

Guideline

Joint position statement on atrial shunts (persistent [patent] foramen ovale and atrial septal defects) and diving: 2025 update. South Pacific Underwater Medicine Society (SPUMS) and the United Kingdom Diving Medical Committee (UKDMC)

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Keywords

Decompression illness; Decompression sickness; Echocardiography; Fitness to dive; Health surveillance; PFO; Right-to-left shunt

Abstract

(Smart D, Wilmshurst P, Banham N, Turner M, Mitchell SJ. Joint position statement on atrial shunts (persistent [patent] foramen ovale and atrial septal defects) and diving: 2025 update. South Pacific Underwater Medicine Society and the United Kingdom Diving Medical Committee. Diving and Hyperbaric Medicine. 2025 31 March;55(1):51–55. [doi: 10.28920/dhm55.1.51-55](https://doi.org/10.28920/dhm55.1.51-55). PMID: 40090026.)

This consensus statement is the product of a workshop at the South Pacific Underwater Medicine Society Annual Scientific Meeting 2024 with representation of the United Kingdom Diving Medical Committee (UKDMC) present, and subsequent discussions included the entire UKDMC. A large right-to-left shunt across a persistent (patent) foramen ovale (PFO), an atrial septal defect (ASD) or a pulmonary shunt is a risk factor for some types of decompression sickness (DCS). It is agreed that routine screening for a right-to-left shunt is not currently justifiable, but certain high risk sub-groups can be identified. Individuals with a history of cerebral, spinal, vestibulocochlear, cardiovascular or cutaneous DCS, migraine with aura or cryptogenic stroke; a family history of PFO or ASD and individuals with other forms of congenital heart disease have a higher prevalence, and for those individuals screening should be considered. If screening is undertaken, it should be by bubble contrast transthoracic echocardiography with provocative manoeuvres (including Valsalva release and sniffing). Appropriate quality control is important. If a shunt is present, advice should be provided by an experienced diving physician taking into account the clinical context and the size of shunt. If shunt-mediated DCS is diagnosed, the safest option is to stop diving. Another is to perform dives with restrictions to reduce the inert gas load, which is facilitated by limiting depth and duration of dives, breathing a gas with a lower percentage of nitrogen and reducing repetitive diving. Divers may consider transcatheter device closure of the PFO or ASD in order to return to normal diving. If transcatheter PFO or ASD closure is undertaken, repeat bubble contrast echocardiography must be performed to confirm adequate reduction or abolition of the right-to-left shunt, and the diver should have stopped taking potent anti-platelet therapy (low dose aspirin is acceptable) before resuming diving.

Introduction

This position statement is a revision of the 2015 Joint position statement on persistent (patent) foramen ovale (PFO) and diving.¹ It is the product of a workshop held

at the 52nd Annual Scientific Meeting of the South Pacific Underwater Medicine Society (SPUMS) in May 2024, and followed consultation with the United Kingdom Diving Medical Committee (UKDMC), three members of which attended the meeting. The statement must be interpreted

in consultation with a medical practitioner experienced in diving medicine and will be subject to periodic review when new evidence becomes available.

The levels of evidence defined for the position statement are those promulgated in the 2013 ACCF/AHA Clinical Practice Guideline Methodology Summit Report:²

- Ia Evidence from meta-analysis of randomised controlled trials.
- Ib Evidence from at least one randomised controlled trial.
- IIa Evidence from at least one well designed controlled trial which is not randomised.
- IIb Evidence from at least one well designed experimental trial.
- III Evidence from case, correlation, and comparative studies.
- IV Evidence from a panel of experts.

Each statement is followed by identification of the level of evidence in the literature for that statement and the supporting references.

The participants who attended the PFO workshop held at the SPUMS 52nd ASM, May 2024 agreed on the principle of each statement and gave approval for the named authors to agree on the final wording.

Statement 1

Routine screening for a right-to-left shunt (PFO, atrial septal defect [ASD] and pulmonary shunts) at the time of dive medical fitness assessment (either initial or periodic) is not indicated. (IV – consensus of SPUMS/UKDMC).

Statement 2

Consideration should be given to investigating for a right-to-left shunt under any of the following circumstances:

- A history of cerebral, spinal, vestibulocochlear, cardiovascular or cutaneous decompression sickness (DCS) (IIa);^{3–11}
- A history of migraine with aura (IIa);^{12–18}
- A history of cryptogenic stroke (IIa);^{19,20}
- A history of PFO or ASD in a first degree relative (IIa);^{21,22}
- A history of congenital heart disease (III).²³

Statement 3

If screening for a right-to-left shunt is undertaken, the following is recommended:

- When obtaining informed consent, there should be discussion of the consequences of a positive finding (IV – consensus of SPUMS/UKDMC);
- Testing should be undertaken by centres well practiced in the technique. See online [Appendix 1](#)* (IV – consensus of SPUMS/UKDMC);
- Testing must include bubble contrast, ideally combined with trans-thoracic echocardiogram (TTE), because subjects do not require sedation and this best facilitates cooperation with provocation manoeuvres. Use of two-dimensional and colour-flow Doppler echocardiography without bubble contrast is not adequate (IIa);^{7,8,24}
- Testing must include the use of provocation manoeuvres to promote right-to-left shunt including Valsalva release (where the Valsalva causes a reduction in size of the left ventricle) and sniffing as described in the supporting references and online [Appendix 1](#)* (both undertaken when the right atrium is densely opacified by bubble contrast) (IIa);^{7,8,25}
- The degree of shunting is defined by the number of bubbles seen in the left heart in the frame with the largest number of bubbles;^{4,5,7,8,15,20}
 - < 6 = small;
 - 6–20 = medium;
 - > 20 = large.

Statement 4

Interpreting a positive bubble contrast echocardiogram result:

- A spontaneous shunt without provocation or a large, provoked shunt is recognised as an unequivocal risk factor for those forms of DCS listed in statement 2 (IIa);^{7–9,25}
- Medium shunts are associated with a lower but poorly defined risk of DCS. The significance of small degrees of shunting needs to be interpreted in the clinical setting that led to testing (IIa);^{7–9,25}
- In those with a history of DCS as per Statement 2, a small shunt may require further investigation to confirm that the shunt really is small (IV – consensus of SPUMS/UKDMC).

Those interpreting bubble contrast echocardiograms in divers who had DCS should be aware that pulmonary shunts account for a much greater proportion of cases of shunt-mediated DCS (i.e., the result of paradoxical gas embolism) than the proportion of cases of stroke resulting from paradoxical thromboembolism that are via a pulmonary shunt (IIb).²⁶

* **Footnote:** Appendix 1 can be found on the DHM Journal website: <https://www.dhmjournal.com/index.php/journals?id=351>

Statement 5

Following diagnosis of a right-to-left shunt that is considered likely to be associated with increased DCS risk, the diver should be advised of the following options in consultation with a diving physician:

- Stop diving; It is self-evident that DCS cannot occur without pressure reduction that causes bubble nucleation in the body;
- Close the right-to-left shunt if it is atrial (III);^{8,14,27–30}
- Dive more conservatively (III).³¹

Diving deeper than 15 metres increases the risk of developing bubbles and hence shunt-mediated DCS (IV – consensus of SPUMS/UKDMC).

There are various strategies that can be employed to reduce the risk of significant venous bubble formation after diving and to reduce the inert gas load in tissues able to amplify any arriving arterial bubble emboli. Examples include: reducing dive times to well inside accepted no-decompression stop limits; restricting dive depths to less than 15 metres; performing only one dive per day; use of nitrox with air dive planning tools; intentional lengthening of a safety stop or decompression time at shallow stops.

There are other precautions with a less established basis which may reduce the right-to-left shunting of bubbles across an atrial shunt after diving, (examples include: avoiding heavy exercise and unnecessary lifting or straining and forceful Valsalva for at least three hours after diving) (IV – consensus of SPUMS/UKDMC).

Statement 6

The options outlined in Statement 5 require careful consideration of the risks and benefits and the clinical setting that led to screening, and the diver's stated plans for future diving (IV – consensus of SPUMS/UKDMC);³⁰

The risks and consequences of recurrent DCS in a diver should be considered and taken into account when advice is given, with acceptance of such risk by the diver (IV – consensus of SPUMS/UKDMC).

Statement 7

Before return to diving following closure of a PFO or ASD, the diver requires a repeat transthoracic bubble contrast echocardiogram with provocation manoeuvres as described, that demonstrates adequate reduction or abolition of the right-to-left shunt, a minimum of three months after the closure (III).^{14,26,28,30}

Statement 8

Diving should not be resumed until satisfactory closure of the right-to-left shunt is confirmed, and the diver has ceased potent antiplatelet medication (low dose aspirin is acceptable) (III).^{14,27,28,30}

Statement 9

Advice about pulmonary shunts should be from a cardiologist with expertise in diving medicine (IV – consensus of SPUMS/UKDMC).

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Acknowledgements

We are grateful for the contribution of the participants at the workshop held at the 52nd Annual Scientific Meeting of the SPUMS and of the other members of the UKDMC.

Conflicts of interest and funding

Dr Turner acts as a consultant and proctor for St Jude Medical, Medtronic and Edwards Lifesciences, as a consultant and lecturer for Gore Medical and performs PFO closures on private patients. Professor Mitchell is the editor of *Diving and Hyperbaric Medicine* Journal. However, as a societal position statement this manuscript did not require peer review or a related decision regarding publication. The other authors declare that they have no conflicts of interest.

Submitted: 1 December 2024**Accepted:** 8 December 2024

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