Case Report

Cardiac device-induced right to left shunt causing significant hypoxemia: A case report and review of literature

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ABSTRACT

We describe a patient where a pacemaker lead induced tricuspid valve changes that caused a right to left shunt through a preexisting patent foramen ovale resulting in significant hypoxemia. This event occurred years after the pacemaker had been placed. Surgical closure of the patent foramen ovale resolved the patient’s hypoxemia and dyspnea. We also reviewed the previous cases published in the medical literature concerning significant hypoxemia from cardiac device-induced right to left shunts. Three of the four reported cases occurred 4 or more years after device placement. Therefore, late onset hypoxemia in setting of cardiac device placement without an alternative cause should raise the possibility of this complication.

1. Introduction

The placement of cardiac devices is associated with numerous cardiopulmonary complications. Many of these complications develop immediately after device placement. It is underappreciated that cardiac device placement may result in significant hypoxemia by causing a significant right to left shunt. The onset of this complication may be insidious. In this report, we describe a case of cardiac device-induced right to left shunt that occurred years after device placement. We further describe the pathogenesis of this entity and review previously reported cases.

2. Case report

A 68-year-old man was evaluated because of worsening dyspnea for 6 months. Four months previously, the patient sought medical attention and was found to be profoundly hypoxic requiring supplemental oxygen at 4 L/min via nasal cannula.

The patient had a right-sided dual chamber permanent pacemaker placed 24 years earlier for complete heart block with a right atrial and right ventricular lead. Four years prior to his current presentation, he developed a non-ischemic cardiomyopathy thought to be the result of chronic right ventricular pacing. This cardiomyopathy required an upgrade to a cardiac resynchronization therapy-defibrillator (CRD-T) with 3 new leads implanted on the left side. The older pacemaker leads could not be extracted.

When the patient presented to our facility, he had undergone numerous investigations for the cause of his dyspnea and hypoxemia. Spirometry was normal. A chest computed tomography showed essentially normal lung parenchyma, normal pulmonary vascu-
lature, normal cardiac morphology with two abandoned leads from right-sided pacemaker (one in right atrial appendage and the other in right ventricular apex) and three leads from the CRT-D (one each in right atrium, right ventricle, and coronary sinus). A right heart catheterization showed normal right atrial and right ventricular pressures. The pulmonary artery pressure and pulmonary capillary wedge pressure could not be determined because the catheter was obstructed by multiple CRT-D and pacemaker wires. Prior echocardiograms showed preserved left ventricular ejection fraction.

On physical examination at our facility, the patient had normal vital signs except for an oxygen saturation of 95% while receiving supplemental oxygen at 4 L/minute via nasal cannula. Auscultation of the chest was normal. A grade 3/6 flow murmur was auscultated over the tricuspid area.

Absence of significant structural pulmonary abnormalities and lack of an obvious cardiac cause for hypoxemia on previous assessments suggested that patient's gas exchange abnormality was secondary to right to left intra-cardiac shunt. A 99mTc macroaggregated albumin (99mTc-MAA) imaging study demonstrated significant uptake in the brain and kidneys, confirming the presence of right to left shunt. Concomitant ABG on room air showed PH 7.41, pCO2 30 mmHg, pO2 66 mmHg, and the pO2 only improved to 155 mmHg on 100% FiO2 suggesting a large right to left shunt [1]. A bubble contrast echocardiogram demonstrated left ventricular ejection fraction of 41–49%, moderate tricuspid valve regurgitation with restricted leaflet motion secondary to impingement by a pacemaker wire (Fig. 1) and a right to left shunt at the level of atria (Fig. 2).

It was therefore suspected that the patient had a patent foramen ovale, and a pacemaker lead-induced tricuspid valve obstruction was promoting a functional right to left shunt. Because of these findings, the patient underwent pacemaker lead extraction and PFO

Fig. 1. Apical 4 chamber view on transthoracic echocardiogram showing pacemaker wire impinging and restricting tricuspid valve leaflet movement. **White arrows** show path of pacemaker wire. **Yellow arrows** show tricuspid valve leaflet. RV: right ventricle; LV: left ventricle; RA: right atrium; LA: left atrium. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Fig. 2. Apical 4 chamber view on a transthoracic echocardiogram with bubble study demonstrating right to left shunt. Area demarcated by the **white circle** shows agitated saline bubbles entering left ventricle. RV: right ventricle; LV: left ventricle; RA: right atrium; LA: left atrium.
Table 1
Reported cases of CDRLS.

| Age, Sex | Cardiac Device | Time between device insertion and hypoxemia | Oxygen Requirements | PFO | Outcome after PFO closure | Reference # |
|----------|----------------|--------------------------------------------|---------------------|-----|---------------------------|-------------|
| 33F      | Biventricular ICD | 10 years                                   | None                | Yes | Recovered                 | 6           |
| 62M      | AICD            | 13 years                                   | 100% FiO2           | Yes | Recovered                 | 8           |
| 77M      | Pacemaker       | A few hours                                | 70% O2 saturation on room air | Yes | Recovered                 | 9           |
| 68M      | Dual chamber PPM | PPM insertion: 24 years; CRT-D-leads placed: 4 years | 4L/min NC           | Yes | Recovered                 | Current case |

CDRLS: cardiac device induced right to left shunt; AICD: automatic implantable cardioverter-defibrillator; ICD: implantable cardioverter-defibrillator; PPM: permanent pacemaker; CPAP: continuous positive airway pressure; CRT-D: cardiac resynchronization therapy-defibrillator; PFO: patent foramen ovale; FiO2: fraction of inspired oxygen; NC: nasal cannula; F: female; M: male.

closure. The pacemaker leads were too adherent to the tricuspid valve to be removed. PFO closure resulted in complete resolution of his dyspnea and hypoxemia. He was discharged in an ambulatory condition without the need for supplemental oxygen.

3. Discussion
We report a case a 68-year-old man who presented with new-onset dyspnea after exchange of a pacemaker to a CRD-T done four years prior. He was found to have pacemaker lead-induced tricuspid valve obstruction contributing to a right to left shunt through a preexisting PFO. This defect was surgically closed, and pacemaker leads were removed, which led to complete resolution of his symptoms.

Cardiac device-induced left to right shunts have rarely been reported in the literature. Table 1 shows the 4 reported cases including the present one [6,8,9]. All the patients had a preexisting PFO. All developed very significant dyspnea and hypoxemia. The onset of this complication after device placement occurred acutely in one patient [9] but developed after many years in all the others [6,8]. Closure of the PFO was successful in all cases in reversing the gas exchange abnormality [5]. Clues to the diagnosis of this rare clinical abnormality include placement of a cardiac device and the development of hypoxemia without a likely alternative cause [6]. The hypoxemia may not occur acutely after device placement but rather develop years later [8]. The gold standard for diagnosis is transesophageal echocardiogram with a bubble contrast study that demonstrates an intra-cardiac right to left shunt and usually identifies the specific mechanism by which the device caused the shunt [1,2]. Tests demonstrating a right to left shunt support this diagnosis and include a low arterial pO2 on breathing 100% oxygen and a 99mTc-MAA imaging study demonstrating significant uptake in the brain and kidneys that implies a fraction of the cardiac output has bypassed the pulmonary circulation [1].

4. Conclusion
Cardiac devices with leads across the tricuspid valve may cause significant hypoxemia by causing increased flow from the right atrium to left atrium across a PFO. This complication may not develop acutely after device placement but may occur years later. Closure of a PFO may completely reverse this gas exchange abnormality. Clinicians should be aware of this entity and consider it in a patient who has received a cardiac device who develops significant unexplained hypoxemia, even years after device insertion.

Summary of conflicts of interest
The authors do not have any conflicts of interest to disclose.

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References
[1] D.K. Ming, M.S. Patel, N.S. Hopkinson, S. Ward, M.I. Polkey, The ‘anatomic shunt test’ in clinical practice: contemporary description of test and in-service evaluation, Thorax 69 (8) (2014 Aug) 773–775 https://doi.org/10.1136/thoraxjnl-2013-204103, Epub 2013 Oct 14. PMID: 24127023.
[2] H. Kai, S. Koyanagi, Y. Hirooka, M. Sugimachi, J.I. Sadoshima, S. Suzuki, A. Takeshita, Right-to-left shunt across atrial septal defect related to tricuspid regurgitation: assessment by transesophageal Doppler echocardiography, Am. Heart J. 127 (3) (1994 Mar 1) 578–584.
[3] E.P. Kransdorf, L.N. Kransdorf, F.D. Fortun, J.P. Sweeney, S. Wilansky, Stepwise progression of right-to-left atrial shunting through a combination of patent foramen ovale and tricuspid regurgitation, Tex. Heart Inst. J. 43 (2) (2016) 171–174.
[4] S.P. Borgaonkar, W.W. Lam, M. Razavi, D.R. Parekh, Platypnea-Orthodeoxia syndrome caused by an intracardiac shunt, Tex. Heart Inst. J. 47 (4) (2020 Aug) 298–301.
[5] D. Raja, et al., Unusual cause of hypoxemia after automatic implantable cardioverter-defibrillator leads extraction, Ann. Card Anaesth. 18 (4) (2015) 599–602.
[6] B.K. Kantiharia, T.F. Moccia, B.S. Nagra, F.K. Nakhjavan, Hypoxemia after implantation of a permanent pacemaker, Am. J. Med. Sci. 333 (2) (2007) 125–127.