Diving doctor's diary

Epilepsy, scuba diving and risk assessment. Near misses and the need for ongoing vigilance

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Abstract

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There is ongoing debate about the safety of scuba diving for individuals with a history of epilepsy. An in-water seizure is highly likely to be fatal. Recommendations for fitness to dive vary with some regarding epilepsy as an absolute contraindication to diving (South Pacific Underwater Medicine Society) and other permitting diving under strict criteria (United Kingdom Sport Diving Medical Committee) with diving to be postponed for a period of three to five years without seizures. Long-term follow up of people with epilepsy shows that at least one-third will have a recurrence and that the risk remains elevated for many years. We present three cases where individuals with a history of epilepsy (or likely epilepsy) almost fell through the cracks of health risk assessment, two with near-fatal consequences. These cases inform the on-going debate about fitness to dive for those with current or past epilepsy, and highlight the importance of education for doctors, dive professionals and divers about the risks associated with epilepsy and diving.

Key words

Epilepsy, scuba diving, scuba accidents, fitness to dive, recreational divers

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Introduction

The increase in knowledge in diving medicine, coupled with the changing legal environment in which fitness-to-dive assessments are conducted, have led to changes in the criteria for determining whether a candidate is considered fit to dive. Previously there was a variety of absolute contraindications, which included asthma, diabetes, previous myocardial infarction and epilepsy, among others. Current fitness-to-dive assessments, certainly in Australia, often involve the physician identifying the risks and thoroughly explaining these to the candidate, The candidate then, to a large extent, makes his or her own decision about risk acceptance, based on information and advice provided.

These changes have enabled many individuals with a variety of chronic or previous medical conditions that would have formerly excluded them from diving to take up or continue the activity. Divers Alert Network Asia-Pacific (DAN AP) membership records indicate that in excess of 10% of its members are diving despite admitted histories of asthma, diabetes, cardiac disease and a broad range of other conditions. However, a history of epilepsy is still generally considered an absolute contraindication to diving. This raises potential problems relating to medical education, dive industry education and compliance, and diver/prospective diver education, disclosure and compliance. The following three cases are presented to inform this ongoing debate.

Case 1

A 24-year-old male presented to a dive shop to enroll in an open-water dive course. He explained that he had a history of epilepsy but was now seizure-free and handed the operator a copy of a recent fitness-to-dive assessment. This indicated positive responses to the question about 'migraines; fainting or blackouts; convulsions, fits or epilepsy' and to the question about 'concussion or head injury'. The medical form was accompanied by a letter from a neurologist stating that the patient "*has well-treated epilepsy and has been seizure-free for a period greater than 18 months and is tolerant of and compliant with medication. He is at a very low risk of further seizures and there should be no impediment to him obtaining his certification for scuba diving …*".

Still apprehensive about enrolling the person in a dive course, the operator contacted DAN AP for advice. One of the authors (JL) subsequently called the certifying doctor, who was himself a diver, although untrained in diving medicine. He was aware of the reported risks of epilepsy and diving but had been swayed by the letter from the neurologist. The same author then called the neurologist and informed him of the various guidelines for epilepsy and diving. The neurologist admitted that he had equated the risks of diving with those of driving a motor vehicle. Now concerned about the advice he had given the patient, the neurologist decided that he would contact him to inform him of his change of advice. It is not known whether the person has proceeded with diving with another operator.

Case 2

This 27-year-old male overseas tourist had a history of "a*bsence seizures*" throughout childhood, for which he took

medication (sodium valproate and topiramate). However, he had ceased taking medication some 10 years earlier and his last 'absence' was when he was 19 years old. He stated that he had never become unresponsive during any of these events and described them as him "*losing focus but remaining able to speak*". He had become certified as a diver at college some six years earlier and had done an estimated seven open-water dives in total prior to the accident described below.

On this occasion, the diver was holidaying on the Great Barrier Reef. For two days prior to the dive, he had been 'partying', drinking more alcohol than usual and had had relatively little sleep. On the dive charter vessel, he was provided with a standard dive medical questionnaire which, among other conditions, specifically asked if the prospective diver has or was suffering from 'epilepsy', and separately 'fainting, seizures or blackouts'. The diver answered "*No*" to these questions. He later stated that, given he had never become unconscious or had convulsions he did not consider that he suffered from epilepsy and was not withholding or providing false information. He did not believe that he was at risk. He also stated that he was rushing to get ready and was keen to go diving. His travelling companion was reportedly aware that he had declared that he had suffered from epilepsy when applying for a gymnasium membership.

He entered the water in a group of six divers, submerged to a depth of about 6 metres of seawater with his buddy and was swimming along with another pair of divers behind. After about a minute, his buddy noticed that his body position was "*odd*" and, when she checked, she found he was unconscious. His regulator was out of his mouth and his mask was filled with "*frothy white bubbles*". She signalled nearby divers to help her and they inflated his BCD, brought him to the surface and signalled to the dive boat crew for help.

When brought aboard the tender, he was found to be unconscious, cyanotic and apneic and there was froth coming from his mouth. CPR was begun immediately and fortunately he responded following the second group of chest compressions. He was evacuated to hospital and discharged without sequelae after two days. A follow-up MRI showed no abnormalities. An EEG, conducted after 24 hours without sleep, indicated some abnormal brain activity thought to be consistent with 'absence seizures'. He was then prescribed medication (topiramate) again.

Case 3

A 20-year-old student nurse presented to an experienced diving physician for a recreational diving medical. The only positive history that she gave was having "*fainted a couple of times*" on night duty on a busy surgical ward. On closer questioning, she insisted that these were brief, minor events brought on by lack of sleep and a heavy, stressful workload, that she had carried on to complete the shifts and that she had had no other similar events. Physical examination was entirely normal and, despite this history, she was passed 'fit' to participate in an open-water dive course.

About two weeks later, the diving physician was rung by the diving instructor (whom he knew well) to say that a week previously, the student had had a "*funny turn*" in the swimming pool during training and he thought that she had either panicked or "*passed out briefly*", he was not sure which. Given his (misplaced) confidence in the physician, he had chosen not to refer her back for reassessment, but to continue her training. The first open-water experience was on the day before he phoned – a shore-entry dive off a sandy beach with a slight swell. Whilst wading out in about thigh-deep water she was seen to have a tonic-clonic fit and was promptly recovered without harm from the water by the instructor, assisted by other trainee divers in the class.

Further medical assessment was arranged, but she did not attend several attempted appointments. Soon after, she quit her nursing training programme and disappeared from follow up. The instructor was convinced that this was a full-blown epileptic fit as he had witnessed such convulsions in a family member on several occasions in the past.

Commentary

IN-WATER SEIZURE

There appears to be little argument that a seizure underwater while using conventional scuba equipment is usually fatal, most often due to drowning. While there may be some conjecture as to the cause of loss of consciousness in Case 2, the previous history of absence seizures, a positive follow-up EEG and re-introduction of active treatment suggest that epilepsy was a likely contributor. Absence seizures have a typical EEG pattern. Clinically, the individual is rendered 'incapacitated' during an episode when they sustain an abrupt impairment or loss of consciousness which is not remembered. During this period of incapacity, loss of a regulator from the diver's mouth could lead to drowning. This diver was very lucky to have survived, and did so only as a direct result of close buddy scrutiny and rapid and effective rescue and first aid. Not all divers are so fortunate.[1]

Between 1997 and 1999, DAN America received 29,239 calls to its Medical Information Line of which 212 were regarding seizures, and seven of these involved new onset seizures post diving.[2] Project Stickybeak and DAN Asia-Pacific fatality records indicate that epilepsy may have been a contributing factor in the deaths of at least 11 snorkellers and two scuba divers in Australia since 1972.[3–6] In New Zealand, there were 229 diving-related fatalities derived from Water Safety NZ's *DrownBase* between 1980 and 2006.[7,8] Epilepsy was noted in 10, six snorkellers and four scuba divers, and was suspected of having been contributory to the deaths in all 10 cases. However, it is often difficult to determine with

certainty the role epilepsy played, if any, in the absence of a reliable history, witnesses and/or autopsy, as occurs with some fatality investigations.

Diving and/or snorkelling may involve a variety of factors that can reduce the seizure threshold. These include stress, exercise, sensory deprivation, hypercapnoea, hyperventilation and hypothermia. It has been suggested that the elevated oxygen partial pressures associated with diving, especially using enriched air mixtures, may increase the likelihood of a seizure in a diver with epilepsy.[9] However, there are no reliable data to support this belief.[10] The preceding night's activities combined with diving, may have increased the risk of an event leading to impaired consciousness for Case 2.

GUIDELINES FOR EPILEPSY AND DIVING

Guidelines for epilepsy and diving from diving medical advisory bodies differ. The South Pacific Underwater Medical Society (SPUMS) recommends that "*a candidate with a history of fits (apart from childhood febrile convulsions), or unexplained blackouts should be strongly advised against diving. Any condition associated with fits or blackouts will be a grave risk to life during diving.*"[11]

The United Kingdom Sport Diving Medical Committee (UKSDMC) is less stringent. It advises that it is unsafe for any epileptic to dive while taking anti-epileptic medication because of the likely sedative effects of the drugs. It states that:

> "*The relapse rate in epileptics who are taken off medication decreases exponentially, with the majority of those relapsing doing so within the first eighteen months of ceasing treatment and the rate of relapse becoming insignificant after three years. The suggested requirements for an epileptic to be permitted to dive are therefore set at five years free from fits and off medication. Where the fits were exclusively nocturnal, this can be reduced to three years.*"

According to the UKSDMC,

> *"A past history of petit mal should not disqualify, provided that no attacks have occurred for five years and that the condition has not progressed to epilepsy. Pyrexial convulsions in childhood may be disregarded if not followed by epilepsy."*[12]

There is on-going debate about the suitability of these guidelines, which some argue are too stringent. For example, a review by Almeida and colleagues, after considering available evidence, suggested that

> "*Those who have been entirely seizure-free on stable antiepileptic drug therapy for at least four years, who are not taking sedative antiepileptic drugs and who are able to understand the risks, should then be able to consider diving to shallow depths, provided both they and their diving buddy have fully understood the risks.*"[10]

The prospective diver in Case 1 would have been judged unfit to dive according to any of the three above-mentioned guidelines. Both doctors involved placed this person at risk and themselves in a potentially precarious medicolegal position by suggesting it would be safe for him to dive.

The diver in Case 3 probably would have been passed for recreational diving by almost all physicians. This is an example of how reliant the examiner is on the honesty of the candidate. However, without witnesses, the physician involved, whilst slightly suspicious about the nature of the 'faints', elected (misguidedly) to trust the word of the patient.

LONG-TERM RISKS OF RECURRENT SEIZURES

The diver in Case 2 would have been advised not to dive following the SPUMS recommendation as he had a history of epilepsy. However, he would have been determined as fit to dive in accordance with both the UKSDMC guidelines and those suggested by Almeida et al, as he had been seizure-free without medication for almost eight years, considerably longer than required under the UKSDMC guidelines. It is also relevant to acknowledge that although absence seizures usually do not cause loss of consciousness, they do cause impairment of function that, in the aquatic environment, may place the diver at great risk. There was no evidence of an equipment fault or any other cause to explain his loss of consciousness. The victim has no recollection of having any problem underwater and only recalls taking some photographs and then regaining consciousness on the boat.

A recent long-term follow up of 148 individuals with epilepsy is less reassuring.[13] In this study, 90 individuals who stopped antiepileptic medication because they had achieved five years seizure free, were followed up for an average of 32 years. Overall, 37% of these individuals suffered a relapse of their epilepsy, with two-thirds occurring within three years of treatment cessation. In the remaining population, relapse occurred between three and 28 years, suggesting that it is difficult to predict which individuals are at risk in apparently stable epilepsy. A Canadian study had similar results, with 30% of 260 children experiencing recurrence within five years of discontinuing antiepileptic drugs.[14] These two studies do create uncertainty when applying the UKSDMC guidelines.

An argument advanced by Almeida et al was that there was a lack of data regarding diving and epilepsy, and that

> "*objections to diving by people who have been seizure-free for a long time are largely theoretical.*"[10]

They also stated

> "*current data do not allow precise assessment of the magnitude of any risk assessment.*"

Table 1
Risk assessment matrix;[15]
L – low; M – moderate; H – high; E – extreme

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Severe
Almost certain	M	H	H	E	E
Likely	M	M	H	H	E
Possible	L	M	M	H	E
Unlikely	L	M	M	M	H
Rare	L	L	M	M	H

It is true that these events are infrequent, providing challenges for any meaningful interpretation.

RISK MATRICES FOR ASSESSING RISK

When assessing risk in the absence of precise data, risk matrices derived from Australian/New Zealand and International Standards Organisation Standard 31000:2009 (formerly AS 4360), provide pragmatic guidance (Table 1).[15] These matrices have been validated across many industries from manufacturing to finance and even the Federal Government. Although not formally validated in the health-care setting, risk management is progressively gaining acceptance and a higher profile. For example, the World Health Organisation is in the final stages of producing general quality risk management guidelines, which also utilize a matrix.[16] Risk is calculated by assessing *likelihood* and *consequence*. From this matrix, risks can be classified as low (L), moderate (M), high (H), and extreme (E).[17]

One of the authors (DS) has used the risk matrix since 2004 when discussing health risks with individual divers. It provides a useful semi-quantitative format for risk evaluation in the absence of precise epidemiological data. For a condition such as epilepsy, even though the frequency may be rare, the consequence is severe; hence the risk is evaluated as high. On that basis, we assert that evidence of safety must be provided before any form of diving with epilepsy is considered. Recent data from a large epidemiological study of epilepsy after traumatic brain injury (a different but related issue) suggested that there was increased risk even at 10 years after injury. This paper provided 'decay curves' for risk from their population of over 1.6 million.[18]

GENERAL COMMENTS

Case 1 as presented raises a number of issues regarding the current system of health risk assessment of divers. In Australia, as in most other countries, there is no mandate for recreational divers to receive assessment by doctors trained in diving medicine. Knowledge of the potential risks of impairment in the non-respirable aquatic environment among even expert health professionals is variable, particularly if they have not received training in diving medicine. Guidance material is available, even if it is challenged by some authors.[10–12] This case also illustrates the important role of the dive instructor in the overall system of evaluation of recreational diving candidates. Some dive centres find that establishing long-term links with specific physicians helps in informing a two-way exchange about fitness problems.

Education of dive professionals, divers and health professionals is the key, informed by quality studies or, in their absence, a careful risk assessment applied to the individual circumstances of the potential diver. Equally important is the establishment of a quality database for reporting near misses and non-fatal diving accidents, such as the DAN AP Non-Fatal Diving Incident Reporting Project[19] (the successor to Acott's *Diver Incident Monitoring Survey*),[20] which will permit meaningful analysis of risk, and better inform health professionals who are assessing that risk.

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The database of randomised controlled trials in hyperbaric medicine maintained by Michael Bennett and his colleagues at the Prince of Wales Hospital Diving and Hyperbaric Medicine Unit, Sydney is now at:

<http://hboevidence.unsw.wikispaces.net/>

Assistance from interested physicians in preparing critical appraisals is welcomed. Contact Associate Professor Michael Bennett: <M.Bennett@unsw.edu.au>

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