Should we close hypoxaemic patent foramen ovale and interatrial shunts on a systematic basis?

Faut-il fermer systématiquement les foramens ovale perméable avec shunt chez les patients hypoxémiques?

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In this issue of Archives of Cardiovascular Diseases, Dr El Tahlawi et al. discuss the relationship between patent foramen ovale (PFO) and permanent hypoxaemia, and honestly report the clinical results of percutaneous closure in such patients. The authors focus their study on patients with hypoxaemia associated with PFO and normal or slightly increased pulmonary arterial pressure (PAP). They clearly emphasize the difficulties in ascertaining the responsibility of PFO in the mechanism of hypoxaemia with inconsistent and mitigating results in patients with chronic obstructive lung disease after PFO closure. Indeed, the imputability of a PFO in permanent hypoxaemia must be very carefully assessed due to the high frequency rate of this cardiac abnormality, and a thorough cardiopulmonary evaluation should be carried out to exclude all the other causes of permanent hypoxaemia [1,2].

Patients with severe pulmonary arterial hypertension, from either pulmonary or cardiac causes, leading to the massive reopening of a preexistent PFO, are excluded from El Tahlawi et al. ‘s analysis because the closure of these ‘rescue’ PFOS could be very harmful in this rare situation.

PFO and hypoxaemia: clinical circumstances

The most common, while still rare, clinical situation is platypnoea-orthodeoxia syndrome, combining positional and severe hypoxaemia (arterial desaturation in this pathology is accentuated in the upright posture and relieved in the recumbent position). This is
commonly associated with hyperventilation in the upright position, referred to as platypnoea. This syndrome is commonly described in patients with chronic lung diseases, not related to PFO, including emphysema, pulmonary arteriovenous malformation (especially when located at the lung bases with true vascular lung shunts), acute respiratory distress syndrome and hepatopulmonary syndrome. Cardiac shunting due to PFO with normal PAP may be involved in the platypnoea-orthodeoxia syndrome alongside an intercurrent event or condition, such as right pneumonectomy [3], aortic root enlargement sometimes up to aortic aneurysm [4], diaphragmatic paralysis (more especially when there is an isolated right hemidiaphragm elevation) [5], or abdominal surgery, which can cause diaphragmatic trauma. We recently described a patient requiring emergency PFO closure 1 month after successful left lung transplantation causing right pulmonary atrophy (quite similar anatomically to right pneumonectomy) [6]. This patient presented with life-threatening hypoxaemia: PaO2 was reduced to 41 mmHg despite 20 L/min nasal oxygen therapy; PAP was normal. Hypoxaemia was related to a large PFO with massive shunting; percutaneous closure leads to an immediate recovery. As mentioned in the paper by El Tahlawi et al., the best results of PFO closure in the case of hypoxaemia are obtained in patients with normal PAP.

Right-to-left shunting across a PFO may also worsen systemic hypoxaemia in patients with chronic obstructive lung disease. This is probably the most difficult clinical situation in the decision whether to perform PFO closure, because these patients have a pulmonary cause of hypoxaemia and a slight elevation in PAP. Sudden exacerbation of hypoxaemia with steady pulmonary conditions could indicate PFO as the cause; percutaneous closure may be proposed in some carefully selected cases, and discussed in close collaboration with pneumologists. In this series of 21 consecutive patients, 43% had chronic respiratory insufficiency and despite improvement in their oxygenation parameters after percutaneous PFO closure, the majority of these patients remained dyspnoeic and hypoxaemic with some residual shunt.

Obstructive sleep apnoea (OSA) may also be associated with oxygen desaturation to a varying degree. Prevalence of PFO in patients with OSA seems greater than in control patients (from 27 to 69%) and could contribute to significant hypoxaemia, especially after a Valsalva manoeuvre in approximately one third of these patients [7,8]. This apparent discrepancy between the rates of PFO in OSA patients is due to the fact that the degree of desaturation in relation to apnoeic events was not considered in the two previous studies. In a group of 209 patients diagnosed with OSA, Johansson et al. identified a 60% rate of PFO in the high proportional desaturation group versus 13% in the low proportional desaturation group [9]. PFO closure for severe hypoxaemia during sleep apnoea syndrome has already been published as an isolated case report [10].

Last, but not least, PFO causing position-dependent shunting and severe hypoxaemia was described in a 75-year-old woman shortly after laying down an old and pinching corset, which was successfully treated by PFO percutaneous closure [11].

Pathophysiology

After right-sided pneumonectomy, the commonly accepted mechanism is deviation of the mediastinum towards the right side leading to an orientation of the inferior vena cava flow towards the PFO. Extrinsic compression of the right atrium (especially in the upright position), either by a hydrothorax or a pericardial effusion, can also contribute to this ‘flow phenomenon’. The mechanisms involved in patients with isolated right hemidiaphragm elevation are probably very similar to those observed during these previous conditions. In patients with an enlarged aortic root, a redirection of venous flow caused by an anatomical distortion of the right atrium or atrial septum is also the underlying mechanism involved in cases of platypnoea-orthodeoxia due to cardiac shunting through a PFO. It has been described, in cases of large aortic aneurysms, as a rotation of the heart in a counter-clockwise direction, thereby distorting the position of the atrial septum relative to caval inflow [4]. Eventually, we observed a distortion of the cardiac anatomy not related to elevated right-sided pressures; the atrial septum is frequently displaced towards the horizontal position so that the atrial defect is placed directly in line with the blood flow coming from the inferior vena cava.

In patients with OSA, there are excessive intrathoracic pressure swings that greatly influence central haemodynamics, creating a right-to-left shunt through the PFO, which may cause significant desaturation. Transient right-sided pressure elevation occurs during OSA with a rise in systemic pressure and PAP from the beginning of the apnoea to the immediate post-apnoic segment [8]. Other previous findings reported an increased filling of the right ventricle during the inspiration effort against a closed upper airway, with displacement of the interventricular septum and transmission of right ventricular pressure increase to the atrial chamber [12].

In all cases, the association with an atrial septal aneurysm (defined as an extent of protrusion greater than 10 mm beyond the plane of the atrial septum into either the right or the left atrium) or an abnormally large eustachian valve, which causes selective directional shunting, can facilitate both the importance and the direction of the cardiac shunting through the PFO.

How do we ascertain the role of the PFO in the hypoxaemia?

After excluding all pulmonary causes of permanent hypoxaemia, the diagnosis of cyanosis due to a right-to-left shunt should be suspected when there is a systemic desaturation that persists during a 100% oxygen study (without cardiac shunting PaO2 rises to 600 mmHg; a rise to less than 400 mmHg suggests at least 10% cardiac shunting). Even if the presence of cardiac shunting can be suggested by using transcranial Doppler ultrasound examination, it does not locate the shunt at the interatrial level. Transthoracic echocardiography using second harmonic imaging during a contrast test with agitated saline solution, at rest and during a Valsalva manoeuvre, asserts the interatrial shunt when there is an early opacification (within
three to five cardiac cycles) of the left atrium [13]. This simple technique is a noninvasive tool, easily repeated with a high negative predictive value when the Valsalva manoeuvre is adequately performed. It gives the opportunity to perform optimal provocative manoeuvres, which are sometimes falsely negative in a sedated patient during transoesophageal echocardiography (TEE). Nevertheless, TEE is a useful and complementary tool with which to determine the accurate anatomy of the PFO (size, length of the tunnel), to exclude other possible causes of shunt (atrial septal defect) and to analyse all other abnormalities: eustachian valve and atrial septal aneurysm. The responsibility of the PFO in hypoxaemia must also be confirmed during cardiac catheterization by monitoring blood oxygen saturation, which is normal in the pulmonary veins but shows desaturation at the level of the left atrium. The imputability of PFO is reinforced when the PAP is normal. Theoretically, the diagnosis is eventually confirmed when blood oxygen saturations in the left atrium and aorta return to normal values after an occlusion test of the atrial defect using a balloon-tip catheter [14]. Unfortunately, in our experience, this test is not always explicitly demonstrative in all the cases.

In summary, according to the paper by El Tahlawi et al., and also in our own opinion, the answer to the initial question, should we close hypoxemic patent foramen ovale and interatrial shunts on a systematic basis?, is clearly, no. However, we must keep in mind that there are ideal conditions, sometimes life-threatening hypoxaemia due to cardiac shunting requiring PFO closure (exclusively percutaneously in 2009), especially when the PAP is normal. Moreover, the prevalence of systemic desaturation due to PFO with normal PAP is probably underestimated in the overall population. Indications for PFO closure in patients with chronic obstructive lung disease and a slight elevation in PAP are restricted and need to be discussed individually in close collaboration with pneumologists.

Conflicts of interest
None.

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References

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