED; INEXPERIENCED; CURRENT AND ROUGH WATER AFFECTED RATE OF AIR USE; OLDER WETSUIT LESS BUOYANT, NO BUOYANCY CHECK BY DIVE SHOP; LOW-AIR STATE THEN OUT OF AIR SO BUDDY BREATHING; SEPARATION WHEN BUDDY OUT OF AIR; BUDDY'S CONTENTS GAUGE INACCURATE.

CASE SC 00/2

Both this 30-year-old man and his brother were trained and experienced scuba divers, and on this occasion were diving for crayfish off a small island. The sea was calm, there was some tide flow, and the visibility was poor, only two metres. They anchored in 20-metre deep water and started hunting separately in the rock crevices. These were filled with kelp. After about half an hour of separation the buddy began to worry about his brother's failure to return to their boat and made a search for him. Both this and all subsequent searches were unsuccessful and his body was never found, so the reasons for his death are unknown.

Summary

SCUBA DIVING; EXPERIENCED DIVER; DIVING IN KELP FOR CRAYFISH; BUDDY SEPARATION; BODY NEVER FOUND.

CASE SC 00/3

This 27-year-old professional diver was employed to lead a three-man team tasked with repositioning cyclone moorings. Due to the limited baggage capacity of the plane in which they travelled to join the base ship of this deployment, they were unable to take their wetsuits or other diving equipment except for the Kirby Morgan unit owned by this diver. When they arrived they found that the company's Kirby Morgan unit had been damaged because of poor care and his set was to be used. There were no wetsuits so they were to wear overalls while diving, the voice communication equipment did not work, and they were limited to one surface-supplied breathing apparatus (SSBA) and only one scuba set as only a reserve compressor was operating at the time. No head protection was available as would have been required for the proposed tasks. Their job was to unshackle the anchor chain from the anchor shanks and attach a lifting cable. It was necessary to uncover the chain from the bottom material and the job was undertaken with each of his two fellow divers in turn singly, using first SSBA then scuba. The victim was using scuba on the fatal dive. The sea had become rough and they had to dive from a dinghy. The line tender became alarmed when he saw the line start to drift away, then he found it had become detached from the diver. After a delay, due to having to return to the support tug to get the SSBA, a search was made. This was supplemented by a surface search for bubbles, but neither the diver nor his equipment was ever located.

Comment

The reason for this accident is unknown but before his final descent he was noticed to be breathless and showing signs of tiredness. The work depth was insufficient to implicate narcosis but fatigue and possibly hypothermia may have affected his behaviour. Lack of proper equipment for the job was clearly a contributing factor – no wetsuit, unattached lifeline, no buoyancy aid, no protective helmet, no voice communication to the surface, no retention strap on his regulator. All these matters were required to

comply with commercial diving regulations. Witnesses considered him unfit before final dive descent. Because neither the diver nor any of his equipment was recovered it is not possible to determine whether the problem was contaminated air, a head injury from the lifting equipment, a health factor, or simple loss of the regulator from his mouth.

Summary

EXPERIENCED DIVER; SOLO; SUBSTANDARD EQUIPMENT; DISCONNECTED LIFELINE; FATIGUE FACTOR; DIVER ACCEPTED USE OF POOR EQUIPMENT SO EMPLOYER ESCAPED LEGAL LIABILITY FOR THE DEATH; BODY NEVER RECOVERED.

CASE SC 00/4

The victim, aged 30, and her husband had trained overseas three to four years previously and subsequently made about 200 dives, over 50 being deeper than 40 msw, their deepest to 46 msw. A friend invited them to make a wreck dive with him and his buddy with whom he had made a number of dives on this wreck. It was a deep dive, 55 msw, and he took care to warn them of the possible dangers of such a depth. He noted they had single tanks so loaned each of them twin 72 cu ft tank sets, with a separate regulator on each tank, and stressed that they should abort the dive at any time they wished to do so. It is not known if they had ever previously used such sets. It was planned for them to ascend before the more experienced divers, though the latter were to descend first. Her descent was delayed by her difficulty in venting air from her drysuit.

When they reached the wreck she appeared to lack her usual composure so their friend, despite the 'OK' sign she gave him, decided to abort the dive and return to the surface with her. He held her wrist, then he checked the position of the anchor line, and when he looked back he saw she had lost consciousness. He immediately inflated her BCD, then found she was tethered by her secondary regulator to the wreck's aerial so he ditched her weight belt and the regulator pulled free, the latter just missing her husband as it did so. A rapid ascent followed and when they were about half way to the surface she had two convulsions and went limp.

The friend attempted to slow their ascent rate by venting her BCD but was unsuccessful, the air expansion rate exceeding the venting. At 15 msw he chose to let her go and make a computer-gauge-regulated decompression stop before continuing his ascent to the surface. There he saw her floating face up. The others helped him to get her into the boat and commence CPR but there was no response.

Autopsy

A CT scan before the autopsy showed the presence of air in the right side of the heart and also in her thighs. A small tumour of no clinical importance was noted in the liver.

Comment

The convulsion as she ascended may have been evidence of a cerebral air embolus. The reason for her sudden loss of confidence and then of consciousness at depth is unknown but cold water and narcosis may have played a part.

Summary

SCUBA DIVING; TRAINED; EXPERIENCED TO 46 MSW; DEEP WRECK DIVE TO 55 MSW; COLD, DARK AND NARCOSIS FACTORS; LOSS OF CONSCIOUSNESS AT DEPTH; EQUIPMENT CAUGHT ON WRECK; UNCONTROLLED ASCENT AFTER BUDDY INFLATED HER BCD AND DITCHED WEIGHT BELT; CONVULSION DURING ASCENT; GOOD ASSISTANCE FROM OTHERS; CEREBRAL ARTERIAL GAS EMBOLISM.

CASE SC 00/5

This 29-year-old man had been scuba diving for 13 years, though not in the previous six months, and his buddy had only slightly less experience. The buddy hired the equipment for the day. They made their water entry off a rocky shore and swam out beyond rough water before they descended, the depth being about 10 msw. A short time later, the victim indicated he wanted to ascend and at the surface, where the water was choppy, he said "I don't feel comfortable". They held onto a cray pot float while his buddy talked to him to help calm him. After a time he said he felt OK and they again descended. At a depth of 3 msw he changed his mind and again surfaced, saying "I can't do it, I have to get out". He was so intent on this that he ignored his buddy's advice to swim to the nearest safe exit area a short distance away, instead swimming to the closest rocky ledge. The water here was a turbulent surge over the rocks but the buddy made a safe exit. When he looked back he saw his friend floating on his back out to sea and imagined he had changed his mind about trying to exit here. After taking

off his equipment he went and found a surf lifesaver and asked that a 'rubber ducky' be sent to collect his friend. When he was reached they found he was unconscious and started CPR as soon as they brought him ashore. He did not respond to resuscitation.

Autopsy

The autopsy revealed evidence of drowning and the presence of non-significant localised subarachnoid haemorrhage over his left cerebral hemisphere. The latter observation was in keeping with a history of a motorcycle accident at the age of 18, which had caused a left parietal skull fracture complicated by a subdural haemorrhage needing surgical evacuation. A more recent back injury was blamed for his occasional back pain and 'migraine headaches'. His only recent visits to his doctor had concerned a headache and 'sinus symptoms'.

Comment

His true swimming and scuba ability is unknown, as is whether he found the sea conditions more severe than he felt competent to meet and for this reason he panicked, failing to inflate his BCD or ditch his weight belt in the process and drowned. His wife reported he had two nocturnal episodes of chest tightness during the previous two weeks, their significance unknown.

Summary

SCUBA DIVING; TRAINED AND EXPERIENCED; NIL DIVING FOR SIX MONTHS; ABORTED DIVE; UNSAFE CHOICE OF EXIT AREA; PROBABLE PANIC REACTION TO SEA CONDITIONS; FAILED TO DROP WEIGHTS OR INFLATE BCD; DROWNED.

Surface Supply (Hookah) Fatalities

CASE H 00/1

This 20-year-old man was, like many employed in the harvesting of *beche de mer*, untrained in hookah diving and had never had a 'diving medical'. The diving system employed was for the boat to tow three dinghies from each of which, depending on the depth, a diver would breath-hold dive or use hose supply from a compressor in the dinghy to collect the *beche de mer*. There was doubt concerning the reliability of these compressors such that the skipper had his personal one. It was known that the outboard engine of the dinghy from which the victim was diving was difficult to restart but was reliable once started. There was a second diver with him but when he knew the local depth was 20–25 msw he said it was too hard to breathe at that depth and transferred to another boat to cadge a light for a cigarette. It was a short time later that the accident occurred. A large wave nearly swamped the dinghy and while the crewman was bailing the water out the diver decided to start his dive and jumped out. This made the bow rise and water come in over the stern. The crewman then noticed the hose to the diver was trapped between the transom and the outboard's leg. It was necessary to lift the engine out of the water to free it, but it would first be necessary to stop it as it would run too hot if the inlet for its water cooling was out of the water. Fortunately a diver from another dinghy came and got it free and he was required only to let the engine idle.

While this was happening the boat drifted and suddenly the hose went slack and spun around in the water showing that there was no longer anything connected to it. The crewman checked that the diver had not surfaced, then gave the alarm. The skipper, who had been in one of the other dinghies, checked he had enough fuel for his compressor, then descended to search for him. His first three dives were unsuccessful before he found the victim on the sea bed, his weight belt on and catch bag and regulator lying nearby. He ditched the belt and brought the drowned diver to the surface. Depth here was 10–15 msw.

Autopsy

The finding was of drowning without evidence of any medical disease or barotrauma.

Comment

The lack of training or experience with hookah, whilst not the critical element leading to this death, may have been contributory. It is apparent that the victim either never thought to ditch his weight belt or was so shocked by the loss of his air supply and contact with the surface that he inhaled water before considering this option. The air compressor had many adverse features but these were not implicated in the tragedy. There were three critical issues in addition to his lack of training: he was not wearing a bailout bottle, he had no lifeline, and there was an insecure coupling between his supply hose and his regulator unit. This last fault made it impossible to treat the hose as a lifeline as it separated when so used in an attempt to pull the diver to the surface. The legal responsibility of the company which ran this particular harvesting of *beche de mer* is a moot point, because the ownership of the compressor was disputed and the divers were

described as being self-employed. The absence of enforcement of workplace safety requirements certainly deserves attention.

Summary

HOOKAH; UNTRAINED BUT REPORTEDLY EXPERIENCED SSBA DIVER; CONNECTION HOSE TO REGULATOR UNIT INSECURE; HOSE CONNECTION SEPARATED; NO BAILOUT BOTTLE; NO LIFELINE; FAILED TO DITCH WEIGHT BELT; SAFETY REGULATIONS IGNORED BY DIVER'S EMPLOYER AND GOVERNMENT; DROWNED.

CASE X 00/1

This 31-year-old diver had completed his basic recreational scuba training course less than three months before he commenced employment with this pearl farming enterprise. He had received no instruction and there was no supervision of him on this his first day at work. There were three divers employed to attach pearl panels to an underwater fence line. He apparently experienced some difficulty with his regulator and entered the water last but appeared to be working in a normal manner when seen from time to time by the other divers. His failure to join the other divers when they completed their tasks led them to check on him and to find him on the sea bed. The incomplete nature of the information available makes it impossible to be certain whether he was using scuba or SSBA equipment.

Autopsy

The autopsy reportedly noted he had a congenital brain abnormality which may have predisposed him to having a seizure but further details are not available. This was possibly his first use of hookah diving apparatus. The firm was prosecuted, pleaded guilty, and was fined $10,000.

Summary

HOOKAH OR SCUBA – UNKNOWN; UNTRAINED; NIL EXPERIENCE OR INSTRUCTION; NEW EMPLOYEE; SEPARATION UNDERWATER; POSSIBLE MEDICAL CAUSE FOR SEIZURE FOUND AT AUTOPSY; DROWNED.

DISCUSSION

SNORKEL USERS AND BREATH-HOLD DIVERS

These fatalities fall into two clearly defined types, either breath-hold dives spear fishing (BH 00/3) or swimming while wearing a mask and snorkel (the remainder). The critical factors in the two groups clearly differentiate them. The cause of death of the spear fisherman was probably post-hyperventilation hypoxic syncope resulting in drowning. The danger of hyperventilation to increase one's underwater duration is well documented, but such deaths are sufficiently infrequent to be discounted by divers. Unfortunately survival from a non-fatal blackout incident does not appear to be persuasive in teaching avoidance of 'excessive' hyperventilation.

The larger group consisted of swimmers using snorkels, often for the first time, visitors from out-of-State. These deaths occurred, in the majority of recent instances, despite alert safety watchers. These cases indicate both the serious difficulty of recognising a swimmer in trouble in a crowd of others, in particular when there is no outward sign of any problem, and the problem of sudden death in the apparently healthy. Although two of this group had obtained and worn buoyancy vests initially, one had removed her vest before making her last water entry. As these vests tend to float the wearer face down, they have a limited safety function in an unconscious wearer. If they were designed to keep the wearer face up they would be unsuitable for anyone trying to swim and examine the underwater world.

The most common contributing health factor was cardiac with four, possibly five, dying from this cause. It is probable that it was also critical in the fatality where the body was never found. Whether a person with an epileptic history should be permitted to swim, even if accompanied by a conscientious buddy, is a contentious problem and any decision involves consideration of the risk versus quality-of-life factors. It is certainly easier to have a blanket prohibition on all epileptics swimming, but the 'evidence basis' justifying any decision is debatable: even the most healthy can drown. No explanation has been offered for the sequence of events in case BH 00/6 but adverse sea conditions, his possible first use of a snorkel, and being solo, would explain his panic and have resulted in the commotion the witness labeled as 'a convulsion'.

The problem of death among snorkel-swimming visitors to the Great Barrier Reef is a major concern to those involved in taking visitors to view the reef and to tourism authorities generally. It is not clear

what action can be taken to effectively reduce these fatalities, as a large proportion are in the age group where unpredictable cardiac events are most common. The majority of victims appeared to be healthy, though a few had failed to reveal their true health history.

The wearing of the type of life jackets suitable for snorkel swimming is of negative benefit should loss of consciousness occur. It is apparent that even the most conscientious safety watch of a group in the water will fail to benefit those who lose consciousness without any outward sign, the only alerting factor being the absence of activity for longer than expected. The safety watchers employed to supervise the safety of swimmers and snorkellers on trips to the Barrier Reef appear to have acted efficiently and are to be commended for the difficult task they perform. The organisations running day trips to the Barrier Reef appear to be taking active steps to ensure efficient safety watch procedures. Whether there is a need to require watchers to hold certificates in life saving is not proven on the evidence presently available, though boats which carry defibrillators ensure those likely to use them have training. As it would be neither practical nor necessarily effective to require a specialist cardiologist to examine all visitors aged over 45 who intend to snorkel swim on the reef, it may be necessary to accept that such deaths are unavoidable until new predictive tests are developed.

SCUBA DIVERS

There were five fatalities identified in association with scuba diving, of which one was due to pulmonary barotrauma/air embolism as indicated by autopsy findings and the clinical history. In one case there was a low-air factor, while the other two divers had adequate remaining air. Inadequate experience and panic are once again apparent.

In case SC 00/3 an unwillingness to risk job loss is the most probable explanation of the number of work-safety violations found in this accident, and indeed helped to protect the employer from the legal consequences of their failure to follow 'best practice' workplace management. In the absence of the victim's body and equipment it is not possible to know the critical factor in this death.

While in case SC 00/4 the diver had shown symptoms suggestive of CAGE during her ascent, she had lost consciousness prior to this for reasons that were never defined but probably included anxiety due to this being her deepest dive, nitrogen narcosis, the cold water, and use of a borrowed twin-cylinder scuba unit. It is probable that this was the first time she had used such equipment, which had a separate regulator for each cylinder.

In the cases where drowning was the given cause of death, the circumstances of each were unique. The dangers of ignoring the 'nanny' advice on safe diving practices is demonstrated, as also the factors of panic, running out of air, and inexperience. The concordance of several adverse factors in these scenarios supports the common belief that the greater the failure to strictly observe advised safe diving procedure the less is the margin of safety.

Scuba diving-related deaths frequently show the presence of multiple risk factors. Rarely does a single adverse factor result in a fatality. Inexperience, absolute or relative, is a predictable factor and this includes those who have not dived recently, as are buddy separation and low-air situations. These breaches of good diving practice are best tackled through training protocols. Buddy breathing cannot be relied on as a safe and sure alternative to monitoring the contents gauge, even assuming the gauge is reading accurately.

SURFACE-SUPPLY SYSTEMS

There is no tradition of zero tolerance of unsafe conditions in the pearling industry, indeed from an examination of these two cases it appears workplace safety is ignored at all levels of the industry. In case X 00/1 complete lack of experience and a possible medical problem leading to a seizure were factors, but unfortunately complete details of this fatality are not at present available. There is clearly an immediate need for a simple 'cross-over' course for those wishing to take up employment in this industry when the only prior training has been recreational scuba diving and not hookah diving.

The examination of the deaths using hookah equipment clearly shows that using faulty equipment can be fatal, and that experience of recreational scuba diving is inadequate preparation for this type of diving. It is a sad fact that no action has been taken to require the completion of a certificated course for divers employed in the pearling, crayfish, and *beche de mer* industries, or enforce the requirement to hold a certificate for employment in this industry.

Permission to access data from the police investigations of these deaths on behalf of the local coroner is a vital element in any investigation into areas where intervention may reduce the occurrence of fatalities.

Where such investigations take a particular note of the medical history, training, experience, and equipment factors, their value is enhanced. One area of difficulty arises where a snorkeller, independent of a commercial enterprise, is decided to have died 'from natural causes' and, very naturally, the cases are not further investigated. Their omission from later reviews is unavoidable but there is nothing to suggest the critical factors in such cases differ from those here considered. The diving community is greatly indebted to coronial and other sources for their understanding and active support of this ongoing investigation.

Acknowledgements

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2001: Australian Diving-Related Fatalities

Overview

During 2001, 12 deaths in association with breath-hold and snorkel use were identified in Australia from official sources. There were also 11 fatalities in association with scuba use, and three where surface-supply air was involved. Case summaries are presented with attention to the medical, equipment and diver performance factors. Significant adverse factors are identified and discussed for each of the groups, with comments on possibilities for reducing the number of fatalities that occur. As in previous years, the scenarios and avoidable factors are diverse. Of particular note, all three of the 'hookah' deaths were due to carbon monoxide poisoning.

Introduction

Project Stickybeak has identified and reported on deaths associated with diving in Australia since 1972 on an annual basis.[1-4] Here, the deaths identified from official sources in 2001 are reported. Cases were identified from a range of sources (government, private, media) as described previously,[1] and copies of the investigation documents obtained. Summaries were made of the data and these form the basis of this review. The general methodology for searching and reviewing fatalities has been described recently.[4]

CASE REPORTS

Breath-hold Divers and Snorkel Users

CASE BH 01/1

During the trip out to the reef cay there was a talk on snorkel use and each passenger was given a leaflet on the subject. After they arrived, this 79-year-old man's wife took a ride in the glass-bottomed boat and he went to sit on the beach, then decided to go for a snorkel. One of the other passengers remembered that they had been told never to swim alone so she followed and watched him. At this time there were about a dozen people in the water with two safety officers watching from the shore. She saw that he seemed to be managing safely, taking a rest as he reached each float station. These were about 100 metres apart. She decided to return to the beach and he also chose this time to start his return, though some distance behind her. When she reached the shallower water she looked back and saw he was possibly panicking and making 'cycling' leg movements, but she was reassured when he resumed normal swimming. A short time later she again looked back and saw he was looking too still. She swam back, some 10–15 metres, and found he was unconscious with his snorkel submerged. She cried out for help and attempted to keep his head above the water. A crew member soon reached them, towed him to shore, and commenced CPR but he failed to respond to resuscitation.

Autopsy

The cause of death was given as drowning. Only moderate coronary artery atheroma and patchy myocardial fibrosis were noted, though the aorta had more severe atherosclerosis.

Comment

Breathing through a snorkel while swimming is not a natural manner of breathing; it is one that requires some adjustment of mindset. That this is so is witnessed on occasion by the death of a swimmer in shallow water while making their first snorkel swim. The witness of this tragedy suggested his 'cycling' was a panic attempt to get a footing on the sea bottom. His swimming and snorkel experience is unknown but it is highly likely it was minimal, if any at all. It is probable the outcome would have been critically improved had he thought to remove his snorkel and breath 'naturally'.

Summary

SNORKELLING; EXPERIENCE UNKNOWN; POSSIBLE PANIC; INHALATION OF WATER; DROWNING; SOME CORONARY ATHEROMA; NO HEALTH HISTORY; CARDIAC FACTOR?

CASE BH 01/2

This 61-year-old woman was among 41 passengers making a day trip to a reef cay. There was the regular health questionnaire and safety talk for those intending to snorkel, and they were advised to wear a buoyancy vest unless very experienced. Neither she nor her partner reported any adverse health history.

They were offered and accepted the suggestion of wearing wetsuits. It is not recorded whether she had ever previously used a snorkel.

After they disembarked at the cay they snorkelled for a time then took a trip in the glass-bottomed boat to view the coral. After lunch back on the boat there was an announcement that those who were not confident could come on a guided snorkel trip to the outer reef of the cay. The skipper was watching their water entry and was reportedly impatient at the victim's slowness in entering the water to join the others after her husband had tightened her buoyancy vest. Once in the water she found the vest was riding up over her head, having been incorrectly fitted. She returned to the boat's stern board but was unable to correct the problem and the skipper helped her remove the vest. She said she was anxious without it and got him to promise to remain close to her. However, he then boarded the outboard inflatable tender and drove away to collect all the others of the snorkel group around him. She swam alone for about 10–15 minutes then saw the glass-bottomed boat and called out that she had swallowed some water and wanted to be taken aboard.

The crewman on this boat offered no assistance and it was the passengers who dragged her part into the boat when she was unable to pull herself aboard. They became anxious when she started making gurgling noises and said she couldn't breathe, and they became vocally aggressive when the crewman refused to take any action. Ultimately their reaction forced him to inform the skipper, who drove over to them and helped pull her fully into the boat. Their resuscitation efforts were not helped by their inability to open the oxygen bottle because of the absence of a spanner. Despite the vociferous objections of the passengers the boat was then driven back to the main vessel bypassing another vessel that might have provided assistance. No call for emergency assistance was made because the two-way radio did not work.

Autopsy

The cause of death was reported as salt-water drowning. She was described as obese and sturdy.

Comment

This tragedy was an example of what can happen if there is a gross failure to act professionally by those responsible for the safety of others. This case is particularly unusual in that there were apparently serious inadequacies by more than one member of the crew in the level of supervision and assistance given to a passenger who requested, and indeed was promised, specific attention. The company concerned was subsequently prosecuted, but this did not help the deceased. It is the obvious responsibility of those with a duty of care concerning the safety of passengers to deliver such care as is necessary. Fortunately the correct level of supervision and assistance is almost always provided.

Summary

SNORKELLING; BUOYANCY VEST REMOVED; LACK OF SUPERVISION BY SKIPPER; SEPARATION; LACK OF ASSISTANCE BY CREWMAN; NO SPANNER FOR OXYGEN CYLINDER; INOPERATIVE RADIO; CREWMAN REFUSED TO SEEK ASSISTANCE FROM OTHER VESSEL; DROWNING.

CASE BH 01/3

This flooded, abandoned, old open-cast mine was a favourite swimming area for the local community. It varied in depth from shallow to about 10−15 metres, where there was a collection of dumped mine equipment. A faded notice warning people to keep out had for long been ignored. The 25-year-old victim was reported to have been drinking heavily the previous evening and had a couple of cans of beer that morning before joining his friends at the mine, plus another can after arriving. He was described as being a professional diver, probably breath-hold for *beche de mer*. There was a buoy marking the position of the dumped equipment.

The length of his first dive was alarming his friends until he surfaced after about two minutes. Although his back was to observers, he is thought to have removed his mask, washed it out, replaced it and then submerged again. They believed he was swimming underwater to a shallow ledge, but he failed to reappear. After four to five minutes a search was started, but they had only one mask and it tended to leak. The police were informed but postponed a search till police divers could attend the next day. This stimulated the locals to organise a search to be made using borrowed hookah equipment. This was successful on the second search dive. The body, mask in position, was lying on the debris below.

Autopsy

The cause of death was reported as drowning following a post-hyperventilation blackout. His blood alcohol level was 222 mg.100ml.

Table 1. Summary of Diving-Related Fatalities
(BH – breath-hold, BNS – buddy not separated, BSB – buddy separation before incident,

CASE	AGE	TRAINING	EXPERIENCE	DIVE GROUP	DIVE PURPOSE	DEPTH (METRES) DIVE	INCIDENT
BH 01/1	79	Not stated	Not stated	BSB	Recreation	Not stated	Surface
BH 01/2	61	Not stated	Not stated	GSB	Recreation	Not stated	Surface
BH 01/3	25	Nil	Experienced	Solo	Recreation	15	Ascent
BH 01/4	76	Nil	Nil	GSB	Recreation	Not stated	Surface
BH 01/5	21	Nil	Nil	BSB	Spear fishing	Not stated	Not stated
BH 01/6	44	Not stated	Experienced	Solo	Spear fishing	3	3
BH 01/7	35	Nil	Nil	BSD	Recreation	Not stated	Surface
BH 01/8	43	Nil	Some	BSB	Spear fishing	5	Surface
BH 01/9	81	Not stated	Not stated	BNS	Recreation	5	Surface
BH 01/10	51	Not stated	Experienced	Solo	Spear fishing	Not stated	Surface
BH 01/11	38	Not stated	Not stated	GSB	Food gathering	Not stated	Surface
BH 01/12	32	Not stated	Experienced	BSB	Spear fishing	25	Ascent

Comment

It is known from swimming-pool deaths that swimming activity can continue after consciousness is lost and this could explain the sequence of events described. Among those who find they can extend their underwater time during breath-hold dives there are always some who refuse to believe that pre-descent hyperventilation has a potential cost – death. Clearly he should not have been freediving following heavy drinking.

Summary

SNORKELLING; BREATH-HOLD DIVER; EXPERIENCED; POST-HYPERVENTILATION BLACKOUT; ALCOHOL; DROWNING.

CASE BH 01/4

During this 76-year-old man's visit from overseas to a childhood friend they decided to include a live-aboard trip to view the Barrier Reef. During this trip they were offered the opportunity to snorkel over the reef and given a safety briefing. The 12 who chose to take up this offer were taken to the selected area in a tender, given further advice, and had their names listed on a slate board before entering the water. The tender remained in the centre of the swimming area, which contained an inflated tyre as a rest station and had a safety watcher making frequent head counts. There were also watchers on a second tender.

After about 10 minutes it was noticed that one swimmer had not moved since the previous check and an immediate investigation found the victim floating face down, head submerged, and unconscious. There was no warning disturbance, the person "had just gone limp". Resuscitation efforts were not successful.

Autopsy

The heart was greatly enlarged and there was severe coronary atherosclerosis. The diagnosis was of myocardial infarction but the autopsy report is limited to these data.

Comment

The victim's friend later recalled that he had made

In Australian Waters in 2001, Breath-Hold Incidents
BSD – buddy separation during incident, GSB – group separation before incident)

WEIGHTBELT ON	KG	BOUYANCY VEST	REMAINING AIR	EQUIPMENT TESTED	WHOSE	COMMENTS
None	n/a	Nil	n/a	n/a		Drowning. Possible cardiac death.
None	n/a	Off	n/a	n/a		Drowning (delayed). Possible cardiac arrhythmia.
None	n/a	Nil	n/a	n/a		Post-hyperventilation blackout.
None	n/a	Nil	n/a	n/a		Cardiac death.
None	n/a	Nil	n/a	n/a		Drowned. Inexperienced. Rip area. Solo.
On	5	Nil	n/a	n/a		Severe head trauma.
None	n/a	Nil	n/a	n/a		Cardiac death.
On	7	Nil	n/a	n/a		Drowned.
None	n/a	Nil	n/a	n/a		Cardiac death.
Off	4	Nil	n/a	n/a		Cardiac death.
None	n/a	Nil	n/a	n/a		Drowned. Borrowed equipment.
On	Not stated	Nil	n/a	n/a		Post-hyperventilation blackout.

frequent rest stops during their earlier sightseeing, though had not made any complaints of health symptoms. It was established that he was taking (un-named) medications for his heart, had his hypertension checked monthly, and had achieved normal blood pressure at the last check. This health problem may have been the reason why he had airfare insurance but no travel health insurance. There is no documentation concerning whether he was asked to fill in a health questionnaire when booking this trip, but even had he disclosed his health condition it is uncertain whether he could have reasonably been refused the opportunity to snorkel. The safety arrangements of this live-aboard travel organisation appeared to be excellent.

Summary

SNORKELLING; SILENT DEATH; WELL-SUPERVISED AREA; UNREVEALED HEALTH HISTORY; SEVERE CARDIAC DISEASE; HYPERTENSION ON MEDICATION; MYOCARDIAL INFARCTION.

CASE BH 01/05

When this 21-year-old man arrived at the beach several of his friends were already there and swimming either in the sea or in a rock pool. They had one set of mask, snorkel and fins and he borrowed this equipment in order to go spear fishing. His friends thought he was inexperienced in this sport. After watching him swimming around for a time, they went for a walk along the beach. When they failed to see him on their return they became alarmed and informed the lifesavers. When he had entered the water there had been two others spear fishing nearby, but they had soon left the water. It was two hours before his body was found floating in shallow water.

Autopsy

No coronary or other disease was identified. Death was recorded as drowning.

Comment

A lifesaver noted that there was a permanent rip in the area of the rocks where the victim had been

swimming, and a police officer suggested he might have drowned when he became trapped under a rock ledge, but his inexperience was the most likely critical factor, presumably allied to the water conditions.

Summary

SNORKELLING; INEXPERIENCED; SPEAR FISHING; SOLO; RIP AREA; DROWNED.

CASE BH 01/6

Although it was his usual practice to have a float and 'diver down' flag, on this occasion this 44-year-old spear fisherman had omitted to use them. He had no success when diving off the beach so had moved to a rocky area close to the entrance to a small harbour that was frequented by recreational fishermen. They used aluminium boats with powerful outboard motors and on this day two decided to return to harbour at about the same time. The local council had put up signs warning boats about the presence of swimmers in the harbour approach waters but these had been repeatedly vandalised and destroyed.

The first intimation of the tragedy was when the spear fisherman's wife became alarmed at his failure to return home. The police were informed and a police boat took police divers to the rocky area where a witness had earlier seen a spear fisherman. They anchored their boat in three metres of water over a rocky ledge at the edge of this area and the victim's body was found on the sea bed close by at a depth of about four metres' sea water (msw). When found, his weight belt was on, his facemask lacked its faceplate and his snorkel had lost its mouthpiece. His gun was damaged and he had signs of trauma on the front of his skull. It was clear this was likely to be from a propeller blade. Investigation located a workshop with a propeller for repair that had been damaged the day of the fatality.

Autopsy

There was a head laceration involving the frontal and left parietal regions approximately 17 cm long with several protruding fragments of the skull. Brain tissue had escaped through this injury. There was a second 5 cm wound over the occipital scalp that did not penetrate the outer table of the skull. There were abrasions on his forehead, a cut in the left thenar eminence, a superficial linear defect over the dorsum of the left forearm, and several other lacerations and abrasions to the upper limbs. The heart appeared healthy with some patchy eccentric atheroma with up to 75% luminal narrowing of the proximal left anterior descending artery and up to 50% of the right coronary artery. The left kidney was congenitally absent. There was pulmonary congestion and blood-stained fluid in both pleural cavities. No rib fractures or pneumothoraces were identified. This finding led the pathologist to suggest cardiac failure preceded the fatal brain injury, though he suggested some delay could well occur before he died from such trauma.

Comment

The death of this spear fisherman from trauma was a consequence of errors by both the victim and the driver of the motor boat. The two boat drivers denied they had been racing each other. The boat's owner was reluctant to admit either that there was a high probability he had hit the diver or that he had been too close to this rocky area. It would be difficult to see a diver's black wetsuit from a speeding boat, but the course taken was incorrectly close to the rock outcrop area. The boat's 'skeg', which projects below the propeller, was broken leaving the propeller exposed. The significance of this broken skeg is unclear, but had it been present the injury caused to the victim might have been less severe. It was natural that the evidence as to whether the driver of the boat had been racing his friend back to the ramp would be disputed, as would the question concerning what a careful boat driver would have seen of a snorkeller at the surface, taking into account the surface wavelets and position of the sun. The evidence of a RAN officer was that identification of such a situation as in this fatality would be easy for anyone keeping the correct lookout; an opinion disputed as unrealistic. The failure on the part of the diver to have a float and 'diver down' flag was an unfortunate break from his usual practice and placed him in danger. The conjecture by the pathologist regarding cardiac failure provided fertile grounds for legal questioning at the inquest.

Summary

SNORKELLING; SPEAR FISHING NEAR HARBOUR ENTRANCE; SOLO; NO FLOAT OR DIVE FLAG; HIT BY BOAT PROPELLER; POSSIBLY BOAT RACING AND INADEQUATE LOOKOUT; FATAL SEVERE HEAD INJURY.

CASE BH 01/7

A friend had suggested this 35-year-old man come to watch while he dived to collect abalone and crayfish. As he was about to get into his car afterwards he asked

the victim if he would like to dive with him, an offer he immediately accepted. Nothing is known concerning his swimming ability or whether he had previously used a snorkel, but it is believed this may have been his first use. After he had donned the offered wetsuit and mask, snorkel and fins, they prepared to enter the water. However, an unexpected wave washed them both off the rocks and they then swam about 20 metres out to sea. The buddy started diving and soon collected 20 abalone and a crayfish, then noticed that the victim was treading water in an attempt to keep his head above the surface. He managed to reassure him and then dived again. When he surfaced he saw the victim floating face down and unconscious, the snorkel firmly clenched in his jaw and its end under the water.

He attempted to tow his friend back to the rocks and get him ashore but the current and the waves over the rocks defeated his efforts and it was a diver dropped from a rescue helicopter who eventually recovered the body.

Autopsy

The autopsy showed that he had had triple bypass surgery and that the left anterior descending coronary artery showed 80% narrowing. There was evidence of an acute myocardial infarction indicating that this was not a simple drowning. It was also found that he had suffered a previous myocardial infarction.

Comment

This case is particularly unusual in relation to the health history at his age, 35 years. Whether he was having any symptoms from his cardiac condition or whether the friend was aware of his health problems is not recorded. Even had he known of the victim's medical history, he could not be blamed for the deceased accepting the offer of the use of the equipment to swim with him. While it is easy with hindsight to question his failure to recognise the danger of leaving anyone who was having difficulty keeping his head above the water, he evidently believed the situation had stabilised before he dived again.

Summary

SNORKELLING; INEXPERIENCED; SOLO WITH SCUBA DIVER BELOW; PREVIOUS AND RECENT MYOCARDIAL INFARCTS AND HISTORY OF TRIPLE BYPASS OPERATION; SUDDEN CARDIAC DEATH.

CASE BH 01/8

This 43-year-old man had done some scuba diving, but was untrained, and some breath-hold spear fishing, but no details are available concerning his experience beyond the statement that he had accompanied his recent friend on seven occasions. This was the first time he had worn his new weight belt. The water was calm close to the waterway wall where they made their water entry and they kept a distance apart to avoid entangling their float lines. When he became swept away from the calm area into the middle of the channel he called for help. His friend had previously advised him that if this occurred he should try to get close to the rocks as the current was weaker there, but he evidently recognised he was unable to do this.

There were two boats anchored in the waterway about 15 metres from him and one of the men fishing from them dived into the water to assist him, but he sank from sight before he could be reached. A search was made and he was found lying on the sea bed, all equipment in position, holding his spear gun.

Autopsy

The cause of death was given as drowning, with no adverse health factors identified.

Comment

The view of his buddy is probably correct: that the critical factors were excessive weight on his belt and his failure to ditch it. Without this weight he could have swum towards the wall, where there was less current, and survived. Probably he panicked when unable to swim against the strong current to regain the calmer water. His inexperience would explain a panicked rather than a reasoned response to the situation.

Summary

SNORKELLING; SPEAR FISHING; PROBABLY INEXPERIENCED; CAUGHT IN CURRENT; FAILED TO DITCH WEIGHT BELT OR SPEAR GUN; NO HEALTH FACTORS; DROWNING.

CASE BH 01/9

This 81-year-old man and his wife took a boat trip to view the Great Barrier Reef. He regretted his failure to snorkel over the coral due to a reluctance to do so from a boat. However, after their return to the resort island, he decided he would go for a snorkel swim near its jetty. There was a notice here warning against

swimming, no doubt because of tourist boats, but locals told him it would be safe. His wife entered the water first as he had limited confidence in entering alone. When she looked back to check on his progress she was alarmed to see him under the jetty, holding onto one of its pylons, gasping for breath. He appeared to be disoriented. She managed to pull him from under the jetty and called for help but he rapidly started talking gibberish, then died. He had expended minimal effort in the short distance he had swum.

Autopsy

There was only mild to moderate coronary atheroma and mild myocardial interstitial fibrosis, so the diagnosis was made of acute cardiac failure due to ventricular fibrillation.

Comment

Before a holiday to New Zealand not long before, he had a check from his cardiologist, whom he attended for an irregular heart rhythm. He was assured that he had no heart damage and to continue his diltiazem. However, whilst on holiday, he suffered an episode of heart symptoms and was fully investigated. He was reassured that this was probably due to a trip in an unpressurised plane. As two cardiologists appear to have down-played the significance of his arrhythmia his decision to swim using a snorkel was legitimate and the outcome unpredictable.

Summary

SNORKELLING; COLLAPSE SOON AFTER WATER ENTRY; HISTORY OF CARDIAC ARRHYTHMIA ON MEDICATION; RECENT CARDIOLOGY TESTS; SUDDEN CARDIAC DEATH.

CASE BH 01/10

The discovery of this 51-year-old man's body was by chance, two tourists having stopped to admire the view and then seeing his body on the beach, head in the water. It was noted that his wetsuit was unzipped and part removed, his weight belt and other equipment off and lying on the beach next to him. He was known to be an experienced and careful spear fisherman so the fact that his spear gun and crayfish gun were both loaded when found was taken as evidence that this had not been a routine return to the beach. It was suggested that he had probably felt unwell, the likely reason for him to leave the water. It was discovered that he had reported experiencing three episodes of chest pain in the past two weeks and had been reassured they were not cardiac in origin after several (unspecified) tests.

Autopsy

This revealed the presence of an enlarged heart and 90% narrowing of an area of the left anterior descending coronary artery. There was also a small scar in the wall of the left ventricle suggestive of a past myocardial infarction. His death was regarded as due to a further infarction.

Comment

The evaluation of the significance of symptoms presented by a patient is undoubtedly influenced by many factors, and in this instance appears to have been incorrect. It is possible the outcome would have been the same even had he not been alone at the critical time, but being alone reduced his chance of acute medical care. Possibly more significance should have been placed on chest-pain symptoms in a man of this age.

Summary

SNORKELLING; EXPERIENCED SPEAR FISHERMAN; SOLO; EXITED WATER AND MANAGED TO PART REMOVE EQUIPMENT BEFORE DIED; CHEST PAINS PAST TWO WEEKS; CORONARY ATHEROMA; ACUTE MYOCARDIAL INFARCTION; SUDDEN CARDIAC DEATH.

CASE BH 01/11

This apparently healthy 38-year-old man was with a family group that was hunting for kina off a rocky shore. The conditions were not good, the water rough and murky, indeed the police later said conditions were unsuitable for this activity. Nothing is recorded concerning his experience with snorkel or his general swimming ability. One of the group, reportedly a good swimmer, was knocked over by the waves several times while standing on a rock in the water. It is unclear from the available information whether he was finding the kina by ducking his head underwater or truly breath-hold diving for them. The former practice is thought the more likely.

They had brought a dog to the beach with them and it was noticed to be leaving the beach in pursuit of another dog. When the victim failed to make this clear to the dog's owner he decided to swim back to the beach to collect it, handing his spear to a female family

member snorkelling near him. None of the others appeared to have noticed his absence until the alarm was raised by witnesses on a hillside overlooking the beach. They saw a body floating face down and both raised the alarm and raced to give assistance, joined by some spear fishermen who were nearby. He failed to respond to their resuscitation efforts.

Autopsy

The cause of death was given as drowning. He was found to have mild ventricular hypertrophy, the significance of which was unknown.

Comment

Neither his swimming ability nor his previous experience using a snorkel are known, but it is apparent that members of the group were overconfident of managing themselves in the rough water.

Summary

SNORKELLING; SEPARATION; EXPERIENCE UNKNOWN; ROUGH WATER; MILD VENTRICULAR HYPERTROPHY; DROWNING.

CASE BH 01/12

This 32-year-old man and his friend were both experienced spear fishermen but he was by far the better, with a usual pattern of diving to a depth of 20 msw. Their half-cabin boat was anchored off a small island, and while the friend remained in the shallower water near the island the victim hunted in the deeper water. His friend remained unconcerned at their separation until, about 60 minutes after their last sighting of each other, a passing dive boat noticed his float in the rough water close to the island. He realised that his friend would never let go of his spear gun and float so something must have happened to him. A search was undertaken and his body was found on the sea bed, weight belt and mask in place.

Autopsy

The cause of death was drowning, undoubtedly following a hyperventilation blackout.

Comment

It is breath-hold divers of superior ability who are most likely to put themselves at risk of post-hyperventilation anoxic loss of consciousness. Spearfishing does not lend itself readily to realistic buddy diving, so scenarios such as this one are not unexpected from time to time. Many freedivers do not follow the 'one up, one down' rule for buddying whilst spearfishing.

Summary

SNORKELLING; EXPERIENCED SPEAR FISHERMAN; SEPARATION/SOLO; POST-HYPERVENTILATION BLACKOUT; DROWNING.

Scuba Fatalities

CASE SC 01/1

This 29-year-old man had made only two dives since his course two or three months previously. His buddy had been diving 'occasionally' for 17 years, and though he had never been trained in scuba diving he claimed experience in using breathing apparatus because of being a fireman. The scuba equipment the victim was to use was borrowed from his buddy. Their plan was to catch crayfish and after entering the water off a rock ledge they swam out about 30 metres using their snorkels before changing to scuba. The depth was about 10 msw. They had been swimming vigorously in their ineffective pursuit of the crayfish. After a time, he showed his contents gauge to his buddy as it showed a low air situation, and they started to ascend. When the buddy reached the surface he was surprised to find his friend already there as he had been lectured by him before the dive on the need to ascend slowly, a matter evidently well stressed during the recent course.

He told his buddy he was feeling unwell so they inflated their BCDs and started to snorkel back to the shore. After they had swum about three metres he again said he felt unwell, then grabbed hold of his buddy's equipment and did not reply when spoken to. During the struggle that followed the buddy's tank slipped from its harness so he was unable to reach his regulator and had to continue on snorkel. He was seriously hampered by the weight of his friend, who was now unconscious, and called for help. They were being repeatedly submerged by the swell so he decided to detach his friend, return to shore to remove his equipment, then return unencumbered. When he returned he found a swimmer trying to keep his friend's head above the water. Together they brought him to a rock ledge where others helped bring him ashore. Their resuscitation efforts were hampered by his regurgitation and were unsuccessful. A witness described the water as being rough and cold.

Autopsy

Pre-autopsy X-rays showed widely disseminated gas bubbles within the brainstem and meningeal vessels, major arteries, the pulmonary arteries, and within both cardiac ventricles. Death was due to cerebral arterial gas embolism (CAGE).

Comment

He was inexperienced, and initiated his ascent when low on air. It would appear that he ascended rapidly, as he was already on the surface when his buddy surfaced. The fatal embolism is likely to have occurred at this time from lung barotrauma sustained during ascent. A valiant attempt at rescue and resuscitation was made by his buddy and others. The equipment was checked and no significant faults were found. There was a delay of several minutes following his reaching the surface before he lost consciousness.

Summary

SCUBA; NEWLY TRAINED AND INEXPERIENCED; BORROWED EQUIPMENT; RAPID LOW-AIR ASCENT; CONSCIOUS AT SURFACE INITIALLY; INFLATED BCD; GRABBED BUDDY CAUSING DANGER TO HIM; LOSS OF CONSCIOUSNESS THEN SEPARATION; BUDDY'S TANK SLIPPED FROM HARNESS; DELAYED RESCUE; CAGE.

CASE SC 01/2

The 29-year-old male victim had trained two years previously but nothing is recorded concerning his subsequent diving experience. On this day he was with his brother, he to scuba dive and his brother to snorkel above and act as a 'one-remove' buddy. Their water entry was off rocks and he then descended into a kelp-filled gulley about two metres deep. He soon became caught in the kelp, which entangled both him and his regulator and tank. His brother saw what had occurred but in his anxious haste he dropped his knife, and the victim had not brought one. There was some delay before his cries for help were understood by others and when help arrived it was too late. The victim was found head-down, his fins at the surface and regulator out of his mouth. He was cut free but was beyond resuscitation, having drowned.

Autopsy

The cause of death was given as drowning. The coronary arteries were healthy. Although there was a history of asthma there was nothing to suggest this or 'flu-like' symptoms over the previous two days contributed to his death.

Comment

The tragic outcome of this dive could so easily have been avoided. Kelp should always be entered with caution, as entanglement is always possible, though proper dive technique should avoid this. In this incident, the buddy's panic response led to him dropping the knife that may have offered the only chance of getting the victim free.

Summary

SCUBA; TRAINED BUT UNKNOWN EXPERIENCE; ENTANGLED IN KELP NEAR SURFACE; 'BUDDY' PANICKED AND LOST KNIFE; TWO DAYS OF 'FLU-LIKE' SYMPTOMS AND ASTHMA HISTORY NOT FACTORS; DROWNED.

CASE SC 01/3

Although claiming 25 years' scuba diving experience, this 42-year-old's actual experience is not recorded. However, she had taken a 'refresher course' three months prior to this dive. She was among 14 divers on a commercially run boat dive. The divemaster, an instructor, was her buddy and he noted she seemed a little stressed after her water entry but soon settled. She had a problem with water entering her mask but this was resolved by her buddy who removed the edge of her hood from under the mask. They exchanged frequent 'OK?' signals and experienced no further problems.

At a depth of 20 msw her gauge showed only 70 bar air remaining. Her buddy had plenty, so it was agreed that she would ascend alone while he continued hunting for crayfish. He watched the first five to six metres of her ascent and, satisfied at her progress, stopped watching. When he surfaced 10–15 minutes later he was surprised to be asked where his buddy was. He was told, in answer to his questions, that a call for help had been heard near some rocks 10–30 metres from the boat before he surfaced. He removed his equipment and left it on the boat, then snorkelled to the rocks and began a search. He soon saw her lying on the sea bed five metres below but was unable to dive to her because he was no longer wearing his weight belt. Another diver recovered her body but resuscitation efforts were without success. Her weight belt was in position, BCD not inflated. After her body

was recovered there was just sufficient air to inflate her BCD but there was reportedly insufficient air to inflate it five metres underwater. Subsequent inquiries revealed a history of a spontaneous pneumothorax in 1996. She was reported to be a 'mild asthmatic' and to be suffering from some abdominal pain following a recent gynaecological operation. She had a 'dive medical' before the refresher course but it is not known whether she revealed her medical history as the doctor, not on the SPUMS list, had kept no records.

Autopsy

Autopsy did not reveal any evidence of CAGE, though there were some adhesions in the right pleural cavity. The cause of death was given as drowning.

Comment

That her buddy, an instructor, agreed to their separation and her solo ascent may not appear anything unexpected or out of the ordinary but it was a breach of basic diving safety rules. Although she was not technically in a 'low air' state she appears to have been out of air at the surface. The failure of those in the dive boat to react to a call for help is unacceptable behaviour. Despite the lack of autopsy evidence, judging from the description of events it is possible she had already suffered a cerebral arterial embolism at that time. Whether she died from this or was incapacitated and then drowned cannot be decided, and neither can the significance of the history of asthma, pain from a recent operation, or surgical treatment for a spontaneous pneumothorax. The failure of the doctor to keep records is noted.

Summary

SCUBA; RECENT REFRESHER COURSE; SEPARATION FOR SOLO ASCENT WHEN LOW AIR; BUDDY AN INSTRUCTOR; NO RESPONSE FROM BOAT TO CRY FOR HELP; WEIGHT BELT ON; MINIMAL REMAINING AIR; POST-OPERATION ABDOMINAL PAIN; HISTORY OF SPONTANEOUS PNEUMOTHORAX; POSSIBLY CAGE; DROWNING.

CASE SC 01/4

This 58-year-old man had not dived often since his course some years previously. A friend loaned him a 90 cu ft tank and other equipment for him to come on a dive to catch crayfish. There were seven divers in the boat and he was in a trio team. After about 20 minutes at 9 msw they saw a crayfish in a crevice and allowed him to try to snare it, but he was unsuccessful. When they checked their contents gauges his read 50 bar, theirs 100 bar, so they arranged for one to remain on the sea bed while the other accompanied him as he ascended.

The buddy kept a close hold on him during the ascent to prevent it being too rapid, though he was not ascending fast. At the surface he saw that he had half inflated his BCD and told him to use his regulator as he lay on his back and finned to the boat. He then descended to rejoin the third member of their group. When they surfaced soon after, they saw him floating face up near the mermaid line and it was only after removing their equipment in the dive boat that they realised he was not just lying there enjoying the sunshine. When reached, they found his BCD was tensely inflated and he was unconscious. They had difficulty pulling him into the boat because he was a large man.

Autopsy

X-rays taken before the autopsy showed a fluid level in the right atrium. Some air escaped when the heart was opened under water. There was a small fibrous pleural adhesion in the left pleural cavity, thought to result from a previous road accident. His heart was enlarged, the left ventricle wall thickened, and he was described as being obese (BMI 32). Cause of death was CAGE.

Comment

The buddy acted correctly, ascending with him, but should not have separated from him on the surface. Despite the apparently correct ascent and absence of any indication of distress at the surface, a CAGE occurred. He possibly experienced some intimation of this and fully inflated his BCD. The constricting effect of a hyper-inflated BCD may have been a critical adverse factor. The controlled nature of his ascent would not have prevented pulmonary barotrauma if he failed to exhale correctly during the ascent. There is nothing to clearly implicate his medical history of asthma or the small adhesion in his death. The police did not test the equipment. There was a short delay between his surfacing and the onset of the CAGE symptoms.

Summary

SCUBA; TRAINED; INEXPERIENCED; CONTROLLED LOW-AIR ASCENT ACCOMPANIED BY BUDDY; SEPARATION AT SURFACE WITH HALF-INFLATED

Table 2. Summary of Diving-Related Fatalities

(BNS – buddy not separated, BSB – buddy separation before incident, BSD – buddy separation during incident,

CASE	AGE	TRAINING	EXPERIENCE	DIVE GROUP	DIVE PURPOSE	DEPTH (METRES) DIVE	DEPTH (METRES) INCIDENT	WEIGHT BELT ON	WEIGHT BELT KG
SC 01/1	29	Trained	Nil	BSD	Cray fishing	10	10	On	Not stated
SC 01/2	29	Trained	Not stated	Solo	Recreation	2	2	On	Not stated
SC 01/3	42	Trained	Experienced	BSB	Recreation	20	20	On	Not stated
SC 01/4	58	Trained	Nil	BNS	Cray fishing	9	Ascent	On	14
SC 01/5	64	Trained	Experienced	BSD	Recreation	11	1	On	6
SC 01/6	30	Nil	Not stated	BNS	Recreation	1.5	Surface	Buddy off	Not stated
SC 01/7	38	Trained	Some	GSB	Recreation	20.5	Surface	On	2
SC 01/8	26	Nil	Nil	BNS	Class	9	9	On	9
SC 01/9	56	Trained	Some	BSB	Recreation	10	Ascent	On	8
SC 01/10	65	Trained	Experienced	BSB	Recreation	6	Land	Off	Not stated
SC 01/11	55	Trained	Some	BNS	Recreation	Not stated	Surface	On	Not stated
H 01/1	23	Some	Experienced	Solo	Work	5	5	On	Not stated
H 01/2	35	Nil	Nil	BNS	Cray fishing	Not stated	Not stated	On	Not stated
H 01/3	32	Nil	Nil	BNS	Cray fishing	Not stated	Not stated	On	Not stated

BCD NEAR BOAT; FOUND FLOATING ON BACK WITH OVER-INFLATED BCD; OBESE; HISTORY PAST RTA CHEST INJURY AND ASTHMA; CAGE.

CASE SC 01/5

This 64-year-old woman and her husband had been making occasional dives for about 10 years, a total of about 100 dives. She was reportedly in good health, but had undergone left knee surgery six weeks earlier. When they booked for a live-aboard dive trip they were assessed before being accepted. After the second day's diving she said she was feeling more fatigued than she had expected. The next day the couple made a successful reef dive and after surfacing they decided to swim back to the boat just under the surface, the husband a little in advance of his wife. He began to feel breathless and found he was low on air, indeed had too little to inflate his BCD so he orally inflated it. Then he noted the absence of his wife and signalled to the dive tender. A short search located her, weights on, floating a little below the surface. It is not stated whether her BCD was inflated.

Autopsy

Her heart and coronary arteries were healthy, the cause of death being given as drowning.

Comment

It is probable that the combination of fatigue from swimming against the current, a tight wetsuit, low-air

In Australian Waters in 2001, Scuba and Hookah Incidents

CAGE – cerebral arterial gas embolism, GSB – group separation before incident, H – hookah, SC – scuba)

BOUYANCY VEST	REMAINING AIR	EQUIPMENT TESTED	EQUIPMENT WHOSE	COMMENTS
Inflated	Low	No fault	Own	CAGE.
Not inflated	Not stated	Not stated	Own	Drowned. Entangled in kelp. Buddy dropped only knife.
Not inflated	Low	NAD	Own	CAGE? Spontaneous pneumothorax. 1996 asthma. Post-operation abdominal pains.
Partially inflated	Low	Not tested	Borrowed	CAGE. Obese, BMI 32. History of chest injury and mild asthma.
Inflated	Nil	No fault	Own	Drowned. Separation. Fatigue. Tight wetsuit. Infected knee.
Buddy inflated	++	Not tested	Borrowed	Drowned. Nil training/experience. Surface rough. BCD not inflated, weight belt on. Could have stood up.
Inflated then deflated	Nil	No fault	Hired	Drowned. No diving for 4 to 5 years. Recent back pain. Deflated BCD.
Buddy inflated	++	Fault	Borrowed	CAGE. Under instruction. Damaged mouthpieces. Medical history.
Inflated	+	NAD	Hired	CAGE.
Not inflated	Low	NAD	Own	Cardiac death.
Buddy inflated	++	NAD	Own	Cardiac death.
Nil	n/a	Fault +	Employer	CO poisoning.
Nil	n/a	Fault +	Borrowed	CO poisoning.
Nil	n/a	Fault +	Borrowed	CO poisoning.

status such that, like her husband, she could not fully inflate her BCD, and failing to think to drop her weight belt, led to her drowning. She may have been distracted by pain from an infection in the left knee mentioned by her husband, but there was no complaint of any problem while diving and the condition of the knee was not reported at the autopsy.

Summary

SCUBA; TRAINED; MODERATE EXPERIENCE; LOW-AIR SWIM JUST BELOW SURFACE; SEPARATION; TIGHT WETSUIT; PAINFUL LEFT KNEE DUE TO POST-OPERATIVE INFECTION; FAILED TO DROP WEIGHT BELT; SILENT DEATH; DROWNING.

CASE SC 01/6

This 30-year-old man met a friend at the beach and after they had been surfing together he suggested they go for a scuba dive. The friend had been diving for many years, mainly for golf balls, but only taken a course a year ago. He knew that the victim had a wetsuit and surfed and never thought to ask whether he was trained, or had ever used scuba previously.

Their plan was for this to be a snorkel dive but wearing scuba 'for use in case of emergency'. The buddy loaned the victim the scuba equipment and checked that his equipment was in order before they entered the water from a beach. They waded out about 10 metres before reaching sufficiently deep water to begin snorkelling.

There was a slight swell at the beginning of the surf zone. They were only two to three metres apart at this time. A short time later the buddy heard a woman shouting out that someone was in trouble. He saw her returning to the beach and two swimmers, about 40 metres from the beach, trying to support another person's head above the water. There were 0.5–1 metre high waves breaking over them.

When the buddy reached the scene he heard his friend saying "I'm freaking out, I'm going in". The buddy jammed the regulator into the victim's mouth but he spat it out. It was possible here to stand on the seabed with head above the surface. They started to return to the beach, the victim 'dog paddling', but they became separated. The victim was found underwater after a short search, and the buddy released his weight belt and inflated his BCD to bring him to the surface, then brought him ashore with assistance from others.

Autopsy

There was an area of 50% narrowing of the left anterior descending coronary artery of unknown significance. The cause of death was given as drowning.

Comment

Panic, possibly due to total ignorance of scuba use, occurring in the rough but relatively shallow water, prevented him from remembering the life-saving response of ditching his weight belt and inflating his BCD and/or going onto scuba. As the victim's buddy had dived for years before obtaining training, not checking the victim's experience beforehand was understandable, though unwise. Whether his coronary condition affected his response cannot be known. This was really a snorkelling death whilst wearing scuba.

Summary

SCUBA BUT SNORKELLING; UNTRAINED; FIRST USE SCUBA; BORROWED EQUIPMENT; SEPARATION THEN PANIC IN ROUGH WATER; FAILED TO DROP WEIGHT BELT OR INFLATE BCD; FAILED TO GO ON SCUBA; COULD HAVE STOOD UP; SOME CORONARY ATHEROMA; DROWNING.

CASE SC 01/7

This 38-year-old diver had not dived for over four years because of a back injury. There was apparently no significant disability now and he was accepted for this live-aboard dive trip after disclosing his medical history. The instructor on the boat accepted his evidence of 40 previous dives as reason not to formally test his ability but a fellow passenger, his assigned buddy for the first three dives, was a qualified instructor and was satisfied with his ability. The passengers were transferred from the first boat following these dives to the one with sleeping quarters, and the first night he joined the guided night dive and was assessed as a confident diver. The next morning he was in a trio group, one member the boat's instructor, which experienced a strong current, and after they returned to the boat he took a rest.

That afternoon the same trio group dived again and the current was still strong. During this dive the instructor became separated but they met again after surfacing. They signalled for the tender to collect them as they floated with inflated BCDs. The victim became separated from the other two by the current and gave a signal for the others to be collected first. He appeared to look relaxed as he floated comfortably at the surface, but before the tender reached him he was seen to deflate his BCD and submerge. The initial search for him was unsuccessful but he was located later on the sea bed, all equipment in place, with just sufficient remaining air to inflate his BCD to assist raising his body.

Autopsy

The autopsy showed only signs of drowning in a healthy man. There is no evidence that the past injury to his back was implicated in the incident. The cause of death was given as drowning.

Comment

Cause of death was drowning but the reason why this occurred is conjecture. The work of swimming in the strong current plus the choppy surface conditions may have affected his actions. It is possible he pressed the deflate button in error and was too surprised by his submergence to react immediately by dropping his weights, then he inhaled water.

Summary

SCUBA; TRAINED; NO DIVES FOR 4–5 YEARS POST BACK INJURY; APPEARED COMPETENT DIVER; SURFACE SEPARATION BY STRONG CURRENT; BCD INFLATED THEN DEFLATED AND SANK; LOW AIR; FAILED TO DROP WEIGHT BELT; DROWNING.

CASE SC 01/8

An instructor offered to teach five of his friends to scuba dive using hired equipment. He insisted that they first obtain a medical certificate of their fitness to dive. At the time of the first lesson most used the excuse that they could not get an appointment in time, while the 26-year-old victim said he had been examined, which was untrue, but had left the note at home and he would bring it later. After the first lesson, during which he reportedly did not appear to be paying attention, they practised the basic skills in a pool, followed by an open water dive to a maximum depth of 6 msw. The planned duration of the dive was 26 minutes but after 12–13 minutes the victim indicated his need to return to the surface. There he explained he had felt claustrophobic but now felt better and the instructor, who had ascended with him, took him down to rejoin the others and the dive continued uneventfully.

The next day they made their second open water dive at the same location. Water entry was off a sloping rock shelf into shallow water, depth here 9 msw, but they descended initially to about 7 msw. Once again he soon indicated a wish to ascend. At the surface he again reported claustrophobia, but was reassured and he descended with his buddy, the instructor's assistant, to rejoin the others. All proceeded well until he was 'spooked' by a fish and started to make a panic ascent. His buddy grabbed him and tried to calm him but he struggled loose. His buddy just managed to catch one of his fins and, using his own weight, tried to slow the rate of ascent. At the surface, his buddy inflated his BCD for him and responded to his urgent desire to return to land by agreeing to tow him back to the beach. A short time later he "uttered an incredible sound, not a scream", and began making panting or grunting sounds. This was followed by his arms locking, and this muscle spasm lasted till he was only about 10 metres from shore. He was unconscious and not breathing; resuscitation efforts were unavailing.

Examination of the equipment showed damage to both the primary and secondary mouthpieces such that water entry occurred with inhalation. Subsequently, his medical history of bronchitis at age three and seven, prescription of sodium chromoglycate until he was 14, a motorcycle accident in 1998 and a fractured left wrist became available.

Autopsy

A CT scan showed a left-sided tension pneumothorax with a collapsed lung, a smaller pneumothorax on the right side, air in the right ventricle outflow tract but not in the heart, and subcutaneous emphysema. The coronary arteries were healthy. Histology of the lungs showed hypertrophy of the bronchial smooth muscle and basement membrane consistent with a history of asthma.

Comment

When good intentions meet Murphy's Law, the latter wins. Such was the case here. The instructor had not taken all reasonable care when he set aside the non-production of the medical certificates before commencing open water training. He did manage the panic episodes well. Handling any pupil showing panic or claustrophobia requires far more than a black and white decision. Also, the asthma history appears to have been hidden from the instructor. It is not possible to know whether the victim had genuinely forgotten his asthma history or decided to conceal it. The concordance of the latent asthma bronchial sensitivity with the defective mouthpieces producing salt-water aspiration, and his panicked ascent, resulted in him developing pulmonary barotrauma.

Summary

SCUBA; TRAINING CLASS; PANIC EPISODES; ASTHMA HISTORY NOT REVEALED; BORROWED EQUIPMENT; FAULTY MOUTHPIECES ALLOWED INHALATION OF SEA WATER; ADEQUATE AIR; VALIANT RESPONSE BY INSTRUCTOR TO SITUATION; PULMONARY BAROTRAUMA WITH BILATERAL PNEUMOTHORACES.

CASE SC 01/9

This 56-year-old man had an advanced diver qualification and had made a total of 20 dives. He was with his wife, son, and son's girlfriend, and they had signed up for a dive organised by his wife's instructor's dive shop. They were given a pre-dive briefing and had their equipment checked by the instructor before he allowed them to enter the water. His buddy had completed training six weeks previously and was now making his first post-course dive. There was some current and they were advised to snorkel out from the beach to a buoy 15–20 metres offshore before diving, which they did after each added some further weights.

Their contents gauges were reading 100–150 bar when they decided to begin their ascent after the victim had fixed his buddy's loose fin. They were at 10 msw and about two metres apart when they neared a steep rock wall and became separated. The buddy was unable to

find him so surfaced in shallow water close to rocks and exited the water. He then heard a shout for him to call an ambulance.

The victim's son was at the surface when he saw his father floating vertically in the rough water close to the rocks, but saw nothing unusual until there was no response to his signal suggesting he join him. When he swam closer he saw his father was now face down and not reacting as the waves washed him over the rocks. He had inflated his BCD although retained his weight belt. His son started to tow him into calmer water and called for help, but nobody heard. The dive class was below them and the son got his father's buddy to descend and get the attention of the instructor. The class was brought up and the instructor helped bring him ashore. Resuscitation efforts were unsuccessful.

Autopsy

A pre-autopsy CT check showed a small amount of air in the right ventricle outflow tract but it was not certain whether this resulted from off-gassing, the vigorous resuscitation efforts, or CAGE. The coronary vessels were healthy. The cause of death was given as drowning.

Comment

The clinical story of the incident suggests CAGE as the most likely cause. It is possible he made a hurried ascent after separating from his buddy, inadequately exhaling as he ascended. The 'advanced open water' certification may have hidden his real inexperience and a lack of confidence. It was noted that he had been under recent work and personal stress.

Summary

SCUBA; 'ADVANCED' DIVER WITH 20 DIVES; BUDDY MAKING FIRST POST-COURSE DIVE; SEPARATION; INFLATED BCD; FAILED TO DROP WEIGHT BELT; PROBABLE CAGE; DROWNING.

CASE SC 01/10

His wife regarded this 65-year-old instructor as healthy but he had confided in his dive buddy that he had recently become short of breath. They had discussed the matter but he did not attend for medical advice. This appeared to be a normal dive until at a depth of about 5 msw he became separated from his buddy. When the buddy surfaced he saw his friend sitting on a rock, gasping for breath. He was brought ashore but collapsed and did not respond to attempts to resuscitate him. He had ditched his weight belt and had plenty of air remaining.

Autopsy

Autopsy revealed severe ischaemic heart disease sufficient to account for death. There was marked coronary atherosclerosis, particularly in the left anterior descending artery, and evidence of a myocardial infarct during the previous six months. There was also some overexpansion of the lungs and it was reported as possible that the decedent had inhaled some water on the return swim.

Comment

This man failed to recognise the significance of his symptoms so did not seek medical advice. He probably left his buddy when first aware of chest or respiratory symptoms and correctly decided to return to the surface.

Summary

SCUBA; EXPERIENCED; INSTRUCTOR; SEPARATION; LEFT WATER BEFORE COLLAPSING; CORONARY ARTERY DISEASE; SUDDEN CARDIAC DEATH.

CASE SC 01/11

This 55-year-old man and his wife had trained 18 months previously and subsequently passed an 'advanced diver' course, but their actual experience is not documented. He was out of character this day, anxious and in an apparent hurry to get started on the dive organised by a friend. Just before they started, a fourth diver joined them and was buddied with his wife, his usual buddy. His wife and her buddy had already descended before he and his friend followed and were unaware of the drama that followed until after they had completed their dive.

Before they descended the buddy made the float with the divers' flag secure, then noticed a fin floating nearby and handed it to the victim, who had apparently not noticed his had come off. While he waited for him to replace his fin the buddy's thoughts were interrupted by a shout warning him someone was in trouble, followed by the command 'inflate your vest'. He then noticed the victim was putting his regulator in and out of his mouth. He quickly inflated both their BCDs and started to tow him to the shore, holding onto his hands. The buddy was badly exhausted when he reached the rocks but helpers

there pulled them from the water and started CPR, the witness who had called the warning among them. He happened to be the instructor for the victim's basic training course.

His wife reported that his breathing had been shallower for about nine months, but when he saw his doctor he was told it was due to being overweight.

Autopsy

The autopsy report was that the heart appeared normal and coronary atheroma moderate, maximal narrowing 50% in both right and left main arteries. The left ventricle wall was a normal 15 mm thick. The liver appeared abnormal, with a generalised patchy pallor. The official finding was of cardiac arrest due to coronary artery disease. As there was no formal inquest the police never followed up the widow's request that a report be obtained from the doctor.

Comment

No explanation was known for his behaviour change as he offered none, and no report was obtained from his doctor. His 'automation' actions with his regulator imply some cerebral dysfunction. The official investigation was terminated as soon as it was found that death was from natural causes. This prevented discussion of the reason for his behaviour, or a request for medical information from his doctor.

Summary

SCUBA; TRAINED; AT SURFACE ABOUT TO DESCEND WHEN BEHAVIOUR CHANGED; BUDDY INFLATED BOTH BCDs AND TOWED HIM TO ROCKS; RECENT BREATHING SYMPTOMS ATTRIBUTED TO OBESITY; CORONARY ARTERY DISEASE; SUDDEN CARDIAC DEATH.

Surface-Supply Breathing Apparatus (SSBA)

CASE H 01/1

This 23-year-old man was employed to dive for crayfish. Because these divers are required to provide their own equipment except for the air compressors and the dories they use, they are regarded as being self-employed and workplace safety regulations are not applied. He held a basic open water scuba certification and had a medical certificate of fitness to dive, so met the requirements for this employment. He was regarded as a careful and experienced diver, and indeed had been given a diver holding both basic and advanced open water certification to train.

The mother boat towed three working dories, the one used by the victim being described as difficult to handle, leaking, and poorly laid out. He was wearing shorts, wetsuit jacket with hood, mask, fins, and a weighted jacket. There was no bail-out bottle. It was the tender's job to follow his bubbles in the dory as he hunted for crayfish. Neither examined the compressor on board properly before diving. After 30 minutes he surfaced 10–15 metres from the dory but descended a short way before the dory could reach him. This ascent and descent was made four times, his gauge later showing he descended 3–6 metres each time, before his last descent. On the last occasion he surfaced he moved his hand over his face making the tender think he was having an equalisation problem like he had the previous day.

This behaviour was strange and outside the tender's experience so it was several minutes before he gave a three-pull recall, using the hose. At this time the compressor stopped but there was adequate air in its reservoir tank so the tender decided to pull the victim up using the hose. When he came into view he was limp, unconscious, and not breathing. There was no response to resuscitation.

Autopsy

The autopsy confirmed that he had been a healthy man. There was no evidence of pulmonary barotrauma, the chest being opened under water to exclude a pneumothorax. There was no air in the heart. Lung histology showed there had been aspiration of food, common in drowning. The carboxyhaemoglobin level was 35%, sufficient to alter his level of consciousness and to lead to confusion and collapse on exertion. The cause of death was given as drowning secondary to acute carbon monoxide (CO) poisoning.

Comment

None of the divers had obtained training as commercial divers because this cost $10,000 and was largely irrelevant to their needs. Open water scuba certification does not include training in maintaining an air compressor or the use of surface-supplied (hookah) breathing apparatus. The equipment had many faults, in particular that the air intake hose kinked easily and had cracks, and the compressor was low in the dory so had reduced air cooling and ran too hot for the lubricating oil used. The jacket weights could not be dropped easily. The absence of a bail-out bottle was not significant in this case as it would have contained CO polluted air. The pressure relief valve

was set too low so it was difficult for a diver at depth to obtain enough air.

Summary

HOOKAH; SCUBA TRAINED ONLY; EXPERIENCED; POORLY MAINTAINED HOME-MADE AIR COMPRESSOR; WEIGHT VEST DIFFICULT TO RELEASE; INADEQUATE PRESSURE TO SUPPLY SUFFICIENT AIR AT DEPTH; CARBON MONOXIDE POISONING; DROWNING.

CASES H 01/2 and H 01/3

The air compressor was owned by one of the six friends who took it to a rocky coastal area to hunt for crayfish. Only four planned to dive, and none was either trained or experienced in its use. One was aware of the need to have the inlet upwind but nobody was deputised to supervise its functioning. The first two surfaced after five minutes and complained about the air quality and of headaches. The compressor was moved from the rock hollow onto a pile of stones, so as to be more in the breeze, and two metres of the hose were cut off, stuffed into the intake opening and 'sealed' there with a plastic bag. They then continued their dive till they surfaced again reporting dry mouths. The compressor was now noted to be so hot it had burned the grass near it, so was turned off and the air reservoir vented. There was a single air hose from the compressor and this had a float at the 'Y' junction where the hoses to supply the two divers were attached.

Soon after the next couple of divers entered the water, smoke was seen coming from the air compressor, but this ceased after the air intake was pulled out and the divers continued unaware of this. But 5–10 minutes later the tanks were noticed to be getting hot and someone suggested they pull up the divers. When they came to the surface they were unconscious, and could not be revived.

Autopsy

Pre-autopsy CT examination showed no evidence of arterial gas embolism in either decedent. Both divers had healthy coronary arteries. The carboxyhaemoglobin levels were 28% in H 01/2 and 55% in H 01/3. The cause of death was given as drowning secondary to CO poisoning.

Comment

This double tragedy illustrates the fact that hookah equipment is not a fail-safe alternative to scuba. The two divers would have lost consciousness and drowned without becoming aware of their danger. The level in H 01/3 was approaching the lethal range of CO, while that in H 01/2 was sufficient to cause disorientation or, possibly, loss of consciousness. The compressor unit was home-made and had many potentially lethal factors present, such as loose fittings, and a filter consisting of a nylon bag of cotton wool balls and stocking filled with activated charcoal. Tests of air quality revealed CO and oil levels too high to measure. The divers' toleration of 'dirty air' proved fatal. It is likely that other divers use poorly maintained air compressors and are at similar risk but fail to realise the fact.

Summary

HOOKAH; UNTRAINED; NO EXPERIENCE OF HOOKAH DIVING; HOME-MADE AIR COMPRESSOR WITH MANY MAJOR FAULTS; CARBON MONOXIDE POISONING; DOUBLE FATALITY; DROWNING.

DISCUSSION

BREATH-HOLD DIVERS AND SNORKEL USERS

These fatalities, as usual, fall into two clearly defined groups: those making (or intending to make) breath-hold dives, particularly to spear fish, and those simply swimming while wearing a mask and snorkel. There were six cases in each group. The apparent critical factors clearly differentiated the two groups.

The causes of death in the breath-hold divers were post-hyperventilation blackout drowning in two (BH 01/3, BH 01/12), water power in two (BH 01/5, BH 01/8), trauma (BH 01/6), and acute myocardial infarction (BH 01/10). The danger of hyperventilating to increase underwater duration is well documented but the risk of death from this is sufficiently low to be ignored by those determined to extend their underwater times and disbelieving of the experience of others. Spear fishing is not an altogether safe sport.

The fatal trauma from an outboard motor's propeller resulted from inadequate safety practices on the part of both the victim and the boat driver, and avoidance of such events depends on all parties following recommended safe practices. The acute heart attack was a truly unpredictable event, though had the victim's doctor recognised the true cause of his reported symptoms it is possible he would have been advised not to dive. Water power was the apparent

critical factor in two cases, inexperience leading to their inability to correctly manage the conditions. It can be fatal to be in water beyond one's comfort zone.

The other group consisted of swimmers using snorkels, often for the first time, chiefly elderly visitors from out of state. Death among snorkel-swimming visitors to the Barrier Reef is an ongoing problem. While completion of a health questionnaire by boat passengers before permitting them to snorkel is now generally a requirement, it is undoubtedly true that many are unaware of their true medical status. There is also the problem of deciding acceptable levels of risk; to live constantly consulting one's actuarial risk of death may be thought an unhealthy choice. In one case (BH 01/2) the person's obvious anxiety was ignored, and there was failure by those responsible for the safety of the passengers.

The majority of these deaths occurred despite alert safety watchers who may not recognise that a swimmer is in trouble in a crowd when there are no outward signs of a problem, as is often the case. Although one of this group had obtained and worn a buoyancy vest initially, this had been removed before swimming away from the boat. The intended function of these flotation aids is different from that of a life jacket. As these vests tend to float the wearer face down they have a limited safety function in an unconscious wearer, and if they were designed to keep the wearer face up they would not be appreciated by anyone trying to view the marvels of the underwater world! Whether greater stressing of the advice to swim with a buddy would alter behaviour is debatable.

The most common critical factor in this group was cardiac disease with at least three dying from this cause (BH 01/4, 01/7, 01/9) and possibly a fourth (BH 01/1). Simple drowning was the finding in two cases (BH 01/5, 01/11) and here inexperience was a significant factor influencing the course of events.

SCUBA DIVERS

There were 11 fatalities identified in association with scuba diving, of which three (SC 01/1, SC 01/4, SC 01/8), probably a fourth (SC 01/9), and possibly a fifth (SC 01/3) were diagnosable as due to pulmonary barotrauma/air embolism, based on autopsy findings and/or the case history. In two cases (SC 01/1, SC 01/4), the deceased were aware of a looming low-air situation. It is of interest that in case SC 01/4 the victim was accompanied during the ascent and the rate reportedly not excessive. Failure to exhale adequately may occur during an apparently correct ascent. In one case the buddy was unable to fully control the victim's rate of ascent (SC 01/8) and in two cases (SC 01/1, SC 01/9) separation occurred during the ascent. In all of these cases there was a brief delay after surfacing before consciousness was lost. Three of the scuba divers can be considered to have been inexperienced. Claustrophobia has the potential to cause panic and is best not experienced while immersed.

Cardiac factors were thought critical in two cases (SC 01/10, SC 01/11) and in each there had been symptoms mentioned of some occasional breathlessness during the weeks preceding their deaths. It was unfortunate that when SC 01/11 attended his doctor concerning his symptoms his obesity was targeted rather than his heart. Although diver SC 01/3 attended a doctor before her 'refresher' course it is not known whether she revealed either her asthma or history of spontaneous pneumothorax and surgery. Failure by the doctor to keep any notes of the consultation could be regarded as negligent.

The question of the possible significance of a history of childhood asthma in relation to diving safety is raised by cases SC 01/3 and SC 01/8, though in each there were significant additional adverse factors that played a major part in the outcomes.

In the cases where drowning was the given cause of death, the circumstances were unique to each. The dangers of ignoring the 'nanny' advice on safe diving practices is demonstrated, as are the factors of panic and of running low on air. Scuba-related deaths, other than from acute cardiac events, usually show the presence of more than one adverse factor, attention to any one of which would have possibly prevented the fatal outcome. The concordance of several adverse factors supports a contention that the greater the failure to observe the advised safe diving procedures, the less is the margin of safety. This suggests the problem is best tackled through improved training protocols, which should inculcate an intolerance of allowing a low-air situation to develop. Buddy breathing cannot be relied upon as a safe and sure alternative to monitoring the contents, gauge, even assuming the gauge is reading accurately. Panic is a killer.

SURFACE SUPPLY BREATHING APPARATUS (SSBA)

Major risk factors are CO in the air through faults in the compressor or positioning of the air-intake hose, and hookah hose disconnection, particularly if no

'go home' bottle is worn and no lifeline attached. CO is a silent killer and refusal to accept 'dirty air' and imperfectly maintained compressors would be a lifesaver. The lack of enforceable health and safety regulations in the pearling, crayfish, and *beche de mer* industries is a serious concern. Closer controls on the employment of divers appear long overdue. There should be zero tolerance of unsafe working conditions rigorously enforced by all those who oversee workplace safety. It should be mandatory for employed divers to receive formal training in SSBA and diving techniques before using them. It is difficult to see how recreational hookah users can be persuaded of the need for training additional to basic scuba training or the foolishness of tolerating 'dirty air'.

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The involvement of the State Coronial Departments, Workplace Health and Safety Queensland, Queensland and NSW Police, the NCIS, and DAN Asia-Pacific is essential to the success of Project Stickybeak.

References

1. Walker D. *Report on Australian diving deaths 1972-1993*. Melbourne: JL Publications Ltd; 1998.

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3. Walker D. *Provisional report on diving-related fatalities in Australian waters 1999*. SPUMS J. 2005; 35: 183-93.

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2002: Australian Diving-Related Fatalities

Overview

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.[1–5] 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.[4] 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.

CASE REPORTS

Breath-hold and Snorkel Users

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. 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 JELLFISH 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.

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 around 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.

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 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 could 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

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

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 reinstituted. 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.

In Australian Waters in 2002, snorkel and breath-hold incidents

BSD - buddy separation during incident, GSB – Group Separation Before Incident)

DEPTH (msw)		WEIGHT BELT	COMMENT
DIVE	INCIDENT		
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	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

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 warfaring 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 as 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 the 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 the 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-yearold 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.100m1^{-1}. 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 breathhold 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 to 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, sertaline 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 therosclerosis, 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 mmo1.L^{-1} 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

SPEAR FISHING; 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 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,[7] 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[7]. In summary, she was obese, with limited mobility from a previous back injury. She was diving 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; 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 5mm wetsuit, over which she had a thermal short-sleeve vest with a hood. After a buoyancy check, she dived with 10.5kg 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 12kg 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 40m 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.

Table 2. Summary of diving-related fatalities in Australian waters in 2002, scuba & 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
Scuba							
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
Hookah							
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

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 re grouping 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

(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)* INCIDENT	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

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 $mg.m^{-3}$; the recommended upper limit <100 $mg.m^{-3}$) 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. 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 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 as 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[8]. 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 he 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.

Surface Supply Breathing Apparatus (SSBA)

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.[7]

It was an excellent day for diving, a calm sea with visibility of 6–9 metres, water temperature 22ºC 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 $kg.m^{-2}$) 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 it 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 50m (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.[10]

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.[11] 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 cutoff 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.

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SUMMARY OF DIVE-RELATED DEATHS 1999 – 2002

DEATHS BY DIVING ACTIVITY

These reports include details of 86 dive-related deaths reported during this period, an average of 21.5 deaths per year. This has risen from an average of 18.4 deaths per year for the period from 1994 to 1998.* The breakdown of diving activities being undertaken at the time of death is shown in Table 1 and pictorially in Figure 1.

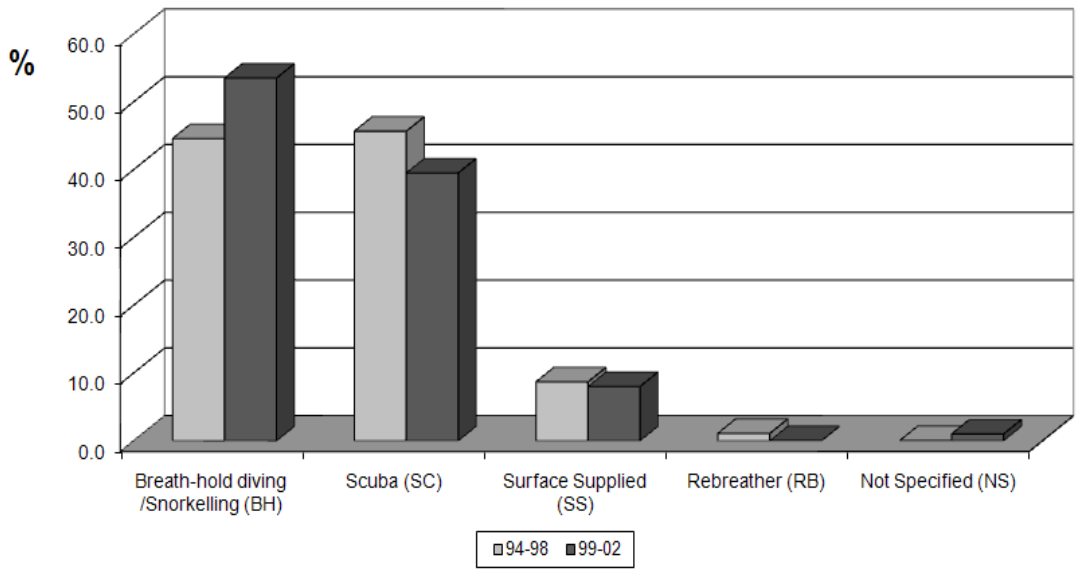
Table 1

Diving activity undertaken when death occurred 1999-2002.

Activity	Number	%
Breath-hold diving/snorkelling (BH)	44	51
Scuba (SC)	34	40
Surface supplied (SS)	7	8
Not specified (NS)	1	1
Total	**86**	**100**

Figure 1

Diving activity undertaken when death occurred (%), 1994-1998 (n = 92) and 1999-2002 (n = 86).



***NOTE:** Since the various annual provisional reports for 1994-98 were published DAN AP received scant details of another five diving related fatalities, including one using scuba, three snorkel and one where the equipment was not specified. All of these cases were recorded as deaths due to drowning. However, these five cases are not included in the above summaries as insufficient details are known.

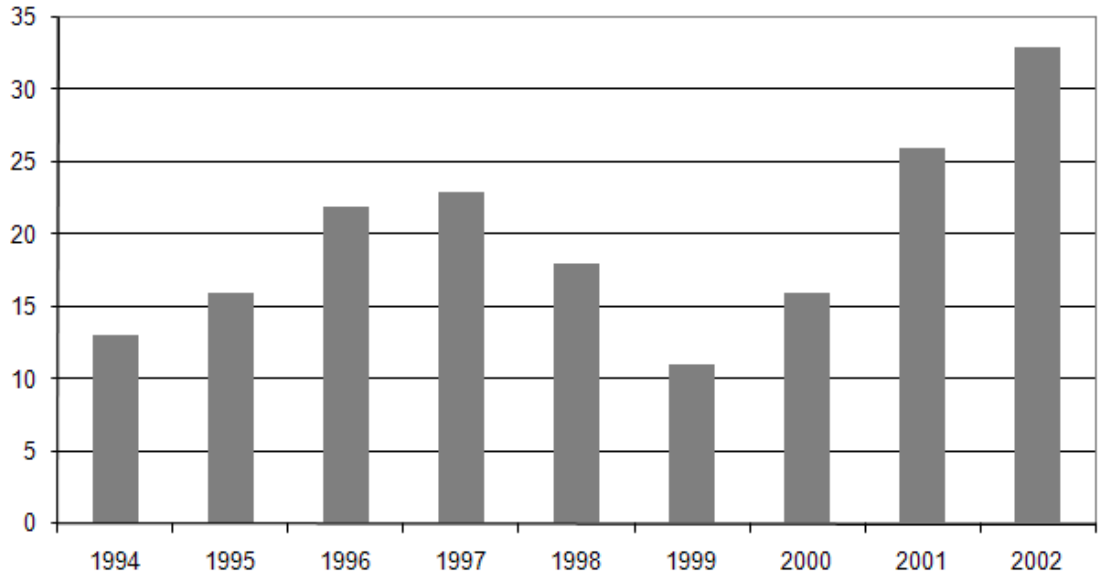
Table 2

Annual diving-related deaths 1999-2002.

Activity	1999	2000	2001	2002	Total
BH	6	9	12	17	44
SC	5	5	11	13	34
SS	0	1	3	3	7
NS	0	1	0	0	1
Total	**11**	**16**	**26**	**33**	**86**

Figure 2

Annual diving-related deaths 1994-2002 (n = 178).



AGE DISTRIBUTION OF VICTIMS

The figures below do not include the deaths of divers using surface supply and those in which the equipment used was not specified. Although during the 1999-2002 period the highest frequency of victims fell into the 20-29 years age group, 61.5% of victims were 40 years of age or older.

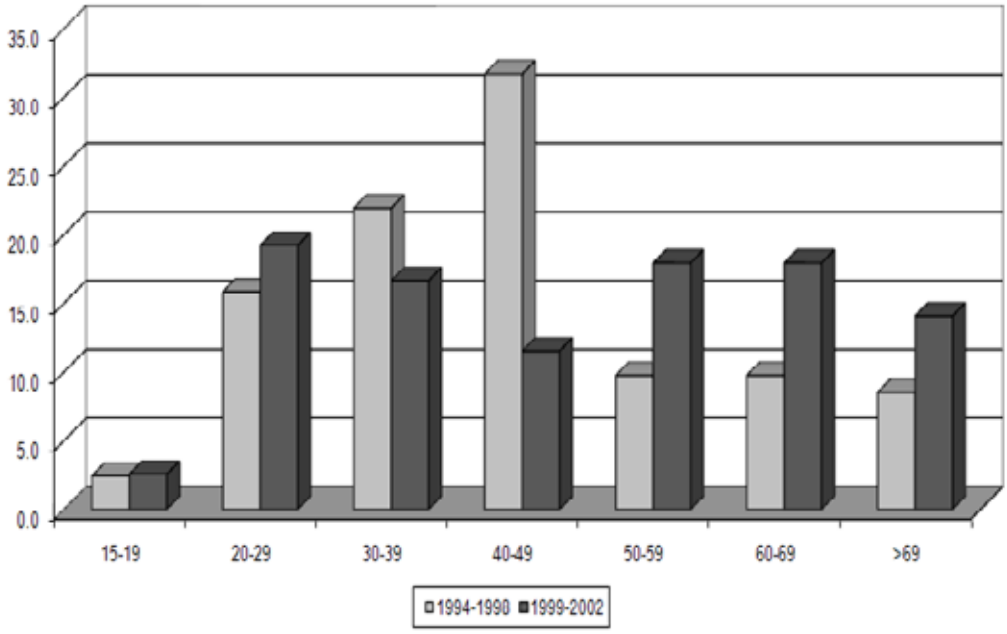
Table 3

Age distribution of 78 scuba, breath-hold and snorkeller fatalities 1999-2002 (n = 78).

Age	<15	15-19	20-29	30-39	40-49	50-59	60-69	>69
Deaths	0	2	15	13	9	14	14	11

Figure 3

Age distribution (%) of scuba, breath-hold and snorkeller fatalities, 1994-98 (n = 82) and 1999-2002 (n = 78).



It is important to note that, in the period 1999-2002, a total of 53% of scuba victims were aged 40 years or older. Similarly, 68% of the snorkel/breath-hold-related deaths occurred in victims aged 40 or more and these deaths were more frequent in those aged 70 years or older. Many of these deaths were cardiac-related.

Table 4

Age distribution of scuba fatalities 1999-2002 (n = 34).

Age	<15	15-19	20-29	30-39	40-49	50-59	60-69	>69
Deaths	0	1	8	7	4	8	6	0

Figure 4

Age distribution (%) of scuba fatalities 1994-98 (n = 42) and 1999-2002 (n = 34).

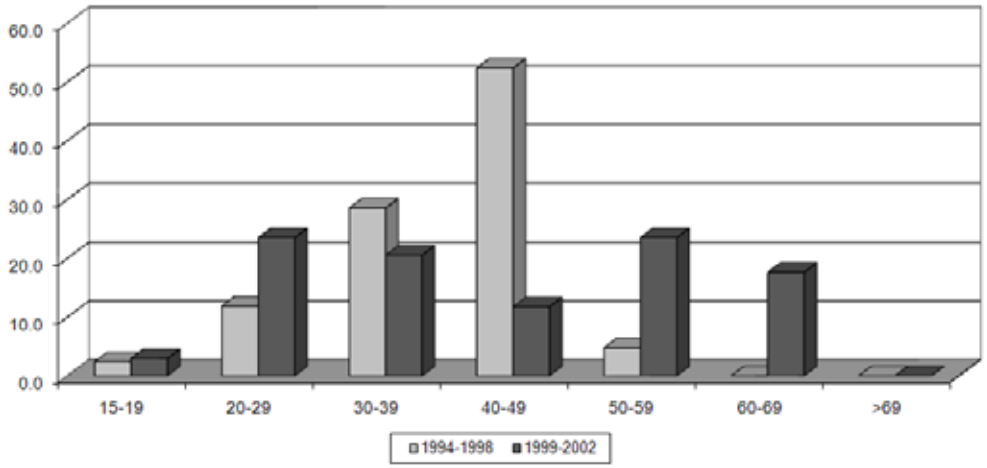


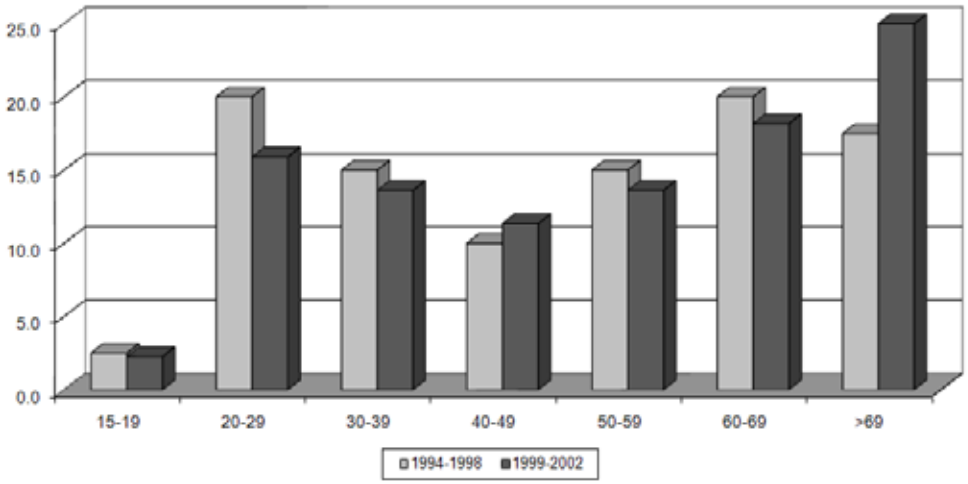
Table 5

Age distribution in 44 breath-hold and snorkel fatalities 1999-2002.

Age	<15	15-19	20-29	30-39	40-49	50-59	60-69	>69
Deaths	0	1	7	6	5	6	8	11

Figure 5

Age distribution (%) of breath-hold and snorkel fatalities 1994-98 (n = 40) and 1999-2002 (n = 44).



GENDER OF VICTIMS

Although the distribution varied from year to year, in the period from 1999 to 2002, overall approximately two thirds of the victims were males and one third females, which is likely to be reflective of the gender breakdown of divers in Australia during that period.

Table 6

Gender in 34 scuba fatalities 1999-2002.

Year	Male	% Male	Female	% Female
1999	3	60	2	40
2000	3	60	2	40
2001	9	82	2	18
2002	8	62	5	38
Total	**23**	**68%**	**11**	**32%**

Figure 6

Gender (%) in scuba fatalities 1994-1998 (n = 42) and 1999-2002 (n = 34).

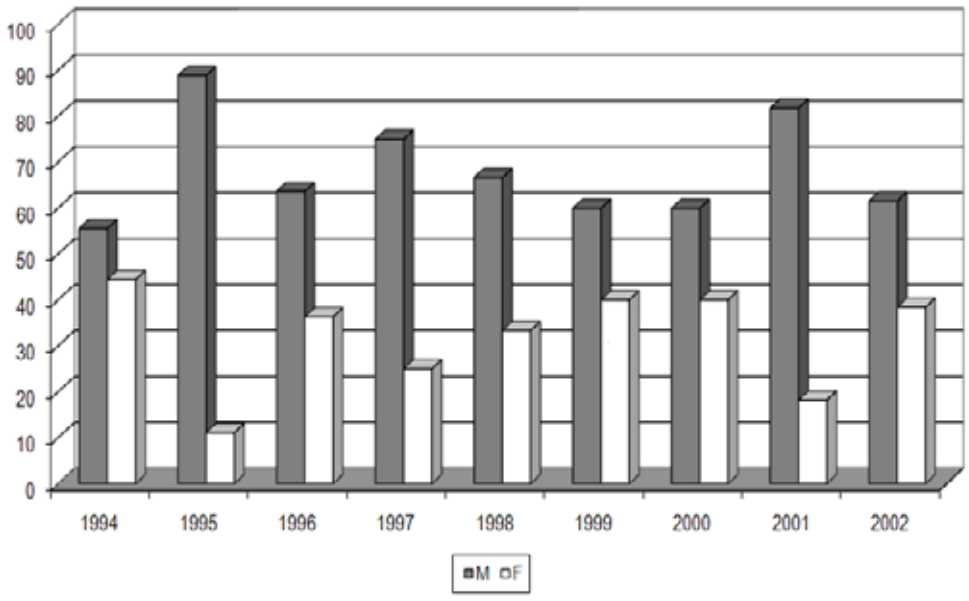


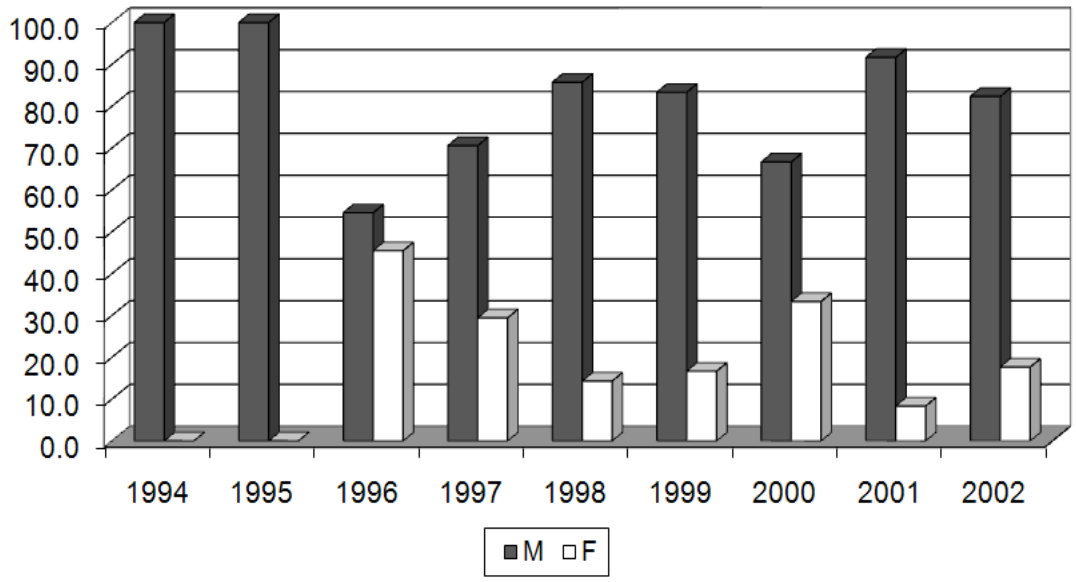
Table 7

Gender in 44 breath-hold and snorkel fatalities 1999-2002.

Year	Male	% Male	Female	% Female
1999	5	83	1	17
2000	6	67	3	33
2001	11	92	1	8
2002	14	82	3	18
Total	**36**	**82%**	**8**	**18%**

Figure 7

Gender (%) in breath-hold and snorkel fatalities 1994-1998 (n = 40) and 1999-2002 (n = 44).



CAUSE OF DEATH

Table 8

Cause of death in 34 scuba divers 1999-2002.

Cause	Number
Drowning	12
Cardiac	11
CAGE	9
Not specified	2
Total	**34**

Figure 8

Cause of death in scuba divers 1994-1998 (n = 42) and 1999-2002 (n = 34).

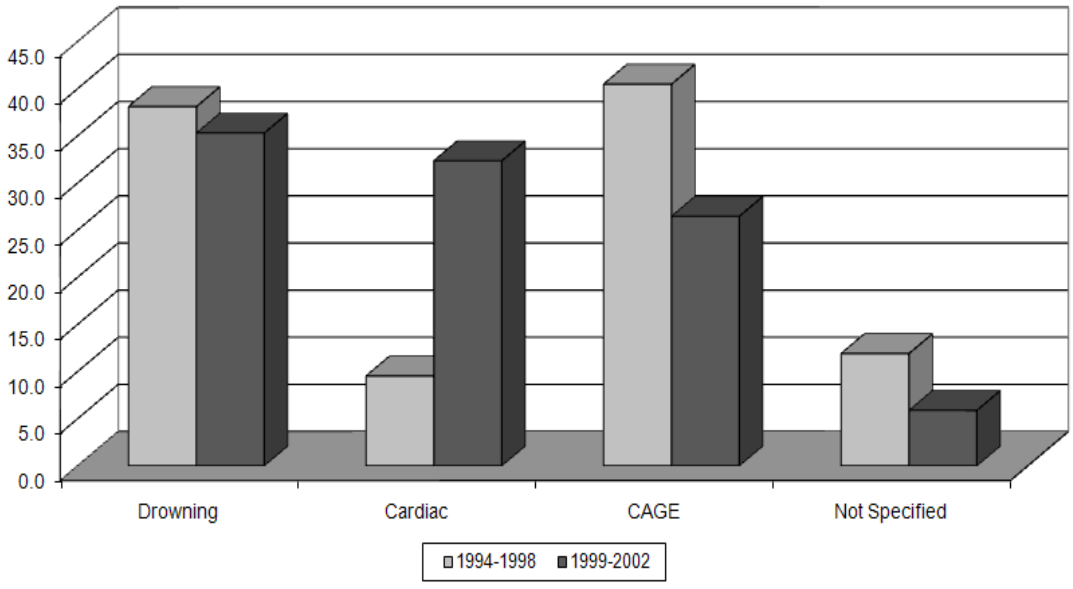


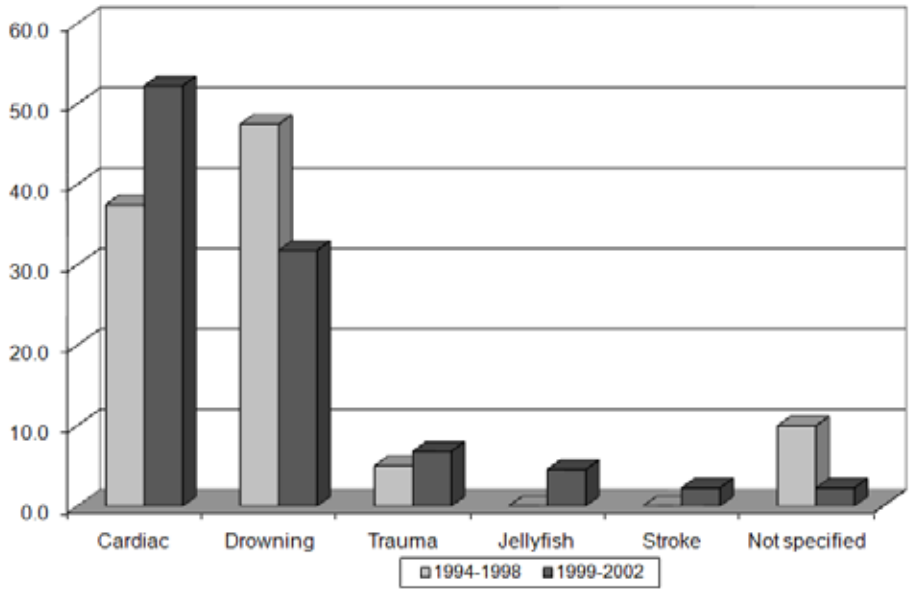
Table 9

Cause of death in breath-hold/snorkellers 1999-2002 (n = 44).

Cause	Number
Cardiac	23
Drowning	14
Trauma	3
Jellyfish sting-related	2
Stroke	1
Not specified	1
Total	**44**

Figure 9

Cause of death in breath-hold/snorkellers 1994-1998 (n = 40) and 1999-2002 (n = 44).



ROOT CAUSE ANALYSIS

The process of root cause analysis (RCA) can be applied to the investigation of diving fatalities with the aim of improving understanding of the sequence of events associated with such an accident. Categories include trigger, disabling agent, disabling injury and cause of death. Sometimes the disabling injury can be more relevant to the assessment of a diving fatality than the cause of death. An example of this is a situation in which a diver suffers a cerebral arterial gas embolism (CAGE) becomes unconscious in the water and subsequently drowns. The cause of death, in this case drowning, may not provide as good an insight into the accident as the fact that the diver suffered from CAGE. This process has been applied to each case in this series as shown in Table 10.

Table 10
Root Cause Analysis of 34 scuba fatalities 1999-2002.

Trigger	Disabling Agent	Disabling Injury	Cause of Death
Out of air	Rapid ascent	CAGE	Drowning
Rough water	Loss of gas supply	Asphyxia	Drowning
Stress / exertion	NS	? Cardiac incident	?Cardiac-related
Stress / exertion	CVD	Cardiac incident	Cardiac-related
Buoyancy problem	Buoyancy problem	Asphyxia	Drowning
Stress / short of breath	CVD	Cardiac incident	Cardiac-related
Stress / cold	?CVD	? Cardiac incident	? Cardiac-related
Exertion	CVD	Cardiac incident	Cardiac-related
Cardiac (LQTS)	Loss of consciousness	Cardiac incident	Cardiac-related
Exertion / current	CVD	Cardiac incident	Cardiac-related
Stress	CVD	Cardiac incident	Cardiac-related
Mild exertion	CVD	Cardiac incident	Cardiac-related
Ascent	Lung cyst burst	PBT/CAGE	CAGE
Tight suit	CVD	Cardiac incident	Cardiac-related
Shell fish collection	Shark attack	Trauma	Trauma
Boat impact	Blow to head	Head injury	Delayed complications
Insufficient gas	Breathhold during ascent	CAGE	CAGE
Entrapment	Insufficient gas	Asphyxia	Drowning
Buoyancy problem	Insufficient gas	Asphyxia	Drowning
Insufficient gas	Breathhold during ascent	CAGE	CAGE
Exertion	Insufficient gas	Ashpyxia	Drowning
Panic / rough water	Loss of gas supply	Asphyxia	Drowning
Exertion / current	Loss of gas supply	Asphyxia	Drowning
Stress	Rapid ascent	PBT / CAGE	CAGE
Rough water	Rapid ascent	CAGE	Drowning
Mild exertion	CVD	Cardiac incident	Cardiac-related
Stress	CVD	Cardiac incident	Cardiac-related
Equipment problem	Gas contamination (CO)	Asphyxia	Drowning
Equipment problem	Gas contamination (CO)	Asphyxia	Drowning
Equipment problem	Gas contamination (CO)	Asphyxia	Drowning
Insufficient gas	Loss of gas supply	Asphyxia	Drowning
NS	NS	NS	? (body missing)
NS	NS	NS	? (body missing)
Stress	Loss of consciousness	CAGE	CAGE
Exertion	Exhaustion	Asphyxia	Drowning
Equipment problem	Loss of gas supply	Asphyxia	Drowning
Stress	Rapid ascent	CAGE	CAGE
Stress	Insufficient gas	Asphyxia	Drowning
NS	NS	PBT / CAGE	PBT / CAGE
U/W avalanche	Rapid ascent	PBT / CAGE	PBT / CAGE
Stress	Rapid ascent	CAGE	CAGE

NOTE: NS = insufficient information on which to make a suggestion; PBT = Pulmonary Barotrauma; CVD = Cardiovascular Disease; CAGE = Cerebral Arterial Gas Embolism.

DIVING ACCIDENT REPORT

DAN is a non-profit dive safety organisation whose aim is to sponsor data collection and research into diving incidents, and their prevention. To support this research, DAN collects and analyses information about diving incidents. DAN Asia-Pacific undertakes to hold the names and contacts of individuals involved as confidential.

INFORMATION ABOUT THE INCIDENT

Date: _____ Time: _____

Nearest Town: _____ Country: _____

BRIEF DESCRIPTION OF INCIDENT

TYPE OF INCIDENT

☐ Decompression Illness ☐ Drowning / Near drowning ☐ Trauma
☐ Other:

DETAILS OF INJURED PERSON

Name: _____

Contacts: _____

Age / Birthdate: _____

Gender: ☐ Male ☐ Female

Certification Level

☐ Not known ☐ In Training ☐ Open Water ☐ Advanced ☐ Divemaster
☐ Instructor ☐ Technical ☐ Commercial

Experience: Years diving: Total no. of dives:
Total dives in last 12 months:

Outcome: ☐ Fatal ☐ Non-Fatal

REPORTED BY:

Name: _____

Contact Ph: _____

Email: _____

Divers Alert Network (DAN Asia-Pacific) is a world leader in the provision of accident management training for the diving community, home, workplace and beyond.

First Aid

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Cardiopulmonary Resuscitation

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