Snorkelling-related deaths in Australia, 1994–2006

Snorkelling is a popular aquatic activity in Australia. In 2007, there were an estimated 2.2 million snorkelling dives conducted on the Great Barrier Reef alone. From the perspective of this exposure denominator, reports of harm from snorkelling are rare, and it can generally be considered a safe activity.

Nevertheless, a 1999 report on a 10-year survey of snorkelling-related deaths in Australia highlighted the need for increased vigilance on the part of snorkellers and those who care for them. Whereas both the absolute numbers and the rates of all reported drowning deaths have fallen over the past two decades, the absolute numbers of reported snorkelling-related deaths have increased. In 2006, 10 of 16 diving-related deaths involved snorkellers.

In previous studies in Australia and New Zealand, most snorkelling-related deaths followed one of two typical scenarios. One scenario was of a single, sober victim, often a tourist, snorkelling in a small group in relatively calm seas, who was later observed floating, apparently dead. The other involved a relatively young, typically male, spear fisherman who was snorkelling alone or had lost contact with his “buddy” and failed to surface. Some snorkellers died after post-hyperventilation breath-holding (The practice of taking a series of deep breaths with greater than normal expirations before breath-holding can prolong apnoea by reducing the initial blood carbon dioxide levels, with very little associated increase in oxygenation. This, in turn, delays the stimulus to breathe beyond the point where the diver becomes unconscious from hypoxia.)

The aim of our study was to examine the frequency and causes of snorkelling-related deaths in Australia.

Abstract

Objective: To examine the frequency and causes of snorkelling-related deaths in Australia.

Design, setting and subjects: We conducted a retrospective analysis of snorkelling-related deaths recorded in Australia from 1994 to 2006 inclusive, based on information from the Divers Alert Network Asia-Pacific database, the National Coroners Information System, coronial files from all states and territories, and annual national drowning reports.

Main outcome measures: Number and attributed causes of snorkelling-related deaths.

Results: We identified 140 snorkelling-related deaths. Forensic details were available for 130 of these. Four principal cause-of-death categories were identified; deaths from cardiac or suspected cardiac causes (60), deaths from surface drowning (largely in inexperienced snorkellers) (33), deaths from drowning after prolonged breath-hold diving (largely in experienced divers) (19), and deaths from trauma (10). Eight people died of other causes.

Conclusions: In the context of the large population sampled, snorkelling-related deaths are rare. Preventive measures for such deaths could include pre-dive medical assessments for people with a history of cardiac or respiratory disease or with a family history of sudden unexpected death; improved training in how to use snorkelling equipment; better matching of skills to health, fitness and water conditions; better supervision and quality training of supervisors in rescue and resuscitation techniques; and avoidance of hyperventilation before breath-hold diving.

Methods

The Divers Alert Network (DAN) Asia-Pacific, based in Melbourne, provides support to injured divers throughout the Asia-Pacific region. It compiles and maintains a database with details of all diving-related deaths in the region. These include deaths resulting from snorkelling, scuba and surface-supplied diving activities.

In our analysis, we defined snorkellers as swimmers using a mask and snorkel, whether floating or swimming at the surface, including breath-hold diving.

Historical data were obtained through Project Stickybeak reports compiled by DAN Asia-Pacific between 1996 and 2002. More recent data (2003–2006) were compiled from the DAN fatality database; information provided by divers, dive operators, police and workplace authorities; newspaper and internet reports; the annual national drowning reports; the National Coroners Information System; and additional coronial files (for closed cases) from all states and territories of Australia. We began with cases listed in the DAN database, then cross-referenced these with the other information sources.

We reviewed and analysed details of every recorded snorkelling-related death in Australia from 1994 to 2006 inclusive.

Ethics approval

Ethics approval for the ongoing collection and reporting of data by DAN Asia-Pacific has been received from the Victorian Department of Justice Human Research Ethics Committee, the Royal Prince Alfred Hospital Human Research Ethics Committee, the Coroner’s Court of Western Australia, and the Queensland Office of the State Coroner.

Results

Over the 13-year period, we identified 140 snorkelling-related deaths — an
average of about 11 per year. Annual 
frequencies of deaths from 1994 to 
2006 are shown in Box 1. In 10 of the 
140 cases, forensic pathology details 
were unavailable, either because the 
body was never found or there was no 
autopsy. Characteristics of the 
remaining 130 victims are summa-
rised in Box 2.

Four principal cause-of-death cate-
gories in snorkellers were identified, 
each with unique and separate pre-
ventive implications: cardiac-related 
causes (proven or suspected), surface 
drowning (largely in inexperienced 
snorkellers), drowning after extended 
breath-hold diving (almost exclusively in 
experienced divers), and trauma. 

Sixty snorkelling-related deaths 
were attributed to, or thought likely to 
be associated with, cardiac causes. 
Thirty-four of these deaths occurred 
in people with a known history of 
cardiac disease or a significant medi-
cal history with potential cardiac 
comorbidity. The remaining 26 vic-
tims had no prior cardiac condition or 
significant medical history, and five of 
these had no anatomical evidence of 
cardiac pathology at autopsy. Forensic 
pathologists experienced in diving 
cases suggested that the subgroup 
with no cardiac history and no evi-
dence of cardiac pathology were most 
likely the victims of dysrhythmias.

The second-highest cause of death 
after cardiac disease was drowning.

Discussion

The most common cause of death in 
snorkellers appears to be cardiac dis-
ease. People who die from this cause 
are typically sober, middle-aged or 
older males, enjoying the novel expe-
rience, autonomic cardiogenic 
reflexes triggered by the diving reflex 
or tracheal-cardiac vagal reflexes after 
the inadvertent inhalation of small 
amounts of sea water. Such dysrhyth-
miass have been known to trigger fatal 
cardiac-related outcomes in people 
with pre-existing cardiac disease. 
Immersion bradycardia (part of the div-
ing reflex) may progress to various types 
of dysrhythmia, specifically P wave 
abnormalities and abnormal nodal 
rhythms. We posit that this process 
may lead to fatal dysrhythmias not only 
in people who are predisposed by exist-
ing coronary disease (eg, coronary 
artery disease or acute or chronic 
myopathies), electrical conduction 
defects or channelopathies, but also in 
otherwise normal people. Unaccus-
tomed exercise, especially if vigorous, in 
people in an “at-risk” demographic 
group for coronary artery disease is a 
potential trigger for sudden cardiac 
death, whether due to dysrhythmias or 
infarction.

Given the enormous denominator of 
exposure experience in our Australia-
wide survey over a 13-year period, we 
do not wish to overstate the small risk 
of cardiogenic death while snorkelling, 
but rather to highlight the increased 
relative risk of death if pre-existing car-
diac disease is known to be present. 
Some large tourist boats in Queensland 
carry automated external defibrillators. 
However, the availability of a defibra-
tor does not guarantee survival, partly 
because of the delays in the recognition 
of a problem and the retrieval of the 
victim. Intending snorkellers with pre-
existing cardiac disease or other serious 
conditions with potential cardiac 
comorbidity should have a prior medi-
cal consultation and be prudent in their 
physical exertion.

The second major category of 
deaths was among relatively inexperi-
enced snorkellers who drowned. 
Many such deaths occur in novices 
who aspirate water from their snorkel 
because of a lack of skill. Others are 
unable to cope with adverse sea con-
ditions (rough or strong currents). 
These victims are often, but not 
always, poor swimmers.

However, at least a quarter of the 
drowning deaths occurred in highly 
experienced snorkellers. Such deaths 
often followed hyperventilation before 
extended breath-holding, with subse-
quent hypoxic blackout before or imme-
diately after surfacing. Many studies 
have described these preventable trage-
dies, in which a misguided diver...
“blows off” carbon dioxide by hyperventilation. There is then a risk that the normal hypercapnoeic “break point” may occur after the point where hypoxia produces unconsciousness in the submersed diver. If inspiration then occurs while the diver is still submerged, cardiopulmonary reflexes come into play. Hypoxic blackout can also occur without hyperventilation on extended breath-hold dives, especially those involving sustained exercise and ascent.19

Four of the surface drowning deaths occurred in snorkellers with a history of epilepsy. Snorkellers who suffer epileptic seizures are at risk of drowning. Water itself can trigger convulsive seizures, a phenomenon known as “bathing epilepsy”.20 There are two syndromes related to bathing epilepsy: (a) “water immersion epilepsy”, as defined by the International League Against Epilepsy,20 and (b) “hot water epilepsy”. Both syndromes have genetic implications. “Hot water epilepsy” has a particularly strong genetic basis, with recent provisional localisation of the gene concerned (4q24–q28).21 Hyperventilation before swimming underwater may also lead to anoxic seizures after a short (40–90 seconds) and apparently successful underwater swim.22 (The seizures described in this report were anoxic convulsions following hyperventilation coupled with breath-holding.)

Another phenomenon leading to respiratory compromise is that of immersion pulmonary oedema.23 In this potentially fatal syndrome, usually triggered by extreme exertion in the water, pulmonary congestion leads to cough, dyspnoea and haemoptysis. This syndrome, involving surface swimmers, is often associated with extreme exertion, not only in cold but also in warmer waters. Pre-existing diseases as asthma and diabetes also increase the risk of potentially fatal events during snorkelling and diving.24 Most drowning victims identified in our study were either snorkelling alone or had lost contact with a buddy.

Snorkellers who die from trauma often suffer horrific injuries. All three shark attack victims identified in our study were either collecting sea life or close to where sea life was being collected, in areas that sharks were known to frequent. The victim of a crocodile attack was snorkelling in a place known for crocodile activity.

There were some limitations associated with our investigations. It is possible that a few additional fatalities were unreported, and those reported sometimes included incomplete case data. Deaths were sometimes unreported, and reports provided by any witnesses and by police varied in their likely reliability, content and depth, as well as the expertise of the investigators. In addition, autopsy reports are sometimes subject to certain limitations (eg, cardiac arrhythmias may not be detectable on autopsy).

Snorkelling operators should pay careful attention to prescreening participants for apparent health and fitness, anxiety, swimming ability and snorkelling experience to identify those who will need closer supervision. Training in rescue techniques and first aid, including cardiopulmonary resuscitation, is necessary for people who supervise snorkelling activities. Acquiring such skills inspires confidence, sets the snorkelling experience to identify those who will need closer supervision. Training in rescue techniques and first aid, including cardiopulmonary resuscitation, is necessary for people who supervise snorkelling activities. Acquiring such skills inspires confidence, sets the scenery and enriches one of life’s pleasurable experiences.

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