

Original article

Provisional report on diving-related fatalities in Australian waters 2001

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Key words

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

Abstract

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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

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.

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

**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

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 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.

**in Australian waters in 2001, breath-hold incidents
BSD – buddy separation during incident, GSB – group separation before incident)**

Weight belt 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.

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. Spear fishing 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 spear fishing.

Summary

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

Scuba divers

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

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)		Weight belt On	Kg
						Dive	Incident		
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

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 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.

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	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.

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 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 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 member 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 'automaton' 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 PRSSURE 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.

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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