

Joint position statement on persistent foramen ovale (PFO) and diving

South Pacific Underwater Medicine Society (SPUMS) and the United Kingdom Sports Diving Medical Committee (UKSDMC)

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Abstract

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This consensus statement is the result of a workshop at the SPUMS Annual Scientific Meeting 2014 with representatives of the UK Sports Diving Medical Committee (UKSDMC) present, and subsequent discussions including the entire UKSDMC. Right-to-left shunt across a persistent or patent foramen ovale (PFO) is a risk factor for some types of decompression illness. It was agreed that routine screening for PFO is not currently justifiable, but certain high risk sub-groups can be identified. Divers with a history of cerebral, spinal, inner-ear or cutaneous decompression illness, migraine with aura, a family history of PFO or atrial septal defect and those with other forms of congenital heart disease are considered to be at higher risk. For these 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. Reduction in gas load by limiting depth, repetitive dives and avoiding lifting and straining may all be appropriate. Divers may consider transcatheter device closure of the PFO in order to return to normal diving. If transcatheter PFO 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 (aspirin is acceptable).

Key words

Patent foramen ovale (PFO); persistent foramen ovale; fitness to dive; decompression illness; transcatheter closure; cardiovascular; health surveillance; medical society

Introduction

This statement was produced from a workshop held at the 43rd Annual Scientific Meeting of the South Pacific Underwater Medicine Society (SPUMS) on 23 May 2014, and following consultation with the United Kingdom Sport Diving Medical Committee (UKSDMC), two members of which attended the meeting (PW and MT). The statement must be interpreted in consultation with a medical practitioner experienced in diving medicine and will be subject to review based on new evidence becoming available.

The levels of evidence defined for the position statement are those promulgated in the 2015 ACCF/AHA Clinical Practice Guideline Methodology Summit Report:¹

- Ia – Evidence from meta-analysis of randomized controlled trials;
- Ib – Evidence from at least one randomized controlled trial;
- IIa – Evidence from at least one well designed controlled trial which is not randomized;
- 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.

Statement 1

Routine screening for persistent foramen ovale (PFO) (also referred to as ‘patent’ foramen ovale) at the time of dive medical fitness assessment (either initial or periodic) is not indicated (IV – consensus of SPUMS/UKSDMC).

Statement 2

Consideration should be given to investigating for PFO under any of the following circumstances:

- A history of decompression illness (DCI) with cerebral, spinal, vestibulocochlear or cutaneous manifestations (IIa);²⁻⁸
- A current or past history of migraine with aura (IIa);⁹⁻¹⁵
- A history of cryptogenic stroke (IIa);^{16,17}
- A history of PFO or atrial septal defect (ASD) in a first degree relative (IIa).^{18,19}

Statement 3

If screening for PFO is performed, then the following is recommended:

- That testing is undertaken by centres well practiced in the technique (IV – consensus of SPUMS/UKSDMC);
- The screening must include bubble contrast, ideally combined with trans-thoracic echocardiogram (TTE) because this best facilitates cooperation with provocation manoeuvres. Use of two-dimensional and colour-flow echocardiography without bubble contrast is not adequate (IIa);^{6,7,20}
- The screening must include the use of provocation manoeuvres to promote right-to-left shunt including Valsalva release and sniffing as described in the supporting references (both undertaken when the right atrium is densely opacified by bubble contrast) (IIa).^{6,7}

Statement 4

Interpreting a positive PFO screening result:

- A spontaneous shunt without provocation or a large, provoked shunt is recognized as an unequivocal risk factor for those forms of DCI listed in statement 2 (IIa);⁶⁻⁸
- Smaller shunts are associated with a lower but poorly defined risk of DCI. The significance of minor degrees of shunting needs to be interpreted in the clinical setting that led to testing (IIa).⁶⁻⁸

Statement 5

Following diagnosis of a PFO considered likely to be associated with increased DCI risk, the diver may consider the following options in consultation with a diving physician:

- Stop diving (IV – consensus of SPUMS/UKSDMC);
- Dive more conservatively: There are various strategies that might be employed to reduce the risk of significant venous bubble formation after diving, or the subsequent right-to-left shunting of such bubbles across a PFO. The appropriateness of this approach, and the strategies chosen, need to be considered on an individual basis, and in discussion with a diving medicine expert. Examples include: reducing dive times to well inside accepted no-decompression 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; avoidance of heavy exercise and unnecessary lifting or straining for at least three hours after diving (IV – consensus of SPUMS/UKSDMC).
- Close the PFO (III).^{7,11,21-24}

Statement 6

The options outlined in statement 5 require careful consideration of the risks and benefits and the clinical setting that led to screening (IV – consensus of SPUMS/UKSDMC).²⁴

Statement 7

Following closure of a PFO and before returning to diving, the diver requires a repeat bubble contrast echocardiogram demonstrating shunt closure, a minimum of three months after the closure (III).^{11,21,22,24}

Statement 8

Diving should not be resumed until satisfactory closure of the PFO is confirmed, and the diver has ceased potent antiplatelet medication (aspirin is acceptable) (III).^{11,21,22,24}

References

This list is restricted to the original case control studies and main reports. There have been many subsequent reports of the association of PFO and cryptogenic stroke.

- 1 Jacobs AK, Kushner FG, Ettinger SM, Guyton RA, Anderson JL, Ohman EM, et al. ACCF/AHA clinical practice guideline methodology summit report: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol*. 2013;61:213-65. [Available from: <http://www.cardiosource.org>].
- 2 Moon RE, Camporesi EM, Kisslo JA. Patent foramen ovale and decompression sickness in divers. *Lancet*. 1989;333:513-4.
- 3 Wilmshurst PT, Byrne JC, Webb-Peploe MM. Relation between interatrial shunts and decompression sickness in divers. *Lancet*. 1989;334:1302-6.
- 4 Wilmshurst P, Davidson C, O'Connell G, Byrne C. Role of cardiorespiratory abnormalities, smoking and dive characteristics in the manifestations of neurological decompression illness. *Clin Sci*. 1994;86:297-303.
- 5 Germonpré P, Dendale P, Unger P, Balestra C. Patent foramen ovale and decompression sickness in sports divers. *J Appl Physiol*. 1998;84:1622-6.
- 6 Wilmshurst P, Bryson P. Relationship between the clinical features of neurological decompression illness and its causes. *Clin Sci* 2000;99:65-75.
- 7 Wilmshurst PT, Pearson MJ, Walsh KP, Morrison WL, Bryson P. Relationship between right-to-left shunts and cutaneous decompression illness. *Clin Sci*. 2001;100:539-42.
- 8 Cantais E, Louge P, Suppini A, Foster P, Palmier B. Right-to-left shunt and risk of decompression illness with cochleovestibular and cerebral symptoms in divers: case control study in 101 consecutive dive accidents. *Crit Care Med*. 2003;31:84-8.
- 9 Del Sette M, Angeli S, Leandri M, Ferriero G, Bruzzone GL, Finocchi C, et al. Migraine with aura and right-to-left shunt on transcranial Doppler; a case control study. *Cerebrovasc Dis*. 1998;8:327-30.
- 10 Anzola GP, Magoni M, Guindani M, Rozzini L, Dalla Volta G. Potential sources of cerebral embolism in migraine with aura. A transcranial Doppler study. *Neurology*. 1999;52:1622-5.
- 11 Wilmshurst PT, Nightingale S, Walsh KP, Morrison WL. Effect on migraine of closure of cardiac right-to-left shunts to prevent recurrence of decompression illness or stroke or for haemodynamic reasons. *Lancet*. 2000;356:1648-51.
- 12 Wilmshurst P, Nightingale S. Relationship between migraine

- and cardiac and pulmonary right-to-left shunts. *Clin Sci*. 2001;100:215-20.
- 13 Schwerzmann M, Nedeltchev K, Lagger F, Mattle HP, Windecker S, Meier B, et al. Prevalence and size of directly detected patent foramen ovale in migraine with aura. *Neurology*. 2005;65:1415-8.
 - 14 Wilmshurst PT, Pearson MJ, Nightingale S. Re-evaluation of the relationship between migraine and persistent foramen ovale and other right-to-left shunts. *Clin Sci*. 2005;108:365-7.
 - 15 Wilmshurst P, Nightingale S, Pearson M, Morrison L, Walsh K. Relation of atrial shunts to migraine in patients with ischaemic stroke and peripheral emboli. *Am J Cardiol*. 2006;98:831-3.
 - 16 Lechat P, Mas JL, Lascault G, Loran P, Theard M, Klimczac M, et al. Prevalence of patent foramen ovale in patients with stroke. *New Engl J Med*. 1988;318:1148-52.
 - 17 Webster MWI, Chancellor AM, Smith HJ, Swift DL, Sharpe DN, Bass NM, et al. Patent foramen ovale in young stroke patients. *Lancet*. 1988;332:11-12.
 - 18 Wilmshurst PT, Pearson MJ, Nightingale S, Walsh KP, Morrison WL. Inheritance of persistent foramen ovale and atrial septal defects and the relationship to familial migraine with aura. *Heart*. 2004;90:1315-20.
 - 19 Wilmshurst P, Panikkar J, Pearson M, Nightingale S. Relation between inheritance of cyanotic congenital heart disease and persistent foramen ovale. *Am J Cardiol*. 2009;104:148-9.
 - 20 Ha JW, Shin MS, Kang S. Enhanced detection of right-to-left shunt through patent foramen ovale by transthoracic contrast echocardiography using harmonic imaging. *Am J Cardiol*. 2001;87:669-71.
 - 21 Wilmshurst P, Walsh K, Morrison L. Transcatheter occlusion of foramen ovale with a button device after neurological decompression illness in professional divers. *Lancet*. 1996;348:752-3.
 - 22 Walsh KP, Wilmshurst PT, Morrison WL. Transcatheter closure of patent foramen ovale using the Amplatzer septal occluder to prevent recurrence of neurological decompression illness in divers. *Heart*. 1999;81:257-61.
 - 23 Billinger M, Zbinden R, Mordasini R, Windecker S, Schwerzmann M, Meier B, et al. Patent foramen ovale closure in recreational divers: effect on decompression illness and ischaemic brain lesions during long-term follow-up. *Heart*. 2011;97:1932-7.
 - 24 National Institute for Health and Care Excellence. *NICE interventional procedure guidance – percutaneous closure of*

patent foramen ovale for the secondary prevention of recurrent paradoxical embolism in divers (IPG371 December 2010). [cited 2015 April 26]. Available from: <http://www.nice.org.uk/guidance/ipg371/documents/percutaneous-closure-of-patent-foramen-ovale-for-the-secondary-prevention-of-recurrent-paradoxical-embolism-in-divers-consultation-document>

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Conflicts of interest

MT 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. The other authors declare that they have no conflicts of interest.

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