




# Iatrogenic perforation of a pulmonary artery side branch—a case report

Juergen Leick <sup>1</sup>, \*Stefan Leinen <sup>2</sup>, Ivar Friedrich <sup>3</sup>, and Nikos Werner<sup>1</sup>

<sup>1</sup>Heart Centre Trier, Department of Cardiology, Barmherzige Brueder Hospital, Nordallee 1, 54296 Trier, Germany; <sup>2</sup>Heart Centre Trier, Department of Internal Intensive Care Medicine, Barmherzige Brueder, Hospital, Nordallee 1, 54296 Trier, Germany; and <sup>3</sup>Heart Centre Trier, Department of Cardiac and Thoracic Surgery, Barmherzige Brueder, Hospital, Nordallee 1, 54296 Trier, Germany

Received 29 December 2020; first decision 19 March 2021; accepted 30 April 2021

## Background

The use of a pulmonary artery catheter (PAC) continues to be important for the diagnosis and therapeutic control of severe heart failure and in the diagnosis of pulmonary arterial hypertension. One of the most feared complications of this examination is perforation of a pulmonary artery with an estimated incidence of 0.031–0.05% and mortality rates of up to 70%.

## Case summary

We report on an 80-year-old female patient who experienced a perforation of a pulmonary artery branch during the work-up of pulmonary arterial hypertension by PAC. Immediately after the perforation, haemodynamic shock developed rapidly, necessitating cardiopulmonary resuscitation. Occlusion of the pulmonary artery branch with a semicompliant balloon was applied immediately. After 40 min of occlusion, the bleeding persisted, and endovascular coil implantation was performed. Subsequently, the bleeding stopped, and the haemodynamics stabilized. After treatment, the patient was discharged home without any significant sequelae.

## Discussion

Treatment options in pulmonary artery perforation are limited, especially if the patient is inoperable and if balloon occlusion fails. Based on our results, endovascular coil embolization can be considered a therapeutic option.

## Keywords

Complication • Perforation • Balloon occlusion • Coil embolization • Case report

## Learning points

- Pulmonary artery rupture is considered the most dangerous complication of a right heart catheterization.
- Rapid action and an interdisciplinary approach are one of the pillars in the treatment of this complication.
- Endovascular coil embolization may be considered as a safe and quick procedure when balloon occlusion fails.

## Introduction

Current guidelines recommend that right heart catheterization (RHC) be considered part of the diagnosis and management of patients with known heart failure who remain severely symptomatic despite initial standard therapies and whose haemodynamic status is unclear.<sup>1</sup> Further, RHC is recommended for the work-up of chronic thrombo-embolic pulmonary hypertension to confirm the diagnosis and assess the severity of haemodynamic impairment.<sup>2</sup>

This article was judged to be one of the best cases presented at the German Cardiac Society Annual Congress 2020. It was reviewed by team from that organization.

\* Corresponding author. Tel: +49651208981911, Email: [j.leick@bk-trier.de](mailto:j.leick@bk-trier.de)

Handling Editor: Amardeep Ghosh Dastidar

Compliance Editor: Linh Ngo

Supplementary Material Editor: Nida Ahmed

© The Author(s) 2021. Published by Oxford University Press on behalf of the European Society of Cardiology.

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact [journals.permissions@oup.com](mailto:journals.permissions@oup.com)

However, due to its invasiveness, RHC is linked to a risk of complications, ranging from access-site-associated complications and arrhythmias to life-threatening complications, such as injury to the right heart or pulmonary arteries. In a systematic review of 7218 RHC procedures, Hoepker *et al.*<sup>3</sup> observed four fatal events that resulted in an overall procedure-related mortality rate of 0.055% (95% confidence interval 0.01–0.099%). Pulmonary artery rupture is considered the most dangerous complication, with an estimated incidence of 0.031% and 0.05% and mortality rates of 70% and 50%, respectively, in two studies with large sample sizes.<sup>4,5</sup> Overall, despite the low rate of life-threatening complications, the literature lacks clear recommendations regarding their management, often necessitating individual decisions about a patient's further care.

## Timeline

Time	Description
Hospital admission Day 1	Admission due to further evaluation of the patient's dyspnoea (New York Heart Association III) and mild oedema of the lower legs. Medical history, physical examination, laboratory analysis, transthoracic echocardiography, X-ray image of the lungs
Cath lab Day 4	Complication: perforation of the pulmonary artery Rapid haemodynamic deterioration Contacting anaesthesia and cardiac surgery: interventional treatment preferred Balloon occlusion for a total of 40 min. Persistent bleeding of the pulmonary artery Coil embolization of the perforation cavity as a bail out procedure
Intensive care unit Day 4–14	Haemothorax on the left side: relieved by drainage Extubation on Day 5 Pneumonia treated with ampicillin/sulbactam Computed tomography scan of the thorax on Day 14: favourable result after coiling
Normal ward Day 14–30	Pre-existing atrial fibrillation with significant AV-block: implantation of a permanent pacemaker before discharge Discharge at Day 30 after admission.

## Case presentation

We report an 80-year-old female (body mass index 20.8 kg/m<sup>2</sup>) who presented to our clinic for further evaluation of her dyspnoea [New York Heart Association (NYHA) functional classification III]. Her cardiovascular risk factors included arterial hypertension, and her relevant medical history contained atrial fibrillation, rheumatoid arthritis,

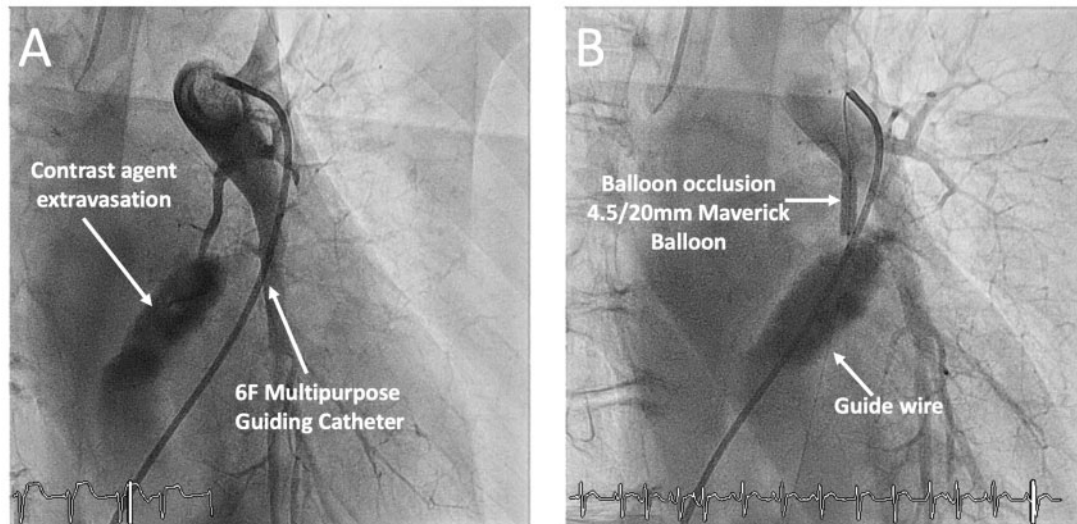
and a bilateral pulmonary embolism in 2014 after varicectomy. The patient was on diuretics, a beta-blocker, an angiotensin-converting enzyme inhibitor, and oral anticoagulation.

The physical examination revealed the following abnormalities: mild oedema of the lower legs bilaterally and reduced breathing sounds bilaterally. Auscultation of the heart showed a holosystolic murmur (II/VI) at the apex and left lower sternal border. The echocardiography demonstrated normal left ventricular function and moderate mitral and tricuspid regurgitation. The right ventricle was enlarged, with preserved function (tricuspid annular plane systolic excursion: 21 mm). In the continuous wave Doppler measurement, pulmonary artery systolic blood pressure was significantly elevated at 86 mmHg. Coronary heart disease and pulmonary venous congestion had been ruled out by coronary angiography and chest X-ray, respectively. However, there were small pleural effusions on both sides.

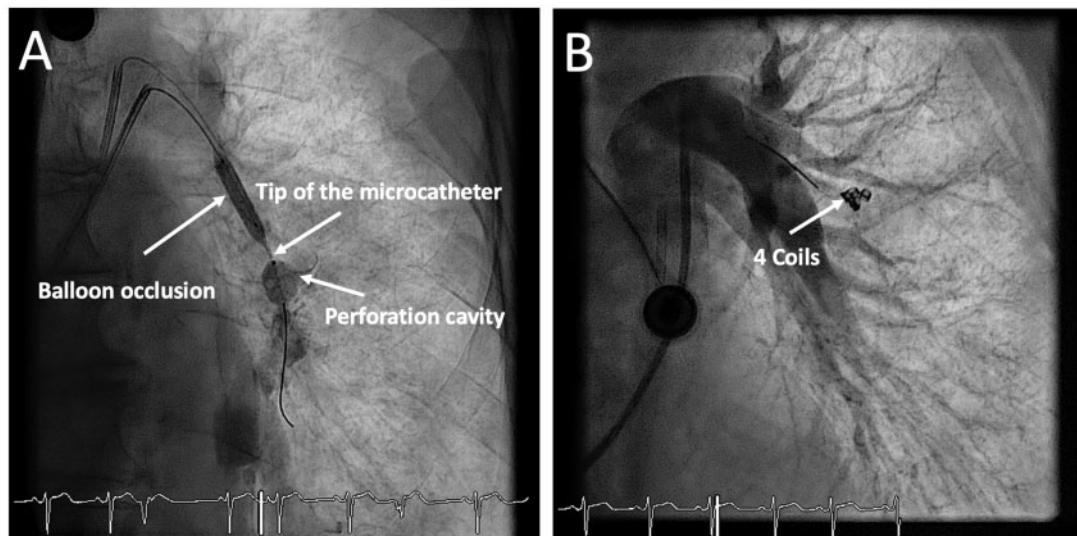
Due to the patient's complaints and the pathological findings, we decided to examine the right heart with a balloon-tipped pulmonary artery catheter (PAC) for further clarification. The RHC was performed in the catheter lab via the right femoral vein. We used a standard balloon-tipped PAC (5French, CORODYN™, B. BRAUN), which was placed in the left pulmonary artery under radiological control. Immediately after the pulmonary capillary wedge pressure measurements, haemoptysis occurred, which rapidly increased in intensity and led to respiratory failure. This event was accompanied by rapid haemodynamic deterioration, necessitating cardiopulmonary resuscitation (CPR) for 4 min. The patient was orally intubated and ventilated immediately.

Concurrently, angiographic imaging of the left pulmonary artery was performed via a 6Fr multipurpose guiding catheter (MB1, Medtronic). As a result, rupture of a lateral branch of the left pulmonary artery could be identified as the cause of the haemorrhagic shock (Figure 1A). Due to the patient's comorbidities and age, we initially decided against surgical treatment, in consultation with the heart surgeon. We inserted a coronary intervention wire (Runthrough®, TERUMO®) into the periphery of the perforated vessel and performed balloon occlusion [Maverick Monorail™, Boston Scientific; 4.5 mm × 20 mm; pressure: 6 atmosphere (atm)], proximal to the perforation. The new angiographic image now showed a complete balloon occlusion of the perforated vessel (Figure 1B). Balloon occlusion was continued for a total of 40 min.

Meanwhile, the patient's haemodynamic situation stabilized. The activated clotting time (ACT) was 123 s. The repeat angiographic image continued to show contrast agent leakage from the perforation site after 40 min. Due to persistent bleeding from the perforated pulmonary artery, we decided to embolize the perforated vessel with microcoils (Hilal Embolization Microcoils™, COOK®, Medical). For safety reasons, to control bleeding and ensure a stable haemodynamic situation throughout the planned bail-out procedure, we decided to implant the coils through a second interventional catheter. To this end, another 6 Fr MB 1 guiding catheter was placed in the left pulmonary artery via the left femoral vein. We then used this catheter to insert a second wire (Runthrough®, TERUMO®) into the target vessel past the blocked balloon. For this purpose, the inflation pressure was briefly reduced to 2–4 atm. We then advanced a microcatheter (Finecross® MG, TERUMO®) via the second interventional wire.



**Figure 1** Contrast agent extravasation following perforation of a pulmonary artery side branch (A) with subsequent balloon occlusion (B).



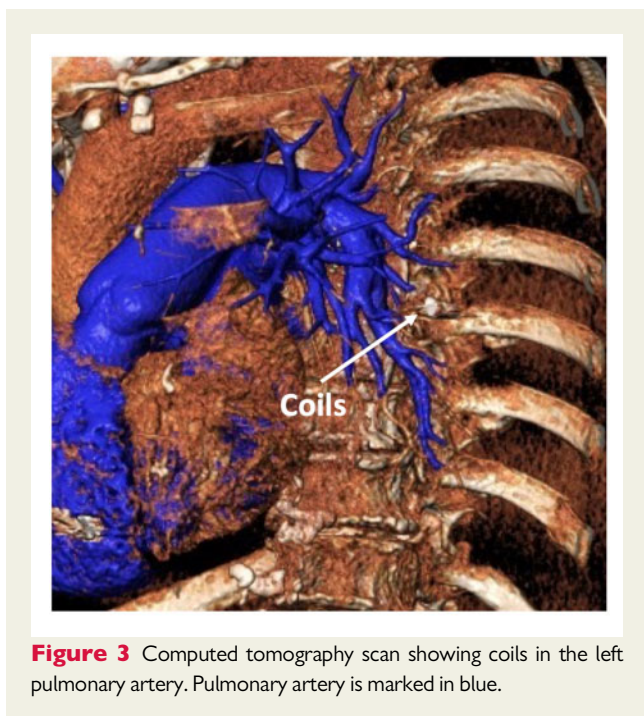
**Figure 2** Selective visualization of the perforation cavity via the inserted microcatheter (A). Complete embolization of the perforation cavity after implantation of four coils (B).

The perforation cavity was selectively visualized via the inserted microcatheter (Figure 2A), after which embolization was performed with four coils into the cavity. The angiographic image showed complete embolization of the perforation cavity (Figure 2B). Consequently, the patient's haemodynamic situation stabilized at this point.

Following the procedure, the patient was transferred to the intensive care unit while haemodynamically stable. Sonography revealed a haemothorax on the left side, which was relieved by drainage. Laboratory findings showed a decrease in haemoglobin concentration from 12 g/dL to 9 g/dL. The patient was extubated on the

following day. During her stay, she developed pneumonia, which was treated with antibiotics (ampicillin/sulbactam). Ten days after the index procedure, a computed tomography scan of the thorax was performed, which showed a favourable result after coiling (Figure 3). In addition, there was no evidence of chronic thrombo-embolic pulmonary hypertension.

Due to the patient's pre-existing atrial fibrillation, with significant atrioventricular block in the clinical follow-up, a permanent pacemaker was implanted before discharge. On Day 26 post-index event, the patient was discharged without further sequelae. The echocardiography at discharge showed a systolic pulmonary artery pressure of



**Figure 3** Computed tomography scan showing coils in the left pulmonary artery. Pulmonary artery is marked in blue.

50 mmHg, perhaps due to the increase in diuretic doses compared with the day of hospital admission.

At follow-up, 1 month later, the patient reported no further episodes of haemoptysis or any discomfort related to the pulmonary artery rupture. Echocardiographic findings were without significant changes.

## Discussion

Right heart catheterization is an invasive method for further evaluating heart failure in patients whose haemodynamic status is unclear and in the continuing diagnosis of pulmonary hypertension.<sup>1,2</sup> Serious complications of RHC occur in 0.1% of cases and pulmonary artery rupture is considered the most dangerous complication.<sup>4,5</sup> The following risk factors are associated with an increased risk of pulmonary artery injury in PAC: age > 60 years, female gender, pulmonary hypertension, systemic anticoagulation, long-term steroid use, and surgically induced hypothermia.<sup>6</sup> Our case had four of these risk factors.

Treatment options for pulmonary artery rupture include surgery and endovascular therapy. Due to the rapid deterioration in haemodynamic and respiratory function, rapid diagnosis, and initiation of therapy are essential for survival. In parallel with the interventional treatment below, additional measures should be taken simultaneously, such as activating the CPR team, the anaesthesiologist and cardiac surgeon; resuscitation, if necessary; administration of intravenous fluids in case of hypotension; securing the airway with a selective lung intubation; and protamine injection if heparin was administered.

There are no clear recommendations for interventional treatment of this rare but life-threatening complication. Existing recommendations are based on case reports,<sup>7–11</sup> including selective thrombin

injection into the vessel, percutaneous embolization with an AMPLATZER™ vascular plug (Abbott), implantation of a covered stent and coil embolization.<sup>9,10,12–14</sup>

In our case, we decided on a step-by-step approach with balloon occlusion first to stabilize her haemodynamics. After checking for adequate ACT and failure to stop bleeding after prolonged balloon occlusion, the heart team reconvened to hold an interdisciplinary discussion. The risk of emergency surgery was considered to be unacceptably high. Although implantation of a covered stent can maintain perfusion of the treated artery,<sup>7,10</sup> we decided against this strategy, because the distal landing zone of the stent remained unknown, despite angiographic controls. Similarly, implantation of a vascular plug was not an option in this case, because the angiographic controls did not allow for an accurate assessment of the anatomy that was distal to the perforation. The simultaneous insertion of a microcatheter past the blocked balloon permitted us to selectively visualize the perforation cavity and subsequent coil implantation without having to compromise the gain in stability. This method is a safe and rapid approach to pulmonary artery perforation when balloon occlusion fails and when the patient is considered to be inoperable or at high risk. A disadvantage of this method is that a local pulmonary infarction is induced. However, this drawback must be considered after weighing the risk–benefit ratio.

## Conclusion

Perforation of a pulmonary artery during pulmonary artery catheterization is an acute threat for which treatment options are limited. Rapid action and an interdisciplinary approach are the pillars in the treatment of this complication. Endovascular coil embolization may be considered a safe and quick procedure when balloon occlusion fails.

## Lead author biography



Dr Juergen Leick completed his medical studies at the Justus Liebig University in Gießen (Germany). He received his cardiology training at the Kerckhoff Clinic in Bad Nauheim. He currently works as a senior physician in the field of interventional cardiology at the Heart Centre Trier.

## Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

**Slide sets:** A fully edited slide set detailing these cases and suitable for local presentation is available online as [Supplementary data](#).

**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.

**Conflict of interest:** None declared.

**Funding:** None declared.

## References

1. Ponikowski P, Voors AA, Anker SD, Bueno H, Cleland JGF, Coats AJS et al. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: the Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC) Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. *Eur Heart J* 2016;**37**:2129–2200.
2. Galie N, Humbert M, Vachiery JL, Gibbs S, Lang I, Torbicki A, et al.; ESC Scientific Document Group. 2015 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension: the Joint Task Force for the Diagnosis and Treatment of Pulmonary Hypertension of the European Society of Cardiology (ESC) and the European Respiratory Society (ERS): Endorsed by: Association for European Paediatric and Congenital Cardiology (AEPC), International Society for Heart and Lung Transplantation (ISHLT). *Eur Heart J* 2016;**37**:67–119.
3. Hoepfer MM, Lee SH, Voswinckel R, Palazzini M, Jais X, Marinelli A et al. Complications of right heart catheterization procedures in patients with pulmonary hypertension in experienced centers. *J Am Coll Cardiol* 2006;**48**:2546–2552.
4. Kearney TJ, Shabot MM. Pulmonary artery rupture associated with the Swan-Ganz catheter. *Chest* 1995;**108**:1349–1352.
5. Bossert T, Gummert JF, Bittner HB, Barten M, Walther T, Falk V et al. Swan-Ganz catheter-induced severe complications in cardiac surgery: right ventricular perforation, knotting, and rupture of a pulmonary artery. *J Card Surg* 2006;**21**:292–295.
6. Nellaiyappan M, Omar HR, Justiz R, Sprenker C, Camporesi EM, Mangar D. Pulmonary artery pseudoaneurysm after Swan-Ganz catheterization: a case presentation and review of literature. *Eur Heart J Acute Cardiovasc Care* 2014;**3**:281–288.
7. Araszkievicz A, Jankiewicz S, Zabicki B, Grygier M, Lesiak M. Rescue implantation of covered stent in pulmonary artery rupture during balloon pulmonary angioplasty. *J Invasive Cardiol* 2018;**30**:E122–E123.
8. Atreya AR, Arora S, Valania G. Pulmonary artery rupture with pseudoaneurysm formation secondary to Swan-Ganz catheter balloon inflation. *Acute Card Care* 2015;**17**:77–79.
9. Boukantar M, Gallet R, You K, Tacher V, Mouillet G, Kobeiter H et al. How should I treat a pulmonary artery rupture occurring during a right heart catheterisation in the cathlab? *EuroIntervention* 2017;**12**:e2280–e2282.
10. Ejiri K, Ogawa A, Matsubara H. Bail-out technique for pulmonary artery rupture with a covered stent in balloon pulmonary angioplasty for chronic thromboembolic pulmonary hypertension. *JACC Cardiovasc Interv* 2015;**8**:752–753.
11. Landi A, Nai Fovino L, Fabris T, Napodano M. Pulmonary artery rupture during right heart catheterization: successful endovascular treatment with Amplatzer Vascular Plug. *Eur Heart J* 2018;**39**:3982.
12. Dobies DR, Cohoon AL, Bates AA. Images in cardiovascular medicine. Repair of a perforated pulmonary artery due to a Swan-Ganz catheter using thrombin injection. *Circulation* 2009;**119**:e521–2–e522.
13. Ianniello A, Carrafiello G, Nicotera P, Vaghi A, Cazzulani A. Endovascular treatment of a ruptured pulmonary artery aneurysm in a patient with Behcet's disease using the Amplatzer Vascular Plug 4. *Korean J Radiol* 2013;**14**:283–286.
14. Gottwalles Y, Wunschel-Joseph ME, Hanssen M. Coil embolization treatment in pulmonary artery branch rupture during Swan-Ganz catheterization. *Cardiovasc Intervent Radiol* 2000;**23**:477–479.