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A CASE OF DECOMPRESSION SICKNESS ASSOCIATED WITH PFO IN A DIVE MEDICAL OFFICER

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STRESZCZENIA / ABSTRACTS

Current medical guidelines and regulations do not require routine examinations for the right-to-left shunt at divers. We present the case of a Polish Navy Dive Medical Officer (DMO) who more than 20 years ago suffered from decompression ilness - bends accompanied by cutis marmorata, numbness in one limb and mild vertigo. After treatment in decompression chamber all symptoms entirely resolved. Since then, despite of continuing diving, he experienced no decompression ilness symptoms. Twenty years later, then 52 years-old, the DMO was admitted as a patient to the Neurology Department at the Gdańsk Naval Hospital due to episodes of transient ischemic attacks. Contrast-enhanced transcranial Doppler ultrasound and transesophageal echocardiography were performed and he was diagnosed with severe right-to-left shunt across a patent foramen ovale (PFO). Retrospectively analyzing incident of DCI he suffered 20 years earlier, we suppose that it may have been caused by paradoxical air embolism associated with the RLS across the PFO, which was not diagnosed at the time of this incident yet. We conclude that although the risk of severe neurological, cutaneous or vestibular forms of DCI is very low, in order to increase diving safety, it seems to be reasonable to develop standards for initial PFO screening in certain groups of divers - professional divers, military divers and medical diving personnel. Contrast-enhanced transcranial Doppler ultrasound seems to be useful in RLS screening in divers. Using multi-compartment chambers equipped with an entry lock should be preferred for safe recompression treatment of divers.
Keywords: decompression sickness, diving, paten foramen ovale, contrast Transcranial Doppler (cTCD), contrast-enhanced transthoracic echocardiography (cTEE), right – to – left shunt.

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INTRODUCTION

Patent foramen ovale (PFO) is an anatomical variant occurring in approximately in 25% of the population, connecting right and left atrium of the heart. In the foetus, the foramen ovale is vital to allow oxygenated blood flow to from the right to the left heart, bypassing the lungs that do not function in foetal life. The oxygenated blood from the mother's placenta flows into the right atrium, from where it goes through the foramen ovale into the left atrium and left ventricle and then as arterial blood into all tissues of the body Normally, in most infants it closes during the first year of life [1]. In some healthy people, however, it does not close completely and forms a channel of variable diameter. While in the majority of cases PFO has no clinical significance, in certain situations related to increased pressure in the right atrium (coughing, sneezing, abdominal pressures during defecation, weight lifting, pulmonary hypertension, tricuspid valve regurgitation) venous shunt from the right to the left atrium may occur (Fig. 1). Such a shunt may result in paradoxical embolism, when embolic material from the venous system enters the arteries, causing, among others, ischemic stroke [2].

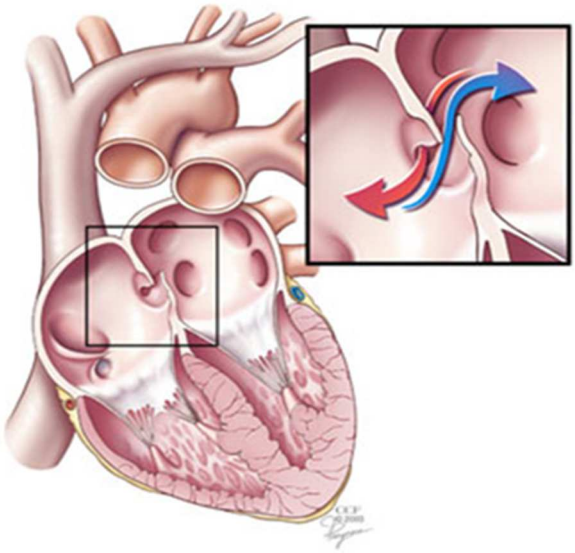

Fig. 1 Shunt of venous blood from the right to the left atrium [3].

During any dive, and especially in the case of decompression sickness, gas bubbles with a composition similar to the breathing mixture circulate in the diver's venous blood. As a result of the increased pressure in the chest during diving (underwater work, Valsalva manoeuvre) or after a dive (carrying diving equipment, coughing, sneezing, climbing into boats), gas bubbles may enter the systemic circulation through the patent foramen ovale. Bubbles circulating in body arteries may cause relatively mild, symptoms such as skin rash or cutis marmorata. On the other hand, as a consequence of arterial air embolism, a severe, neurological or vestibular form of decompression sickness may develop [4,5,6].

CASE REPORT

A 52 year old doctor, previously serving as an officer in the Polish Navy, was admitted as a patient to the Neurology Department at the Navy Hospital in Gdańsk in order to investigate episodes of transient, short-lasting diplopia that had occurred several times over the past few years. The patient additionally reported a single incident of transient weakening of the right upper limb. He had not experienced any loss of consciousness and his symptoms were not accompanied by headache and nausea. The patient denied suffering from chronic diseases and taking any drugs on a regular basis. .

On taking a medical history, nothing of significance was noted, apart from the decompression sickness incident which had occurred 20 years before, during his service as a Diving Medical Officer (DMO) in the Polish Navy. The patient reported, that he had been called to a military diver suffering from type 1 decompression sickness with the bends. The diver had been treated in a single – compartment hyperbaric chamber using the US Navy Treatment Table 5. The diver breathed oxygen with three 5-minute breaks during which he breathed air. During this treatment, the DMO, also present in the hyperbaric chamber, breathed air for 2 hours and 15 minutes. The diver's symptoms ("the bends") subsided in the first twenty minutes of the treatment.

Approximately two hours after the end of the treatment, the DMO had experienced pain in his shoulders and knees joints accompanied by an increase of body temperature to 38 degrees C. In addition, itchy cutis marmorata appeared on his chest and abdomen and he also reported mild numbness in the right lower limb and mild vertigo. Type I decompression sickness was diagnosed and treatment in the hyperbaric chamber was initiated. The US Navy Treatment Table 5 was used again. During this treatment the DMO, as a patient, breathed oxygen with three 5-minute breaks, during which he breathed air. After 18-minute of oxygen breathing, his symptoms subsided completely. At the time of this episode, the doctor had a valid Naval Medical Board medical certificate for diving operations.

He had not reported any medical problems before this incident and had not previously suffered from decompression sickness. The initial transthoracic echocardiography performed before he commenced his diving career was normal. Annual medical checkups and laboratory tests, both before and after the above episode showed no abnormalities. Subsequent to this incident, until the end of his service as a Dive Medical Officer, and later, as a civilian diver, he did not experienced any further episodes of decompression sickness or any other diving related pathology.

The neurological examination at admission to the hospital was normal. During his hospitalization, the patient underwent a number of additional tests. Brain magnetic resonance angiography (MRA), ABPM, Holter ECG monitoring, cervical and vertebral arteries Duplex ultrasonography and laboratory tests showed no significant abnormalities. In order to exclude paradoxical embolism, a contrast-enhanced transcranial Doppler ultrasound (c-TCD) was performed. During the examination, after the Valsalva manoeuvre more than 30 bubbles (seen as High Intensity Transient Signals or HITS) in the right middle cerebral artery were detected. The test result proved presence of a significant degree of the right-to-left shunt, probably through a patent foramen ovale (Fig. 2).

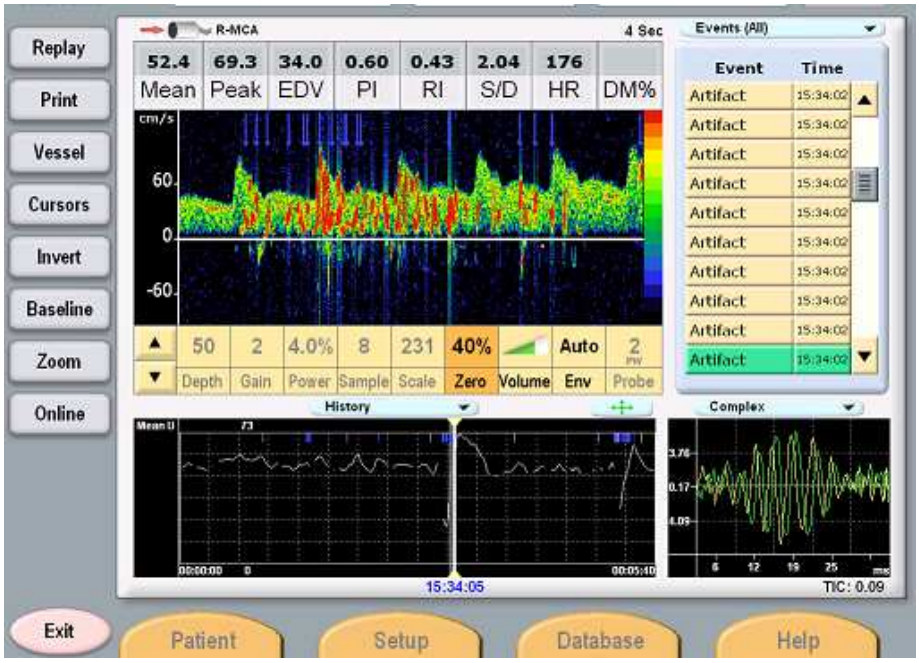

Fig. 2 Spectrum of the middle cerebral artery with HITS signals.

To confirm the presence of a patent foramen ovale, transesophageal (TEE) contrast enhanced echocardiography was performed. It showed a PFO canal with a significant shunt from the right to the left atrium. The patient was referred to a cardiac surgeon and qualified for percutaneous PFO closure with an PFO occlusion device. He decided not to undergo this procedure and gave up diving.

DISCUSSION

Treatment of decompression sickness involves compressing the diver in a decompression chamber. In the case described above, the military diver was accompanied by a qualified and experienced Diving Medical Officer. Both were compressed in a single-compartment hyperbaric chamber. After the end of hyperbaric treatment of the diver, the DMO himself developed decompression sickness classified then as type I. All DCI symptoms experienced by the DMO resolved after the hyperbaric treatment. Retrospectively analyzing this incident, it may be noted that type I decompression sickness was accompanied by mild nervous system impairment (numbness in the lower limb), cutis marmorata and subtle vertigo. Taking into account presence of PFO, which was found during hospitalization many years later, it may be presumed, that neurological and vestibular manifestations may have been caused by paradoxical air embolism across the PFO, which was not diagnosed at the time of this incident yet [6,7,8].

The guidlines for the preliminary medical assessment of candidates for military divers in the Polish Armed Forces do not include screening tests for PFO. The Naval Medical Board uses the standard, transthoracic echocardiography (TTE). The sensitivity and specificity of TTE in PFO detecting is very low [9,10]. Until recently, as the gold standard in the PFO detecting was considered contrast – enhanced transesophageal echocardiography (TEE), which achieves sensitivity and specificity rate of up to 100% compared to autopsy [11]. Due to the fact that TEE is an invasive examination, it is not routinely used for divers' examinations. It carries the risk of potentially dangerous complications, such as laryngospasm, arrhythmias including cardiac arrest, esophageal perforation, and very rarely death (less than 0,01%) [12]. It is also emphasized that the high cost and suboptimal availability of the equipment required are factors limiting the wider use of TEE in PFO screening for divers.

An alternative to TEE is contrast-enhanced transcranial Doppler ultrasound (c-TCD). It is a simple, cheap, non-invasive and safe method which has very high sensitivity and specificity in the detection of right-to-left shunt (97% -100% and 93-98% respectively) [9,10,14]. Detection of RLS with c-TCD is based on the standard described in 2000 by Jauss and Zannette [15]. During examination the spectrum of blood flow in the MCA is monitored before and after the administration of intravenous contrast.

Assessment of the RLS size can be achieved by TCD in a semi-quantitative manner by counting the microbubbles in the medial cerebral artery after intravenous contrast administration [15,16]. According to the Jauss and Zannette protocol, the number of bubbles is counted both at rest and after the Valsalva maneuver [15].

In recent years, the approach to PFO diagnostics has changed. In 2019 the European recommendations for the management of patients with patent foramen ovale were published [17].

In this paper the authors presented a meta-analysis of studies on the effectiveness of contrast transoesophageal echocardiography, contrast-enhanced transthoracic echocardiography (cTEE) and transcranial contrast doppler (cTCD) in PFO diagnostics. The presented data show that the sensitivity of cTEE, so far considered the "gold standard" is much lower than previously considered and yielded only 89%. It was emphasized that the surprisingly low sensitivity of cTEE may result from inability to perform an adequate Valsalva manoeuvre during transoesophageal echocardiography which may contribute to the overlooking of some, especially smaller PFOs [18,19]. On the other hand, the sensitivity and specificity of TCD with contrast and contrast - enhanced transthoracic echocardiography in detecting right-to-left shunts reached 94% and 92% and 88% and 82%, respectively.

In conclusion, The European recommendations for the management of patients with patent foramen ovale stated that at present transoesophageal echocardiography can no longer be considered the "gold standard" in the RLS detection (right - to - left shunt) and the diagnosis must be based on the complementary use of all the diagnostic methods described above - transthoracic echocardiography and TCD as screening methods to detect right-to-left shunt and transoesophageal echocardiography to confirm the presence of PFO and assess the morphology of the interventricular septum [17].

The consequences of paradoxical embolism associated with the PFO are usually rare and mild. Occasionally however, RLS may cause severe decompression sickness with neurological, cutaneous or vestibular symptoms [7,8,16]. According to published guidelines and recommendations, screening for PFO is not necessary for each diver or candidate for diver. However, evaluation should be carried out in divers with history of decompression illness (DCI) with cerebral, spinal, vestibulocochlear or cutaneous manifestations, a current or past history of migraine with aura, a history of cryptogenic stroke or atrial septal defect (ASD) in a first degree relative. Screening for PFO is also recommended for divers who suffered DCI after non-provocative dive profile and commercial divers who suffer from migraine with aura [17,20,21,22].

If a diagnosis of the RLS is made, divers are strongly advised to modify their diving behaviour and strictly observe save diving practices [17,22]. In addition, some divers may be offered percutaneous PFO closure with an occlusive device. Although the first percutaneous septal defect occlusion was performed in 1975 [23], its availability and safety did not allow for routine PFO closure for many years. Only recently has published data suggested that in some divers this procedure may be effective in secondary prevention of DCI associated with intra-cardiac shunting [24,25].

In the case described above, neurological, cutaneous and vestibular symptoms in the DMO did not occur during subsequent dives and for many years the patient did not report any other health complaints. The RLS across the PFO was detected only 20 years after the diving incident. However, earlier detection of intra-cardiac shunt, especially at initial examinations before commencing service as a Diving Medical Officer, would have allowed him to be assigned to a position where the risk of diving related accidents was minimal.

Finally, it should be noted that during the recompression therapy described above, both the navy diver and the DMO were in a single-compartment hyperbaric chamber. Fortunately, the DCI symptoms in the DMO developed after the end of the diver's treatment. Single-compartment decompression chambers may pose a threat to compressed personnel in case of any medical emergency. Lack of an entry lock prevents medical staff from entering the main chamber whilst it is under pressure. Some single-compartment hyperbaric chambers are still in use in medical or military facilities but this case shows that in order to increase safety it is strongly advised to only use chambers equipped with a lock.

CONCLUSIONS

The medical guidelines and regulations which are in use, not only in the Polish Navy but also in many countries all over the world, state that examination for the presence of an intra-cardiac shunt is not required for neither the initial nor the subsequent annual examinations, especially in divers without a history of decompression sickness. Although the risk of severe, neurological, cutaneous or vestibular forms of DCS is very low, in order to increase diving safety, it seems to be reasonable to develop standards for initial PFO screening in professional divers performing heavy work, military divers and medical diving personnel. Contrast-enhanced transcranial Doppler ultrasound (c-TCD), as a simple, non-invasive and safe method with very high sensitivity and specificity in the detection of the right-to-left shunt, seems to be useful in RLS screening in initial and periodic examinations in divers.

Using multi-compartment chambers equipped with an entry lock should be preferred for safe recompression treatment of divers.

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