Orthodeoxia and postural orthostatic tachycardia in patients with pulmonary arteriovenous malformations: a prospective 8-year series

ABSTRACT

Postural changes in 258 patients with pulmonary arteriovenous malformations (PAVMs) reviewed between 2005 and 2013 were evaluated prospectively using validated pulse oximetry methods. Of the 257 completing the test, 75 (29%) demonstrated orthodeoxia with an oxygen saturation fall of at least 2% on standing. None described platypnoea (dyspnoea on standing). The heart rate was consistently higher in the erect posture: 74 (29%) had a postural orthostatic tachycardia of \( \geq 20 \text{ min}^{-1} \), and in 25 (10%) this exceeded \( 30 \text{ min}^{-1} \). Orthostatic tachycardia was more pronounced in PAVM patients than controls without orthodeoxia (age-adjusted coefficient 5.5 (95% CIs 2.6, 8.4) min\(^{-1} \), \( p<0.001 \)). For PAVM patients, the age-adjusted pulse rise was 0.79 min\(^{-1} \) greater for every 1% greater drop in oxygen saturation on standing (\( p<0.001 \)). In contrast to the postural orthostatic tachycardia syndrome, in this population, there was a trend for more pronounced orthostatic tachycardia to be associated with better exercise tolerance.

To the editor

Pulmonary arteriovenous malformations (PAVMs) result in hypoxaemia due to right-to-left shunting. Recent studies highlight that chronic hypoxaemia in iron-replete patients leads to secondary erythrocytosis which preserves arterial oxygen content (CaO₂). Both shunt fraction and hypoxaemia severity may increase acutely on standing, a phenomenon ascribed to basally situated PAVMs. Platypnoea-orthodeoxia (dyspnoea and arterial deoxygenation on standing) has been described, particularly in patients with patent foramen ovale. However, platypnoea was not our experience in the PAVM population, suggesting they may be able to compensate for acute falls in CaO₂. The goal of the study was to quantify orthodeoxia and examine potential compensatory mechanisms to facilitate provision of appropriate information to PAVM patients.

The study was ethically approved by the Hammersmith, Queen Charlotte’s, Chelsea, and Acton Hospital Research Ethics Committee (LREC 2000/5764). Full methods are presented in the online supplementary data supplement. In all, 258 consecutive patients with CT-proven PAVMs were prospectively and newly recruited (2005–2013) and evaluated as described. Pulse and oxygen saturation (SaO₂) were measured by pulse oximetry in supine and erect postures for 10 min. Exercise capacity was stratified to a modified Medical Research Council (MRC) dyspnoea scale, with individuals classified as grade 1a if they participated in intense sporting activity at least three times per week.

Full patient demographics are presented in online supplementary Table 1. Ages ranged from 16 to 90 (median 48) years. A total of 89 (34.5%) were male. For 239
As expected, obese patients had lower SaO2 and pulse values demonstrated high within-patient reproducibility (see online supplementary Table 2).

Overall, erect SaO2 was significantly lower than supine SaO2 (figure 1A). In 75/257 (29%) patients, the SaO2 fell by at least 2% on standing compared with the equivalent supine reading. A smaller fall of 1%–2% was present in a further 54/257 (21%) patients. None of these patients reported dyspnoea on standing (platypnoea), although one was unable to complete the 10 min standing due to dizziness.

Comorbidities were more common in patients with higher grade dyspnoea (see online supplementary Figure 1). Replicate SaO2 and pulse values demonstrated high within-patient reproducibility (see online supplementary Table 2).

Sudden falls in SaO2 reduce CaO2 per unit blood volume. However, there was a consistent increase in heart rate on standing (figure 1B). Orthostatic tachycardia was more pronounced in PVM patients than 40 controls (figure 1C, and online supplementary Figures 2 and 3), and in patients exhibiting greater falls in SaO2/CaO2 (see online supplementary Figure 5). Postural orthostatic tachycardia is normally viewed in a detrimental manner, but in this study, more marked orthostatic tachycardia was observed in patients with better exercise tolerance (figure 1D), whether analysed in five groups as shown, or in three groups of athletes (grade 1a), normal (grade 1b) and all dyspnoeic patients (grades 2–4).

To conclude, we provide an extensive consecutive series demonstrating that orthodeoxia is common in PVM patients, though may be masked by obesity. Exuberant postural orthostatic tachycardia may be part of acute compensatory mechanisms that maintain tissue oxygen delivery when CaO2 falls suddenly on standing, and is associated with better exercise tolerance in PVM patients.

V Santhirapala,1,2,3 B Chamali,1,2 H McKernan,4 H C Tighe,4 L C Williams,4 J T Springett,4 H R Bellenberg,4 A J Whitaker,2 C L Shovlin1,4
1NHU Cardiovascular Sciences, Imperial College London, London, UK
2NHU Respiratory Sciences, Imperial College London, London, UK
3Imperial College School of Medicine, Imperial College London, London, UK
4Respiratory Medicine, Hammersmith Hospital, Imperial College Healthcare NHS Trust, London, UK

Correspondence to Dr Claire L Shovlin, NHU Cardiovascular Sciences, Imperial Centre for Translational and Experimental Medicine, Imperial College London, Hammersmith Campus, Du Cane Road, London, W12 0NN, UK; c.shovlin@imperial.ac.uk

Acknowledgements Funding was received from the National Institute of Health Research NIHR: London (NW) Comprehensive Local Research Network; patient donations; and Imperial College BSc project funds (to CLS for VS and BC).

Contributors VS generated the 2005–2010 database and analysed data. BC generated the 2010–2013 database. HM, HCT, LCW and JS performed pulmonary function measurements and pulse oximetry for the early detection of pulmonary arteriovenous malformations. CLS reviewed all patients, contributed to database generation, performed all statistical analyses, generated the figures/tables and wrote the article. All authors reviewed and approved the final article.

Competing interests None.

Ethics approval Hammersmith, Queen Charlotte’s, Chelsea, and Acton Hospital Research Ethics Committee (LREC 2000/5764).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement We fully concur with the principles of data sharing and will provide anonymised primary data in Excel format on request.

REFERENCES