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A Case of “Unexplained” Decompression Sickness in a Commercial Diver

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While working in the Gulf of Mexico, a 24-year-old male commercial diver developed decompression sickness (DCS) with neurological involvement (Type II DCS). This occurred despite closely adhering to US Navy decompression tables that divers follow upon slowly resurfacing from the ocean depths (so-called unexplained DCS). The patient required therapy in a decompression chamber, and subsequently had complete clinical recovery. He was then referred to “rule out” a right-to-left cardiac shunt.

Physical examination, an electrocardiogram, and chest x-ray were all normal. Initial transthoracic echocardiography (TTE) was also normal, having normal cardiac chamber dimensions and function, and normal pulmonary artery pressure calculations. A right antecubital vein intravenous line was placed, and 8 cc of agitated saline using a three-way stop-cock was administered during normal respirations. TTE revealed complete opacification of the right heart chambers. Contrast bubbles appeared within the left heart chambers within two cardiac cycles of its appearance in the right heart (Fig. 1). A transesophageal echocardiogram (TEE) was then performed. At the level of the atrial septum a patent foramen ovale (PFO) was identified with its “slit” ~10 mm diameter during normal respirations. Agitated saline contrast was injected during normal respirations with contrast visualized to traverse right to left via the PFO (Fig. 2). Based on these findings, the patient was felt to have a clinically

significant PFO, and further commercial diving was not resumed until the PFO was percutaneously closed.

An increased incidence of a PFO has been documented in divers with unexplained DCS.¹⁻⁶ Any gas is compressed as a diver descends in water. As the diver submerges, pressure increases and the volume of a gas will decrease.

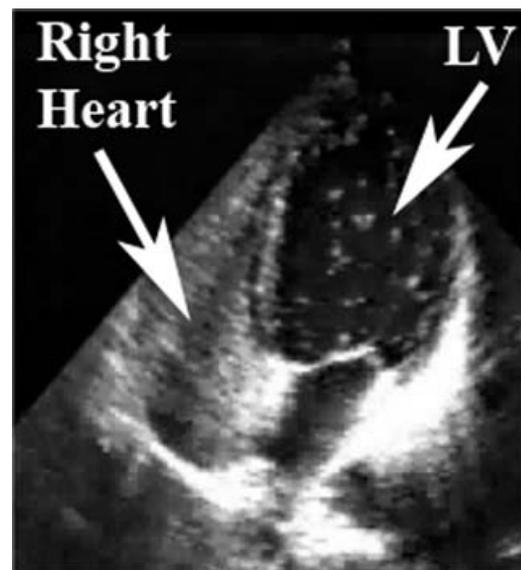


Figure 1. TTE apical four-chamber view during injection of agitated saline via the right antecubital vein. Injection and imaging were performed during normal respiration. The right atrium and right ventricle (right heart) are completely opacified. Saline contrast appeared within the left atrium and left ventricle (LV) only a brief moment after opacifying the right heart. Since contrast appeared within the left heart during normal respirations, the patient had evidence of a “resting shunt.”

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Likewise, the gas will expand upon ascent (Boyle's Law). Gas is dissolved within tissue in a proportional manner to the pressure as mentioned, and also time spent at a particular depth. Other factors particular to the individual (age, body fat, cardiac output, pulmonary diffusion) also influence amount of gas within tissues.⁷

After a dive, one must not ascend too quickly, as nitrogen may come out of solution within blood and form nitrogen bubbles (venous gas emboli). These bubbles form within the venous aspect of capillaries from tissues saturated with gas, and may travel into the central venous system. Unless there is a large bubble load, they normally are captured in the pulmonary capillary network and diffuse via the alveoli.^{8,9} If bubbles pass through the pulmonary system they become arterial gas emboli and may cause ischemia where lodged. Symptoms caused by bubbles (venous capillary system, arterial system) are termed DCS. Type I DCS involves joints, lymphatics, or the lower spinal cord, and Type II DCS the cerebral, high-spinal, cerebellar, ocular, vestibular, or auditory systems.¹⁰⁻¹³

DCS in a diver that is associated with a high incidence (up to 80% of divers) of a significant PFO is that which occurs with the following "dive characteristics": (1) the diver followed US Navy diving tables, (2) symptoms occur usually within an hour of surfacing from a dive, and (3) symptoms are Type II DCS as described above, or are a form of cutaneous symptoms manifested as painful reddish-blue markings on the chest, abdomen, and shoulders (similar to cutis marmorata in newborns).^{6,12-20} Based on the published data,²¹ whether divers should

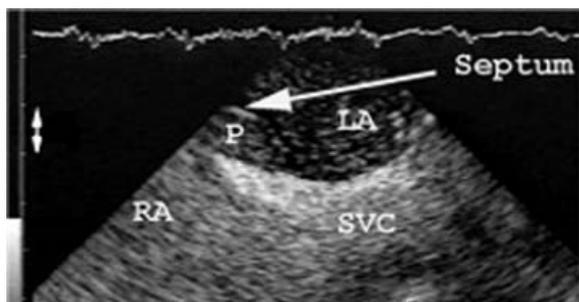


Figure 2. TEE at 90° in the mid-upper esophagus. Saline contrast entered the right atrium (RA) via the superior vena cava (SVC), and was noted to traverse the atrial septum (SEPTUM) through a PFO, into the left atrium (LA). The "resting" PFO slit measured ~10 mm (double arrow on left of image is 10 mm scale).

be "screened" in the echocardiography laboratory for a PFO is a matter of debate,^{22,23} the answer to which is not definitive at this time.

In summary, the following concluding comments may be made:

1. It appears that a PFO is associated with unexplained DCS, especially when the diver presents with "dive characteristics" as described.
2. A "resting PFO" is often associated with a clinically significant shunt. It is defined as a shunt detected by TTE, using saline contrast injection, during normal respirations.

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