Manuscript Title: “Large Pulmonary Artery Pseudoaneurysm After CardioMEMS Implantation: A Case Report”

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**CRediT Author Statement**

Tushar Garg: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Writing-Original Draft, Writing- Reviewing & Editing

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Sidhartha Tavri: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Writing- Original Draft, Writing- Reviewing & Editing
Learning Points:

CardioMEMS Heart Failure System implantation can be associated with pulmonary artery injury and lead to hemoptysis.

Large pulmonary artery pseudoaneurysm in a hemodynamically stable patient can be managed with transcatheter embolization.
### Timeline:

<table>
<thead>
<tr>
<th>Days</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Days</td>
<td>CardioMEMS Heart Failure System is placed. Hemoptysis and dyspnea during the procedure managed with intravenous furosemide. Post-Procedure chest radiograph showed right sided pleural effusion managed with thoracocentesis.</td>
</tr>
<tr>
<td>2 days later</td>
<td>Admitted for recurrent post-procedure hemoptysis episodes and computerized tomographic angiography showed 3.4 cm pseudoaneurysm with active extravasation from the superior segmental branch of the left pulmonary artery.</td>
</tr>
<tr>
<td>5 days later</td>
<td>Patient underwent successful transcatheter embolization of the pseudoaneurysm.</td>
</tr>
<tr>
<td>10 days later</td>
<td>Patient was stable with no further hemoptysis episodes and was discharged.</td>
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</tbody>
</table>
Large Pulmonary Artery Pseudoaneurysm After CardioMEMS Implantation: A Case Report

Abstract

Background:
CardioMEMS Heart Failure System is an implantable wireless pressure sensor that is placed in a branch of the pulmonary artery (PA) for remote monitoring of PA pressures in patients with heart failure. Pulmonary artery injury/ hemoptysis can occur during the sensor placement.

Case Summary:
An 80-year-old male patient with Heart Failure with reduced Ejection Fraction (EF 20%) underwent CardioMEMS HF system implantation for recurrent shortness of breath. He developed hemoptysis and dyspnea during the procedure, which was managed with furosemide. The patient’s computerized tomographic angiography (CTA) showed a 3.4 cm pseudoaneurysm with active extravasation from the superior segmental branch of the left pulmonary artery due to injury during device placement. The decision to embolize the pseudoaneurysm was made after a multi-disciplinary team meeting and discussion with the patient. The embolization procedure was done successfully with the final left pulmonary angiogram showed complete stasis and no further filling of the pseudoaneurysm sac.

Discussion:
The incidence of mortality in patients with pulmonary artery injury from CardioMEMS devices is high, and therefore prompt diagnosis and management are critical. Pulmonary artery pseudoaneurysms are uncommon and present with hemoptysis. Transcatheter embolization has been shown to be a practical, effective and safe therapeutic option in stable patients.
Introduction:
CardioMEMS Heart Failure System (Abbott, Abbott Park IL) is an implantable wireless pressure sensor that is placed in a branch of the pulmonary artery (PA) for remote monitoring of PA pressures in patients with heart failure (HF). In hospitalized patients with HF, patients across a spectrum of ejection fraction have similarly poor 5-year survival and risk of readmission (1). The CHAMPION trial demonstrated a 37% reduction in HF hospitalizations was seen in NYHA class III HF patients with recent HF hospitalizations if hemodynamic monitoring was used (2). Based on this trial, the United States Food and Drug Administration (FDA) has approved the device for this subgroup of HF patients, and it has also been endorsed by the European Heart Failure guidelines (3–5). Device implantation has been found to be safe with a very low rate of adverse events (2, 6, 7).

Case Presentation:
An 80-year-old male with HF with reduced Ejection Fraction (HFrEF; EF 20%) due to ischemic cardiomyopathy NYHA class III symptoms and a recent admission for HF was referred for CardioMEMS implantation. He has a past medical history of atrial fibrillation, moderate chronic obstructive pulmonary disease, chronic kidney disease, peripheral artery disease and implantable cardiac defibrillator placement. Heart failure was being managed with metoprolol tartrate 25 mg twice a day (BID) and torsemide 10 mg every other day, for atrial fibrillation he was receiving apixaban 5 mg BID, and for COPD he was receiving a combination of fluticasone, umeclidinium, and vilanterol along with ipratropium-albuterol. Echocardiogram showed an ejection fraction of 20% with moderately dilated left ventricular cavity, mild mitral regurgitation, and moderate to severe tricuspid regurgitation. Apixaban and clopidogrel were held 24 hours before the procedure. During the deployment procedure, the pulmonary artery systolic/diastolic/mean pressures were 52/21/36 mm Hg, respectively, and the pulmonary capillary wedge pressure was 23 mm Hg. The CardioMEMS device was deployed in the left lower lobe segmental pulmonary artery. The patient developed hemoptysis and dyspnea during the procedure and was given intravenous furosemide 80 mg for suspected acute pulmonary edema in the cardiac catheterization laboratory, after which the patient reported considerable improvement. Post-procedure chest radiograph showed right-sided transudative pleural effusion, which was managed with thoracocentesis along with new consolidation in the mid-left lung on the side of the device placement (Figure 1).

Laboratory testing post-procedure showed down-trending hemoglobin from 9.9 gm/dl to 6.1 gm/dl and International Normalized Ratio (INR) of 2.1 even after transfusion of 1 unit of packed red blood cell (pRBC) and two units of fresh frozen plasma (FFP). The blood urea nitrogen (BUN) was 45 mg/dl and creatinine were 1.6 mg/dl. To further manage post-procedure hemoptysis, the patient was transferred from the community-based hospital to a tertiary-care center. On evaluation, injury to the distal branch of the pulmonary artery during CardioMEMS placement was suspected. The patient developed intermittent episodes of small-volume hemoptysis with ongoing conservative management (IV fluids, Supplemental Oxygen therapy, pRBC and FFP transfusion). As the patient was considered stable, he was taken for a computerized tomographic angiography (CTA), which showed a 3.4 cm pseudoaneurysm with active extravasation from the superior segmental branch of the left pulmonary artery (Figure 2A, B).
and C). After a multi-disciplinary meeting with the patient, embolization of the pseudoaneurysm was planned by the interventional radiology service.

For the pseudoaneurysm embolization procedure, ultrasound-guided right common femoral vein access was obtained. The pulmonary angiogram showed a large pseudoaneurysm arising from a branch supplying the superior segment of the left lower lobe in the left mid-lung (Figure 3). The decision to perform coil embolization was made, a 2 mm coil was placed in the distal pulmonary artery branch beyond the pseudoaneurysm neck, a coil scaffold was created across the neck using a 40 mm x 6 cm detachable ruby framing coil (Penumbra, Alameda, CA), and a 3 mm x 1.2 cm coil was placed along the proximal aspect of the inflow feeding artery along with multiple additional 2 mm packing coils. The final left pulmonary angiogram showed complete stasis and no further filling of the pseudoaneurysm sac (Figure 5). The patient was extubated and transferred to the intensive care unit for monitoring and conservative management (Intravenous fluids, pRBC, torsemide 20 mg started). Investigations the following day showed improvement in dyspnea with stabilization of hemoglobin (7.9 mg/dl) and improvement of creatinine (1.44 mg/dl) and BUN (38 mg/dl), after which the patient was discharged home.

Discussion:

HF is one of the leading causes of hospitalizations in patients over 65 in the US and a major health issue with a global prevalence of 40 million hospitalizations in 2015 (8). CardioMEMS is a novel wireless pressure-sensitive device that the FDA approved in 2014 to help monitor pulmonary artery pressure with the help of microelectromechanical (MEMS) systems technology.

In the first three years after FDA approval, a total of 5500 CardioMEMS device implants were performed in the US, and in these, 28 (0.5%) reports of pulmonary artery injury/ hemoptysis were identified (7). Several possible mechanisms can cause pulmonary artery injury and cause hemoptysis in patients undergoing CardioMEMS implantation. The most common cause of injury is due to migration of the catheter nose cone or wire (9). In addition, pulmonary artery walls of patients with heart failure HF are friable and more prone to injury due to the fragmentation of the internal elastic lamina and deposition of disorganized extracellular matrix (9). The type of wire used for selecting pulmonary arteries can have a bearing on the risk of iatrogenic injury. Glidewires, due to their hydrophilic coating, are notorious for causing dissections and perforations if the operator does not respond adequately to the tactile feedback during the procedure (10). In our case, the segmental pulmonary artery branch injured is spatially distant from the branch in which the device was placed (Figure 2B), and therefore, we assume the injury occurred not from the device placement itself but from the preceding wire-catheter manipulation. Finally, the use of peri-procedural anticoagulation can worsen hemoptysis if caused due to any of the causes mentioned above.

Strategies to decrease the risk of complications in patients undergoing CardioMEMS placement include careful patient selection, identification of the appropriate length and diameter pulmonary artery branch, operator with adequate training who understands the advantages and disadvantages of the different tools and devices and also has the resources and ability needed to identify and manage complications.
The incidence of mortality in patients with pulmonary artery injury from CardioMEMS devices is high, and therefore prompt diagnosis and management are critical (1,6). Pulmonary artery pseudoaneurysms are uncommon and are most commonly acquired and associated with cardiovascular disease. The most common presentation of pseudoaneurysms is hemoptysis, and it can range from severe acute hemorrhage to an incidental finding of imaging. CT Angiography is helpful in prompt diagnosis of pulmonary artery pseudoaneurysms. Treatment options for these pseudoaneurysms include surgical ligation, wedge resection, lobectomy; however, minimally invasive endovascular interventions like embolization and stent-graft placement are preferred. In our patient, the pulmonary artery pseudoaneurysm was managed with transcatheter embolization as the patient was stable, and this has shown to be a practical, effective and safe therapeutic option.

Conclusion:

This case report describes the first documented case of pulmonary artery pseudoaneurysm due to CardioMEMS implantation successfully managed by coil embolization. Although rare, complications of CardioMEMS implantation can be significant and require early recognition and expedited management.

Informed consent: The authors confirm that written consent for submission and publication of this case report, including images and associated text, has been obtained from the patient in line with COPE guidance.
References:


Figure 1: CXR shows a new left mid lung consolidation (white arrow), right sided pleural effusion (arrow) and left lower lobe pulmonary artery CardioMEMS device (arrowhead).

Figure 2A, B and C: Chest CT Angiography showing a 3.4 cm pseudoaneurysm (arrow) with active extravasation from the superior segmental branch of the left pulmonary artery in axial view (2A), sagittal view (2B) and 3D reconstructed (2C). In figure 2B, the location of the implant is different from the branch of the pulmonary artery with the pseudoaneurysm which shows that the arterial injury was during wire/ catheter manipulation before the implant was deployed in the lower lobe branch of the pulmonary artery.

Figure 3: Selective pulmonary angiogram showing a large pseudoaneurysm (arrow) arising from a branch supplying the superior segment of the left lower lobe in the left mid-lung.

Figure 4: Post-embolization angiogram shows coils (arrow) at the location of the pseudoaneurysm with its complete exclusion.