Transcatheter closure of a patent foramen ovale prior to a pneumonectomy to prevent platypnea syndrome

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Abstract

An intracardiac shunt on an atrial level may be a cause of hypoxemia after lung surgery (platypnea–orthodeoxia syndrome). This syndrome may be successfully treated by percutaneous or surgical shunt closure. We present the case of preoperative transcatheter closure of a patent foramen ovale (PFO) for the prevention of possible platypnea after a forthcoming right pneumonectomy.

Keywords: Septal defects; Hypoxia; Cardiac catheterization; Pneumonectomy; Shunts

1. Introduction

Platypnea–orthodeoxia syndrome (POS) is a well-known complication in patients with interatrial shunts (IAS) about to undergo lung surgery [1]. Its clinical manifestations include dyspnea and arterial desaturation, which occur mostly in an upright position; these are caused by a right-to-left shunt via an atrial septal defect (ASD) [1,2].

In the past, surgical and transcatheter closures of the IAS were described in the postoperative period in order to relieve hypoxemia [2–4]. We are, however, presenting the transcatheter closure of a patent foramen ovale (PFO) prior to a right pneumonectomy to prevent POS.

2. Description of the case

A 42-year-old Caucasian male was diagnosed three years ago with moderately differentiated T2N2M0 squamous cell carcinoma of the right lung. After induction chemotherapy, he refused surgery and was treated by sequential chemotherapy and radiation. Following this treatment, the disease was contained within the right lung. Repeated computerized tomography (CT) and positron emission tomography (PET) with fluorodeoxyglucose (FDG) showed no evidence of metastatic dissemination. A recent PET/CT demonstrated a significant enlargement of tumor mass. A right pneumonectomy was proposed as the only way of prolonging this patient’s life, with a chance for cure. A transesophageal echocardiography (TEE) detected an interatrial septal aneurysm (IASA) with a moderate PFO. Our surgeons’ opinion was that the presence of the PFO may predispose the patient to an acute and profound postoperative hypoxemia and increase the overall surgical risk. Transcatheter PFO closure was performed through the right femoral vein using fluoroscopic and TEE guidance. The balloon sizing of the defect was 7 mm; a 7-mm ASD Amplatzer occluder (AGA Medical Corporation, 682 Mendelssohn Avenue, Golden Valley, MN 55427, USA) was implanted to instantly occlude the IAS and stabilize the IASA.

Four days after the procedure, the patient underwent a successful right pneumonectomy with an uneventful peroperative course. Clinical and echocardigraphic follow-ups revealed normal arterial saturation and an optimal position of the occlusive device with no residual shunt.

3. Discussion

The right-to-left shunt at atrial level despite normal intracardiac pressures is a well-known phenomenon. Inside with POS, it may be responsible for several linked diseases, such as paradoxical embolism, migraine with aura, transient global amnesia and decompression thickness in divers [5]. Several hypotheses have been postulated to explain this “water flowing up a hill” phenomenon. While mean right atrial pressure is normally lower than the mean left atrial pressure, transient spontaneous reversal of the left-to-right
intraatrial shunt may take place during early diastole and isovolumic contraction of the right ventricle. Different physiologic maneuvers, which increase right atrial pressure (Valsalva, posture, inspiration, cough), may increase this reversal gradient [5]. Another explanation is a physiologic change in the relationship of the compliance of right and left heart chambers, which could be exacerbated with age [5]. In fetal life, there is a preferential blood flow from the inferior vena cava toward the atrial septum. This circulatory pattern may partially persist in postnatal life. Therefore, an anatomic disarray of the inferior vena cava (IVC) relative to the intraatrial septum may facilitate the flow stream via a PFO. This disarray may be caused by mediastinal shift or by counterclockwise heart rotation following right pneumonectomy, pericardial effusion or ascending aorta enlargement [5].

POS is one of the several causes of dyspnea and hypoxemia after a pneumonectomy. Other causative pathological states such as chronic obstructive pulmonary disease, pulmonary emboli, narrowing of the airway, heart failure, pneumonia and respiratory muscle weakness could be additional and more common causes for hypoxemia. The pathophysiology of this syndrome is not completely understood. Typically, the right-to-left shunt at an atrial level develops despite normal right atrial pressure and is probably related to reduced right ventricular compliance and the subsequent impaired right atrial emptying [1,2]. POS was more frequent after a right than after a left pneumonectomy probably due to the counterclockwise rotation of the heart with following anatomical disarray of IVC and atrial septum [5]. Giombolini et al. [6] suggest that the presence of an atrial septal aneurysm may additionally predispose the patient for the development of POS after a pneumonectomy. Large Eustachian valve directing IVC flow towards the atrial septum was also described as predisposing factor for POS [1]. Although posture dependency was described as a classic characteristic of this complication, a recent report suggested that it was present in 55% of POS patients. Dehydration was reported as another predisposing factor for a right-to-left shunt at atrial level in the presence of an IAS [1].

The precise incidence of POS is not clear. It is considered a rare syndrome; however, its real frequency might be underestimated considering that the prevalence of PFOs is approximately 20% in the adult population [7]. As in the majority of patients POS usually develops not immediately but during the first few months after the surgery, it may be misdiagnosed, especially in its mild form. Dyspnea and hypoxemia may be explained by the more common causes, such as the loss of lung function, heart failure, pneumonia COPD, etc. It may also be difficult to diagnose POS when a patient cannot be weaned off the ventilator [8].

Several diagnostic algorithms were proposed for diagnosis of the POS. Breathing 100% oxygen in recumbent and upright position was recommended as a simple and a sensitive initial test [1]. Perfusion lungs scintigraphy may help to exclude pulmonary embolism, which may have similar symptoms and may also appear after a certain period following pneumonectomy. Echocardiography with and without contrast was proposed to establish the shunt at atrial level. Another less practical approach could be cardiac catheterization [1]. One could speculate that any patient with an interatrial communication, which develops respiratory failure, has more or less significant intermittent or persistent right-to-left shunt at atrial level. The presence of an IAS may be a vent, allowing a right-to-left flow due to transient elevation of pulmonary artery pressure in the postoperative period, maintaining systemic cardiac output. However, our surgical team would not consider to operate on this patient in the presence of a PFO, claiming that the perioperative risk would significantly increase if the foramen ovale will remain patent. Surgical and transcatheter closure of IASs were reported to be effective in the treatment of POS [1–4]. We propose the preventative preoperative transcatheter closure of IAS to avoid postoperative hypoxemia due to a right-to-left shunt at atrial level. In the majority of previously published cases where patients developed this complication had a previously undiagnosed PFO or ASD – probably owing to difficulties in identifying these congenital anomalies by means of a routine transthoracic echocardiography (TTE) [1,2]. Our patient's PFO was diagnosed by a TEE. In the presence of a PFO and an IASA the probability to develop POS was quite high, especially after a right pneumonectomy [1].

The preoperative detection of an IAS may be achieved by intravenous injection of agitated saline during the routine TTE or by the transcranial Doppler (TCD) technique. The TEE could be reserved for patients with poor TTE imaging and may be completed as the initial part of transcatheter PFO closure [9]. It is not clear whether every patient referred for thoracic surgery should undergo an investigation to rule out an interatrial communication. As our surgical team considers the presence of a PFO to be a significant perioperative risk factor, it has become a common practice to exclude or identify PFO/ASD in patients planned for pneumonectomy by means of TCD or TEE with an intravenous injection of agitated saline. However, should POS occur in the postoperative period, transcatheter closure of IAS should be considered as the treatment of choice.

As the percutaneous transcatheter closure of PFOs and small ASDs carries a very small risk in a stable preoperative patient, the risk of postoperative POS and potential difficulties of weaning of ventilation should be weighed against a low risk of IAS closure.

Therefore, the preventative transcatheter closure of a PFO may be proposed as a minimally invasive, safe and nonsurgical approach to avoid postoperative hypoxemia induced by the right-to-left shunt at atrial level.

References


