

Received: 2017.12.12  
Accepted: 2018.01.07  
Published: 2018.03.31

## Hemoptysis After CardioMEMS Implantation: Case Report and Review

Authors' Contribution:  
Study Design A  
Data Collection B  
Statistical Analysis C  
Data Interpretation D  
Manuscript Preparation E  
Literature Search F  
Funds Collection G

ABCDEF **Aniket S. Rali**  
ABCDEF **Zubair Shah**  
ABCDEF **Andrew J. Sauer**  
ABCDEF **Kamal Gupta**

Department of Cardiovascular Diseases, University of Kansas Medical Center,  
Kansas City, KS, U.S.A.

**Corresponding Author:** Kamal Gupta, e-mail: [kgupta@kumc.edu](mailto:kgupta@kumc.edu)  
**Conflict of interest:** None declared

**Patient:** Female, 79  
**Final Diagnosis:** Hemoptysis  
**Symptoms:** Hemoptysis  
**Medication:** —  
**Clinical Procedure:** —  
**Specialty:** Cardiology

**Objective:** Unusual or unexpected effect of treatment





**Background:** The CardioMEMS heart failure system is a small sensor that is placed in a branch pulmonary artery for ambulatory monitoring of pulmonary artery pressures. CardioMEMS has been approved for use in the United States in patients with New York Heart Association (NYHA) class III heart failure and frequent hospitalizations. In this report we describe a patient who had hemoptysis after CardioMEMS implantation. Further, we discuss possible etiologies for the occurrence of hemoptysis and suggest strategies to minimize this risk.

**Case Report:** The patient was a 79-year-old female with NYHA class III heart failure with non-ischemic cardiomyopathy (LVEF 40%) and chronic atrial fibrillation who was referred for CardioMEMS implantation. The procedure was completed uneventfully. The patient was transferred out of the procedure suite to the recovery area where she developed a slight cough approximately 20 minutes after the implantation. Within a few coughs the patient started having hemoptysis. She was transferred to the cardiac intensive care unit for observation. She was kept off warfarin and aspirin and her hemoptysis resolved 3 days later. While the exact etiology of hemoptysis in this patient was unclear, we felt that it may have been precipitated by a minor wire-induced distal branch pulmonary artery injury.

**Conclusions:** Our report discusses hemoptysis as a potential life-threatening complication of CardioMEMS sensor implantation while suggesting possible etiologies and avoidance strategies. As the utilization of this technology expands in the years to come, a more comprehensive national registry for surveillance of device related complications will be crucial.

**MeSH Keywords:** **Cardiomyopathies • Heart Failure • Hemoptysis**

**Full-text PDF:** <https://www.amjcaserep.com/abstract/index/idArt/908508>

 1146   3  6



## Background

The CardioMEMS heart failure system (Figure 1) is a small sensor that is placed in a branch pulmonary artery for ambulatory monitoring of pulmonary artery pressures. CardioMEMS has been approved for use in the United States in patients with New York Heart Association (NYHA) class III heart failure and frequent hospitalizations [1–3]. Overall, it has been shown to be safe with a very low rate of adverse events. The occurrence of hemoptysis post implantation is rare, though it has been described both in the CHAMPION trial and a recent analysis of the MAUDE Database [1,4]. With the growing use of the device, this is likely to increase.

In this report we describe a patient who had hemoptysis after CardioMEMS implantation. In addition, we discuss possible etiologies for the occurrence of hemoptysis and suggest strategies to minimize this risk.

## Case Report

The patient was a 79-year-old female with NYHA class III heart failure with non-ischemic cardiomyopathy (LVEF 40%) and chronic atrial fibrillation who was referred for CardioMEMS implantation. She had been hospitalized 3 times for heart failure in the prior year despite receiving outpatient intravenous diuretic therapy at the heart failure infusion clinic. Warfarin was held for 3 days prior to the implant procedure and her international normalized ratio (INR) was 1.8 on the day of the procedure. She was taking 81 mg aspirin daily. The remainder of her laboratory studies were unremarkable.

Given her obesity and body habitus, we chose the right internal jugular venous approach for the implant procedure. Right heart catheterization was performed and showed right atrial pressure of 5 mm Hg, pulmonary artery systolic/diastolic/mean pressures of 40/14/22 mm Hg respectively and a pulmonary capillary wedge pressure of 12 mm Hg. A 12 F sheath was placed in the right internal jugular vein and 4000 units of intravenous heparin was administered. Diluted contrast injection through the Swan-Ganz catheter identified a suitable sized left lower lobe branch pulmonary artery. A 0.018-inch wire was advanced into the index artery and the pressure sensor was deployed at the chosen location. The procedure was completed uneventfully. The patient started coughing 20 minutes after the procedure with evolved to mild hemoptysis and so the patient was transferred to the cardiac intensive care unit for observation. Intravenous protamine was administered to reverse heparin. She was kept off warfarin and aspirin and the hemoptysis resolved 3 days later. While the exact etiology of hemoptysis in this patient is unclear, we felt that it may have been precipitated by a minor wire-induced distal branch pulmonary artery injury.

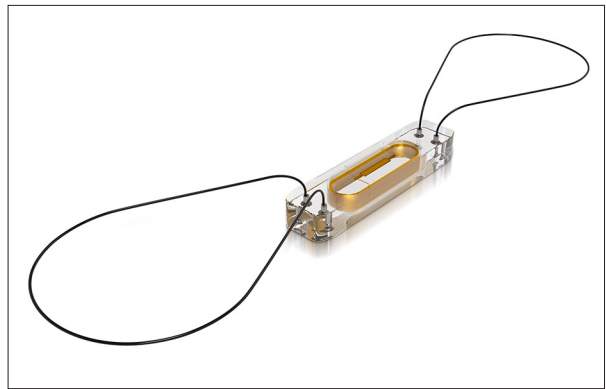


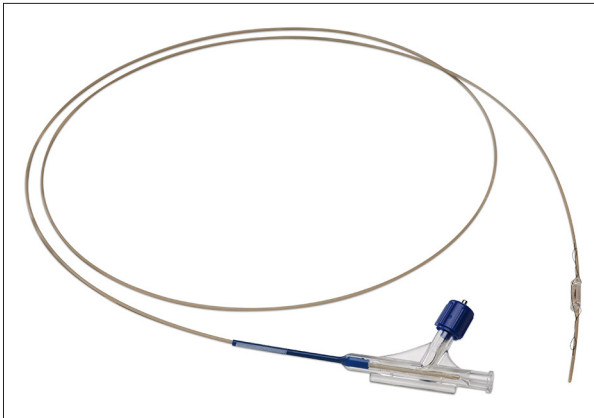
Figure 1. CardioMEMS sensor.

## Discussion

The CardioMEMS heart failure system is an ambulatory pulmonary artery pressure monitoring system designed to help manage patients with difficult to control heart failure symptoms and to reduce the need for hospitalizations due to acute heart failure exacerbations. The landmark trial, CHAMPION, that led to its Food and Drug Administration (FDA) approval and endorsement by the European heart failure guidelines showed a 37% reduction in heart failure related hospitalization compared to the control group over the duration of the study (mean follow up of 15 months) [1,5]. It is currently approved for use in patients with NYHA class III symptoms and a prior hospitalization for congestive heart failure within the last year, regardless of ejection fraction [1,6]. Although not included in the most recent American heart failure guidelines, over 5500 CardioMEMS heart failure systems have been implanted in the United States within the first 3 years of its FDA approval [4].

A recent analysis of the MAUDE database showed 28 reports of pulmonary artery injury/hemoptysis (0.5%), which included 14 intensive care unit stays, 7 intubations, and 6 deaths [4]. Although a rare complication, a better understanding of possible mechanisms of hemoptysis post CardioMEMS implantation is relevant as the device use increases and as new operators learn the implantation procedure [1,4].

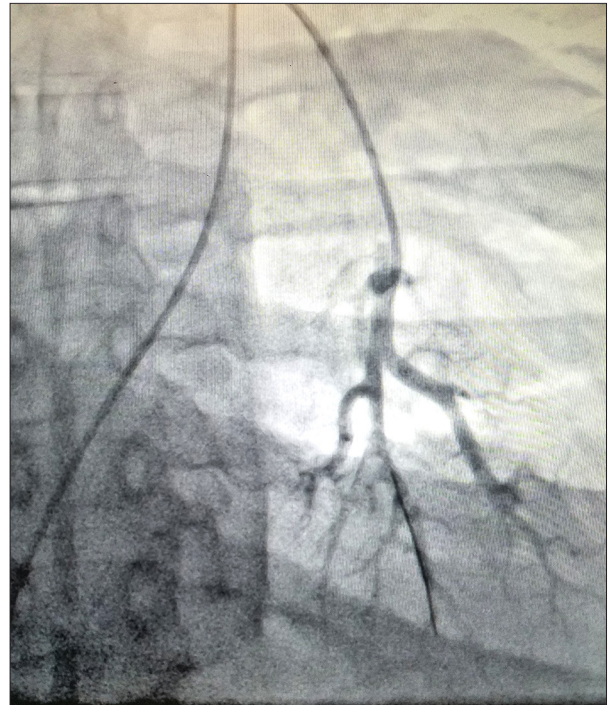
There are several possible mechanisms for the occurrence of hemoptysis. The most likely cause is injury from the catheter nose cone or wire. The delivery catheter has a significant leading edge beyond the sensor to accommodate the distal nitinol loop that is wrapped on the catheter. Even beyond this there is a significant nose cone (Figure 2). Considering that many pulmonary artery branches have rapid tapers, this can result in the nose cone being pushed into an artery whose diameter is smaller than the catheter tip causing arterial injury. The device is delivered over a 0.018-inch exchange length wire. Even these relatively soft tip wires can cause injury and perforation of the small branches of the pulmonary artery



**Figure 2.** Prominent nose cone of the delivery system that extends beyond the distal nitinol loop.

especially if they are pushed in deeper to accommodate the long delivery catheter nose cone. Another cause of hemoptysis could be from implantation of the sensor body into an artery of a smaller than recommended diameter. The recommended diameter is 5–10 mm for the sensor body, and if implanted into a smaller artery there could be frictional injury. This may happen if there are overlapping branches on angiography and if the wire is inadvertently advanced into an unintended branch of smaller diameter. This mechanism was reported in at least one case in a recent publication from the MAUDE database [4]. Alternatively, this may happen if the wire comes back during advancement of the sensor and then goes into a wrong branch when re-advanced. Finally, peri-procedural anti-coagulation may exacerbate hemoptysis caused by any of the aforementioned etiologies.

Several simple strategies can minimize the risk of hemoptysis during an implant procedure. First, caution must be taken to identify an appropriately sized artery that would not only be able to receive the sensory but also has sufficient length distally to accommodate the long nose cone of the delivery catheter. Multiple angiographic views may be useful to remove vessel overlap and definitively identify the target vessel. In some instances, a non-balloon tipped wider lumen catheter (a multi-purpose or JR4) might be better than a Swan-Ganz catheter. This would allow one to inject contrast using a Tuohy-Borst connector while simultaneously advancing the wire to ensure that it is indeed advancing into the intended branch (Figure 3). Second, care must be taken to ensure that the wire is not inadvertently pulled back while advancing the sensor. For new implanters, a more liberal use of fluoroscopy might be especially useful during this exchange. Finally, the use of intra-procedural



**Figure 3.** Contrast injected into the intended branch pulmonary artery simultaneously advancing the wire using a Tuohy-Borst connector.

anti-coagulation must be limited to bare minimum and perhaps be substituted by frequent sheath flushing to prevent catheter thrombus formation.

## Conclusions

In conclusion, our report discusses hemoptysis as a potential life-threatening complication of CardioMEMS sensor implantation while suggesting possible etiologies and avoidance strategies. As the utilization of this technology expands in the years to come, a more comprehensive national registry for surveillance of device related complications will be crucial. The currently ongoing, post approval CardioMEMS study (NCT02279888) will enroll 1200 patients and will likely help in a better understanding of the device related complications including that of hemoptysis.

## Conflicts of interest

None.

## References:

---

1. Abraham WT, Adamson PB, Bourge RC et al: Wireless pulmonary artery haemodynamic monitoring in chronic heart failure: A randomised controlled trial. *Lancet*, 2011; 377: 658–66
2. Desai AS, Bhimaraj A, Bharmi R et al: Ambulatory hemodynamic monitoring reduces heart failure hospitalizations in “real-world” clinical practice. *J Am Coll Cardiol*, 2017; 69: 2357–65
3. Abraham WT, Adamson PB, Hasan A et al: Safety and accuracy of a wireless pulmonary artery pressure monitoring system in patients with heart failure. *Am Heart J*, 2011; 161: 558–66
4. Vaduganathan M, DeFilippis EM, Fonarow GC et al: Postmarketing adverse events related to the CardioMEMS HF system. *JAMA Cardiol*, 2017; 2(11): 1277–79
5. Girotra S, Nallamothu BK, Spertus JA et al: American Heart Association get with the Guidelines-Resuscitation Investigators. Trends in survival after in-hospital cardiac arrest. *N Engl J Med*, 2012; 367(20): 1912–20
6. Shavelle D, Jermyn R: The CardioMEMS heart failure sensor: A procedural guide for implanting physicians. *J Invasive Cardiol*, 2016; 28(7): 273–79