

Cerebral arterial gas embolism in a professional diver with a persistent foramen ovale

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Abstract

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A 33-year-old, male professional scallop diver diving on the Outer Hebrides in Scotland rapidly developed symptoms of cerebral arterial gas embolism following a provocative dive with possibly a fast ascent. During transfer by helicopter to the mainland for treatment, his symptoms improved on surface oxygen. He was recompressed on a Royal Navy Treatment Table 62 (RN TT62) with complete resolution. Just over six weeks later, again diving on the Outer Hebrides and after adopting more conservative diving practices, he developed symptoms and signs of vestibular decompression sickness after a problem-free dive, with dizziness, poor co-ordination and gait, nausea and vomiting, and rotational vertigo. He was again transported to the mainland for recompression treatment. He received an extended RN TT62 and required five further Comex 12 (223 kPa) hyperbaric oxygen treatments over the following three days before he was symptom free. A 4 mm persistent foramen ovale (PFO) was subsequently diagnosed and he underwent successful closure of the defect with Amplatzer device and returned to commercial diving a year later.

Key words

Patent foramen ovale (PFO); persistent foramen ovale; cerebral arterial gas embolism (CAGE); inner ear; hyperbaric oxygen therapy; transcatheter closure; case reports

Introduction

The “king scallop” (*Pecten maximus* (L.)) is an edible marine bivalve mollusc; its meat is considered excellent and a luxury product. It occurs and is fished for in large numbers in the eastern Atlantic Ocean.¹ The largest fishery is in the UK with a significant proportion based in Scotland.^{1,2} Of all scallops landed in the UK, approximately 2% are fished for by diving, the rest by use of dredges.² Scallops caught by diving attract a premium price as real-time selection produces a high-quality catch in terms of size and comes from a sustainable fishery that causes insignificant environmental impact.³ All commercial diving for shellfish in the UK must adhere to the 1997 Diving at Work Regulations⁴ as detailed by the inland/inshore Approved Code of Practice.^{5,6} We present the case of a commercial scallop diver who suffered severe decompression illness (DCI) that threatened his livelihood.

Case history

INCIDENT ONE

A fit, 33-year-old male had been a commercial diver for about six years, running his own diving company based on the Outer Hebrides mainly involved in diving for scallops. He had an in-date (less than 12 months old) UK Health and Safety Executive (HSE) commercial diving medical. Past medical history included migraine with aura. Prior to these events he had not had any previous diving-related medical problems.

On the day of the first incident, this was his first dive for four days. He was supposedly diving on nitrox to a maximum

depth of 35 metres’ sea water (msw) using a *Suunto Gekko* dive computer set to 34% oxygen (estimated pO₂ 1.53 bar). Although the computer recorded an ascent warning, the diver reported the dive as problem-free; he surfaced at approximately 10:00 h with a total bottom time of 25 min.

Ten minutes after surfacing he felt increasingly unwell and developed a severe headache and right-sided weakness. This progressed to collapse and probable loss of consciousness; he was subsequently reported by his partner to have had slurred speech on regaining consciousness. At this point he also complained of “pins and needles” in his right side. He commenced breathing on oxygen on his dive boat and at about 10:30 h contact was made with the emergency coastguard services. On retrieval by rescue helicopter, he was continued on high-flow oxygen and transferred to the recompression chamber near Oban, arriving at about 12:00 h accompanied by a diver from a neighbouring vessel, though not his diving buddy.

On arrival, he was in a good condition being able to self-transfer, and to provide a history of events; he felt “almost normal”. He was fully orientated in time and place, speech was normal and he had no nausea or dizziness; he was able to take oral fluids and pass urine. Neurological examination was completely normal. He was recompressed on a Royal Navy Treatment Table 62 (RN TT62) during which he remained comfortable and symptom-free. Prior to discharge the following day after overnight observation in hospital he was advised that as he had had an unprovoked incident of gas embolism he should be assessed for a persistent foramen ovale (PFO) before returning to diving.

INCIDENT TWO

He returned to diving before investigations for a PFO had occurred and had a second incident six weeks later whilst, again, shellfish diving in a North Uist sea loch. He was using nitrox35 (own-blended and tested by himself), though his computer was set at 33%. He did two dives: the first for 40 min to a maximum depth of 24 msw and a second to a maximum depth of 27 msw for 37 min with a surface interval of 113 min, surfacing from the second dive at about 13:30 h; his computer did not show any problems with either dive.

Thirty minutes after surfacing he developed marked dizziness with associated nausea and vomiting. He had difficulty walking and lacked co-ordination. He commenced breathing on his own oxygen and was retrieved by ambulance to a local cottage hospital. Examination on arrival demonstrated gross rotational nystagmus, normal pulse and blood pressure and mild hypothermia at 35°C. He was continued on oxygen, given intravenous fluids and an anti-emetic, cyclizine, and transported to the Oban chamber by rescue helicopter, arriving at 17:50 h.

On arrival, there had been some improvement, though he was still dizzy but with reduced nausea. He had bilateral gaze nystagmus, full power and sensation, finger to nose pointing was normal but he had poor gait and was unable to perform the sharpened Romberg test. During Romberg testing and heel-toe walking he would fall to his right. He was recompressed on a RN TT62, just over four hours after onset of symptoms. During treatment, he showed only partial improvement so the treatment was extended twice at 18 msw and once at 9 msw, surfacing at 01:05 h. He was still dizzy with unsteady gait and abnormal heel-toe walking and Romberg test (falling to the right) and he still had nystagmus on right gaze. He had received five litres of saline from his initial management; he was transferred to the Oban hospital for post-treatment monitoring.

With residual symptoms, he received further recompressions on a Comex 12 (223 kPa) twice daily. By the third day after five additional treatments, he had complete resolution of his symptoms and signs and felt well. He was discharged with advice not to dive until he had been assessed for a vascular right-to-left shunt. He returned to work as a labourer while awaiting investigations. These subsequently demonstrated a 4 mm PFO which was closed by a Amplatzer™ device. A repeat echo demonstrated no intracardiac shunting a year following closure so he returned to diving and has reported no further episodes of diving-related complications.

Discussion

This patient's past medical history stated that he suffered migraine with aura. Migraine with aura is over four times more prevalent in individuals with a PFO than in those without^{6,7} and PFOs, or right-to-left shunts, account for

large proportions of decompression illness (DCI) cases.^{8,9}

This current case study is presented as an example of a commercial diver who may have benefitted from earlier PFO-screening based on past medical history. At present in the UK, guidance provided to Approved Medical Examiners of Divers by the Health and Safety Executive states that: *“Examination for the presence of an intracardiac shunt is not a requirement of either the initial or annual examinations”* and *“However, examination for a patent foramen ovale should be undertaken in a diver who has suffered neurological, cutaneous or cardiorespiratory decompression illness. This is particularly important where there is a history of migraine with aura or where the dive profile was not obviously contributory, since it may be pertinent to an assessment of the overall risk to the diver of continuing to dive. A positive finding is not necessarily a reason for a declaration of unfitness. However, the opinion of a cardiologist with an interest in diving medicine is recommended”*.¹⁰

Even with the heightened risk of DCI in individuals with PFOs, and the increased incidence of PFOs in people experiencing migraines with aura, other recommendations also suggest only screening for a PFO in divers with migraines with aura following at least one episode of DCI.¹¹ Commercial divers who do screen positive for a PFO may wish to continue diving for reasons of continued employment and may not be able to adopt more conservative diving options open to the recreational diver.¹¹ In such circumstances, including the present case, referral to a cardiologist to examine the possibility of PFO closure is probably the only available option.^{10,11}

The Scottish National Health Service now administers an emergency recompression service based on three facilities: one each for the east and west coasts, and one for the north of Scotland.¹² Since December 2014, guidance provided to commercial divers employing the Inland/Inshore Approved Code of Practice permits contractors of diving operations that are shallower than 50 msw with no more than 20 min of in-water staged decompression to plan for transfer times to a recompression facility of no more than 6 h while making use of emergency services.¹³ The present account, with evacuation times of 2 h 15 min and 4 h, demonstrates the goals set by this new guidance to be achievable even in the remotest areas of the UK.

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