Optimizing PFO Screening for Scuba Divers: A Novel Approach to Reducing Dive-Related Health Risks

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INTRODUCTION

- Patent foramen ovale (PFO) is a cardiac anomaly that results from the failure of closure of the fetal foramen ovale between the left and right atria that normally occurs after birth
- It results in a right to left shunt when right atrial pressures increases that can allow emboli to bypass the pulmonary circulation and enter the systemic circulation, increasing the risk of paradoxical embolism
- PFOs are prevalent in 20-25% of the population and are often asymptomatic

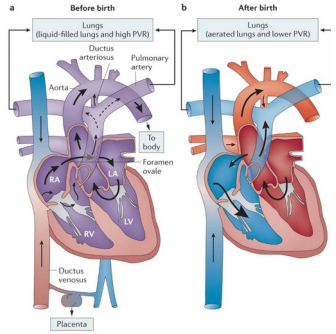


Figure 1: Fetal blood circulation before and after birth. Blood can be seen shunting through the ductus venosus, foramen ovale, and ductus arteriosus[1]

- Decompression sickness (DCS) occurs when inert gasses like nitrogen dissolve in body tissues under high pressure and upon ascent, these gases come out of solution and form bubbles, causing mechanical obstructions
- According to Torti et al., divers with a PFO had a 4.8-12.9-fold higher incidence of major DCS events per 10,000 dives compared to those without a PFO
- Germonpré et al. reported that divers with a right-to-left shunt, such as a PFO, had a 3.02 times higher incidence of confirmed DCS compared to those without a shunt

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METHODS

- During a Valsalva maneuver, the right atrial pressure increases significantly while the left atrial pressure decreases, causing a pressure gradient that promotes a right-to-left shunt
- With the flow of deoxygenated blood across a PFO into the systemic arterial circulation, it is hypothesized that there may be a transient decrease in spO2 that could be detected
- SpO2, or peripheral capillary oxygen saturation, is a measure of the percentage of hemoglobin that is saturated with oxygen in the blood
- The spO2 can be measured using a pulse oximeter that utilizes the principles of photoplethysmography (PPG) and light absorption to measure the difference in oxygenation

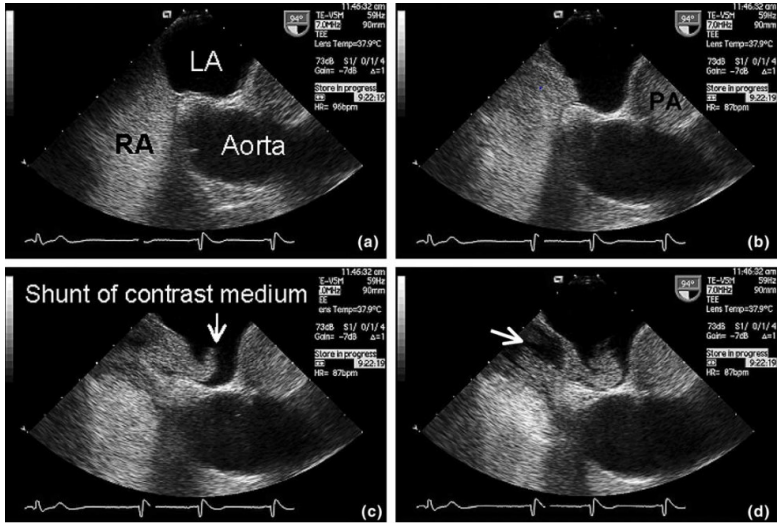


Figure 2: Transesophageal echocardiography (TEE) for the detection of a PFO. Panel a: TEE long axis view showing the right atrium filled with contrast bubbles and the left atrium free of contrast bubbles. Panel b: TEE long axis view immediately after a Valsalva maneuver showing the increase in right atrial pressure and bulging of the interatrial septum into the left atrium. Panel c: TEE long axis view showing shunting of the contrast medium across a PFO. Panel d: TEE long axis view showing filling of the right atrium with contrast-free blood (arrow)[2]

EVIDENCE

- Only one study by Billinger at al. has tested the hypothesis that ear oximetry immediately after the release of a sustained Valsalva maneuver accurately detects patent foramen ovale in scuba divers
- One hundred sixty-five scuba divers underwent TEE followed by ear oximetry within 2 hours before or after the TEE and the average spO2 before and during the release of 4 Valsalva maneuvers was measured
- 117 divers had no PFO and 48 divers had a PFO by TEE
- The average spO2 change was 0.79 ± 1.13% in the group without PFO and 1.67 ± 1.19% in the PFO group (p <0.0001) as seen in Figure 3
- Using receiver-operating characteristic curve analysis, a PFO as defined by TEE could be detected at a threshold of a Valsalva-induced decrease in spO2 of ≥0.825% in comparison to baseline with a sensitivity of 75.6% and specificity of 70.6%

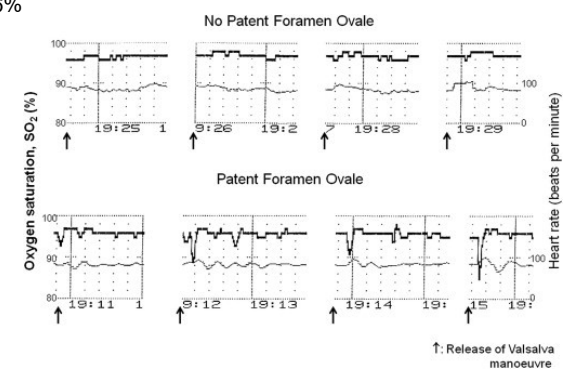


Figure 3: Four SO2 (thick line) measurements each in divers without (top row) and with (bottom row) PFO according to TEE. SO2 recordings are shown immediately after release of the Valsalva maneuver (arrows). Thin line indicates heart rate[4]

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