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Case Report

Hemoptysis after coil embolization for pulmonary arteriovenous malformation: Histopathological confirmation of bronchial epithelium extension [☆]

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ABSTRACT

Coil embolization is widely performed for pulmonary arteriovenous malformations (PAVMs). We describe herein 2 cases of hemoptysis during long-term follow-up after coil embolization for PAVMs. For both cases, lobectomy was performed and histopathological examinations revealed chronic inflammation and bronchial epithelium extension into the sac of the PAVM. In addition, we performed a systematic review of previous reports of hemoptysis after embolization for PAVMs.

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Introduction

Pulmonary arteriovenous malformations (PAVMs) are abnormal vascular structures that most often connect a pulmonary

artery to a pulmonary vein, bypassing the normal pulmonary capillary bed, and resulting in intrapulmonary right-to-left shunt [1]. With this pathology, the lung loses its ability to filter emboli and bacteria, which can then pass directly into the systemic circulation and cause stroke or cerebral abscess [2]. Treatment is thus required even for asymptomatic cases, and coil embolization is widely performed for PAVMs. However, recanalization of embolized PAVM is known as a long-

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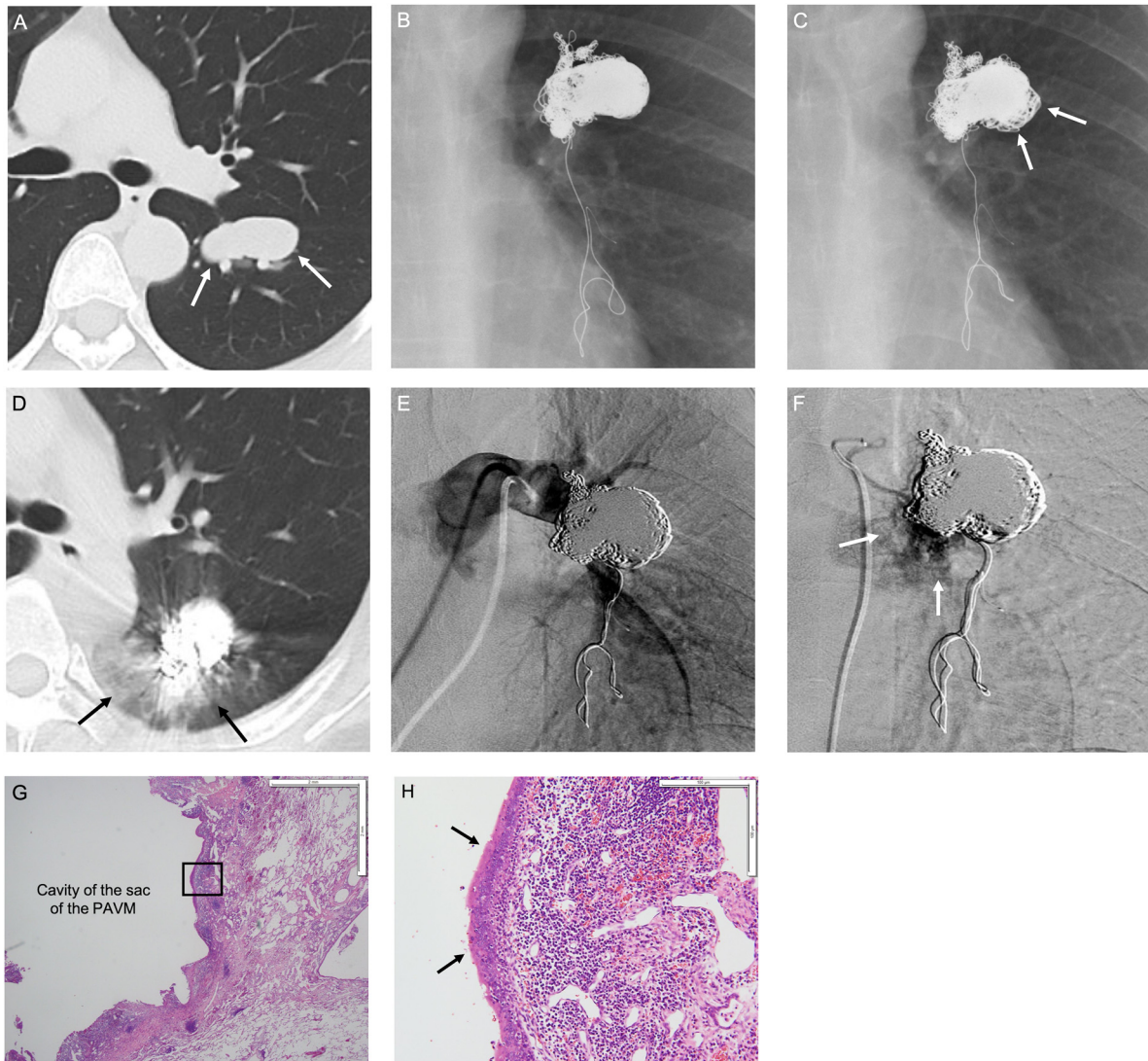


Fig. 1 – A 53-year-old woman presented with PAVM of the left lower lobe. (A) CT showing PAVM of the left lower lobe (arrows). (B) Coil embolization has been performed successfully, although one coil is protruding to the pulmonary artery of the left lower lobe. Chest radiography after embolization shows the placed coils. (C) Chest radiography following hemoptysis after 4 years shows coil deformation (arrows). (D) CT shows ground-glass opacity around coils in the embolized PAVM (arrows). (E) Left pulmonary artery angiography shows no recanalization. (F) Left bronchial artery angiography shows hypervascular parenchyma around the coils (arrows). (G) Histopathological investigation (hematoxylin and eosin staining) of the specimen from lobectomy of the left lower lobe. (H) It shows inflammatory cell infiltration and formation of granulation tissue in the pulmonary artery wall and the presence of epithelial cells the sac of the PAVM (arrows).

term issue [3,4]. Hemoptysis has been reported as another long-term problem of coil embolization [5–7]. However, the mechanisms underlying hemoptysis have not been clarified from histopathological examinations. We present herein 2 cases in which the patients complained of hemoptysis after coil embolization for PAVM and underwent lobectomy and histopathological examination. We also undertook a systematic review of previous reports of this complication.

Case 1

A 53-year-old woman underwent screening computed tomography of the chest because of a family history of hereditary hemorrhagic telangiectasia, and a PAVM of the left lower lobe

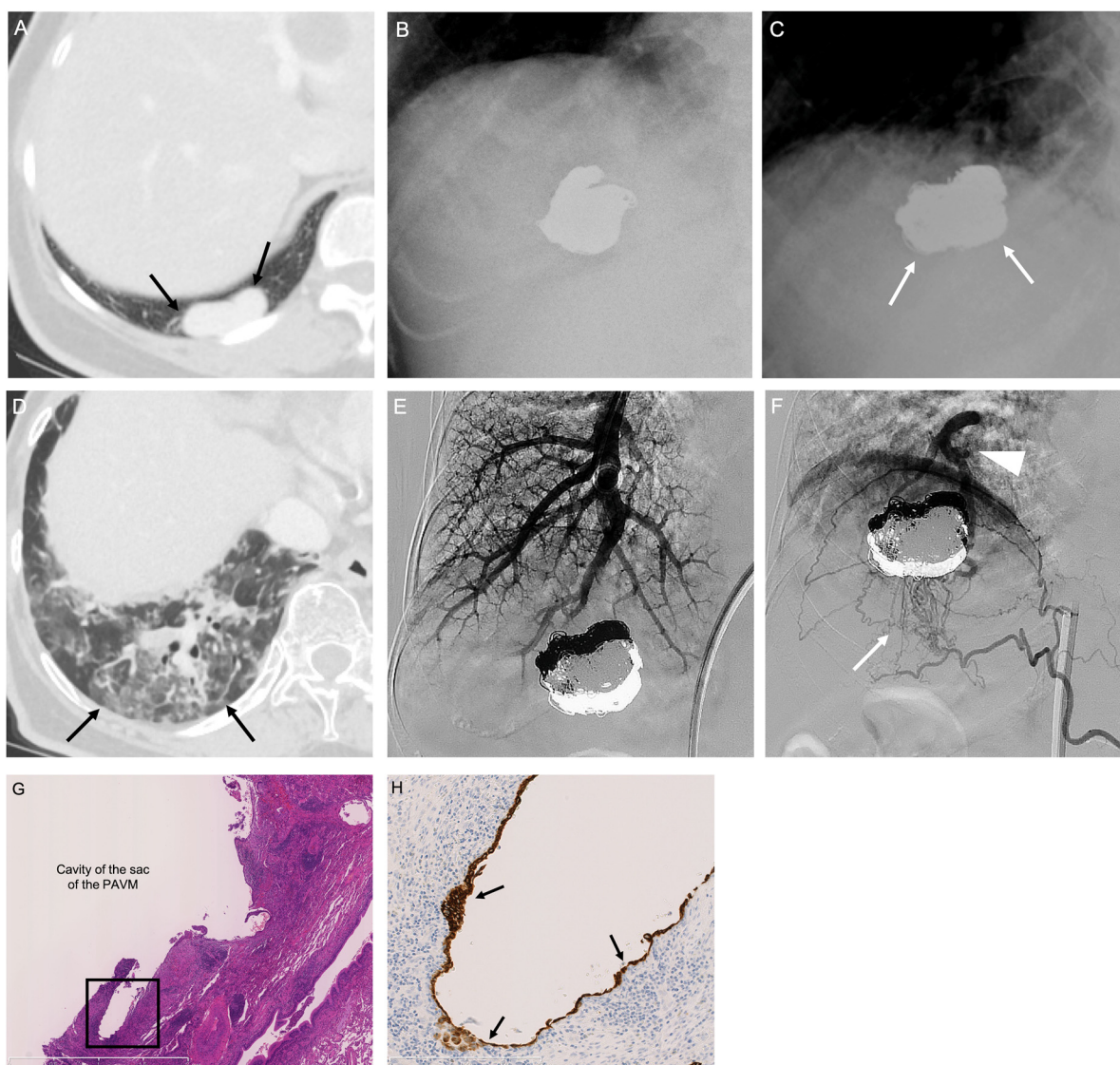


Fig. 2 – A 71-year-old woman presented with PAVM of the right lower lobe. (A) CT shows PAVM of the right lower lobe (arrows). (B) Embolization using coils has been successfully performed. Chest radiography after embolization shows the placed coils. (C) Chest radiography following hemoptysis after 5 years shows coil deformation (arrows). (D) CT shows ground-glass opacity around coils in the PAVM (arrows). (E) Angiography of the right pulmonary artery shows no recanalization. (F) Angiography of the right inferior phrenic artery shows dilated small branches of the right inferior phrenic artery around the coils (arrow) and a shunt to the right pulmonary artery (arrow head). (G) Histopathological investigation (hematoxylin and eosin staining) of the specimen from lobectomy of the right lower lobe shows chronic inflammation of the wall of the sac of the PAVM and bronchial epithelium extension into the sac of the PAVM. (H) Keratin staining reveals epithelium surrounding the sac of the PAVM (arrows).

was identified (Fig. 1A). Coil embolization was performed from the sac to the feeding artery of the PAVM. Although one coil protruded to the pulmonary artery of the left lower lobe, cessation of blood flow for the PAVM was acquired, and embolization was accomplished successfully (Fig. 1B). After embolization, the patient did well, and no recanalization was confirmed on time-resolved magnetic resonance angiography with a follow-up of 4 years. However, the patient subsequently complained of hemoptysis. Radiography of the chest showed deformation of coils in the PAVM (Fig. 1C), and CT

showed ground-glass opacity around the coils in the PAVM (Fig. 1D). Angiography of both the left bronchial artery and pulmonary artery was performed. No recanalization was identified on angiography of the left pulmonary artery (Fig. 1E). Angiography of the left bronchial artery showed hypervascular parenchyma around the coils (Fig. 1F), and embolization was subsequently performed using gelatin sponge. However, hemoptysis remained even after this embolization, so lobectomy of the left lower lobe was performed. Histopathological examination of the resected specimen showed inflammatory

Table 1 – Literature review of hemoptysis after embolization for the pulmonary arteriovenous malformation.

Author	Age	Sex	Location of the PAVM	Embolic materials of embolization for the PAVM	Recanalization	Deformation of coils	Systemic supply	Developed systemic artery	Treatment for hemoptysis	Duration between embolization for the PAVM and hemoptysis (y)	Histopathological examination
Wispelaere [5]	31	F	RLL	Coils	Yes	Not described	Yes	Accessory bronchial artery	Lobectomy	5	Not described
Kasai [6]	23	F	LLL	Coils	Yes	Not described	Yes	Bronchial artery	Lobectomy	12	Not described
Shimohira [7]	28	M	LUL	Coils	No	Yes	Yes	Bronchial artery	Embolization and lobectomy	11	Not described
Gorsi [8]	17	M	RLL	AVP	No	NE	Yes	Multiple systemic arteries	Embolization	Not described	NE
Our case 1	53	F	LLL	Coils	No	Yes	Yes	Bronchial artery	Embolization and lobectomy	4	Yes
Our case 2	71	F	RLL	Coils	No	Yes	Yes	Inferior phrenic artery	Lobectomy	5	Yes

PAVM, pulmonary arteriovenous malformation; RLL, right lower lobe; LLL, left lower lobe; LUL, left upper lobe; AVP, AMPLATZER Vascular Plug, NE, not evaluated

cell infiltration and formation of granulation tissue in the pulmonary artery wall of the sac of the PAVM and presence of epithelial cells in the sac of the PAVM (Figs.1G and H). These findings represented chronic inflammation and bronchial epithelium extension. Hemoptysis disappeared during the subsequent 18 months of follow-up.

Case 2

A 71-year-old woman presented with PAVM of the right lower lobe that was incidentally found during treatment for breast cancer (Fig. 2A). Coil embolization was successfully performed from the sac to the feeding artery of the PAVM (Fig. 2B). Thereafter, the patient showed good condition, and 4-dimensional CT showed no recanalization during 5 years of follow-up. However, hemoptysis occurred suddenly, and the patient was transferred to emergency room. Coil deformation was observed on chest radiographs (Fig. 2C) with ground-glass opacity around coils in the PAVM on CT (Fig. 2D). Right pulmonary artery angiography showed no recanalization (Fig. 2E). Angiography of the right inferior phrenic artery showed dilated small branches of the right inferior phrenic artery around the coils and a shunt to the right pulmonary artery (Fig. 2F). To ensure complete cure, surgical resection of the right lower lobe was performed. Histopathological examination showed chronic inflammation in the pulmonary artery wall of the sac of the PAVM and bronchial epithelium extension into the sac of the PAVM (Figs. 2G and H). Postoperatively, the patient showed a good course with no recurrence of hemoptysis during 15 months of follow-up.

Discussion

We encountered 2 cases of hemoptysis after coil embolization for PAVMs during long-term follow-up. In both cases, coil deformation was found on chest radiography. There was ground-glass opacity probably representing pulmonary hemorrhage and inflammation around the coils in the PAVM on CT. Histopathological examinations after lobectomy revealed chronic inflammation and bronchial epithelium extension into the sac of the PAVM.

To clarify causes of hemoptysis, we reviewed articles extracted from PubMed using search terms “pulmonary arteriovenous malformations” and “embolization” and “hemoptysis.” Four cases of hemoptysis after embolization for PAVMs were identified [5–8]. In total, 6 cases including those 4 cases, and our 2 cases are summarized in Table 1. Embolic materials in the 6 cases were coils in 5 cases and AMPLATZER Vascular Plug (St. Jude Medical, St Paul, MN) in 1 case. In all cases, systemic supplies to the PAVMs were found, and were considered as the likely cause of hemoptysis. The cause of systemic artery development appeared to be chronic inflammation around the embolized PAVM. It was hypothesized that this chronic inflammation might have occurred as a result of infection around the embolized PAVM [7]. The embolic material appeared to act as a foreign material and prevented

healing of the infection, resulting in chronic inflammation around the coils. In addition, it was reported that the presence of non-tuberculous mycobacteria was confirmed by examinations after lobectomy performed for hemoptysis after coil embolization of a PAVM [6]. In contrast, the present article is the first to describe histopathological results including chronic inflammation, and bronchial epithelium extension into the sac of the PAVM. Namely, a connection was identified between the pulmonary artery, and bronchus. Furthermore, expectoration of coils after embolization of PAVMs has been reported during long-term follow-up [9]. This is understandable considering the presence of a connection between the pulmonary artery and bronchus. This connection represents a potentially dangerous situation, because recanalization of the embolized PAVM would result in blood flow from the recanalized PAVM into the bronchus and massive hemoptysis. In 5 of the 6 cases identified in the present review, hemoptysis occurred after a relatively long time, between 4, and 12 years. Long-term follow-up is thus necessary, not only to evaluate recanalization, but also to assess hemoptysis. In 3 of 5 cases of coil embolization, coil deformation was found on chest radiographs before the onset of hemoptysis. Chest radiography should thus be performed in follow-up to evaluate the deformation of coils. When deformation is identified, the patient should be carefully observed.

In conclusion, from a histopathological perspective, chronic inflammation and bronchial epithelium extension into the sac of the PAVM may occur during long-term follow-up, and may result in hemoptysis.

Patient consent

Written informed consent was obtained for the publication of this article.

REFERENCES

- [1] White RI Jr, Pollak JS, Wirth JA. Pulmonary arteriovenous malformations: diagnosis and transcatheter embolotherapy. *J Vasc Interv Radiol* 1996;7(6):787–804.
- [2] Chick JFB, Reddy SN, Pyeritz RE, Trerotola SO. A survey of pulmonary arteriovenous malformation screening, management, and follow-up in hereditary hemorrhagic telangiectasia centers of excellence. *Cardiovasc Intervent Radiol* 2017;40(7):1003–9.
- [3] Woodward CS, Pyeritz RE, Chittams JL, Trerotola SO. Treated pulmonary arteriovenous malformations: patterns of persistence and associated retreatment success. *Radiology* 2013;269(3):919–26.
- [4] Shimohira M, Kiyosue H, Osuga K, Gobara H, Kondo H, Nakazawa T, et al. Location of embolization affects patency after coil embolization for pulmonary arteriovenous malformations: importance of time-resolved magnetic resonance angiography for diagnosis of patency. *Eur Radiol* 2021;31(7):5409–20.
- [5] Wispelaere JF, Trigaux JP, Weynants P, Delos M, Coene BD. Systemic supply to a pulmonary arteriovenous malformation: potential explanation for recurrence. *Cardiovasc Intervent Radiol* 1996;19(4):285–7.
- [6] Kasai H, Sugiura T, Kobayashi T, Okamura R, Oota M, Harada N, et al. Recurrence of pulmonary arteriovenous malformation with non-tuberculous mycobacteria infection caused by perfusion from the pulmonary artery and bronchial artery after coil embolization. *Intern Med* 2019;58(11):1593–6.
- [7] Shimohira M, Iwata K, Ohta K, Sawada Y, Hashimoto T, Okuda K, et al. Hemoptysis due to pulmonary arteriovenous malformation after coil embolization during long-term follow-up. *Case Rep Radiol* 2019;2019:4506253.
- [8] Gorski U, Bansal A, Jugpal TS, Chaluvashetty SB, Sandhu MS. Endovascular management of massive hemoptysis secondary to systemic collaterals in previously treated pulmonary arteriovenous malformation. *Vasc Endovascular Surg* 2019;53(8):674–8.
- [9] Konno-Yamamoto A, Yamamoto S, Suzuki J, Fukami T, Kitani M, Matsui H. Migrated coil expectorated 12 years after embolization of pulmonary arteriovenous malformation, due probably to abscess formation around the coil. *Respir Med Case Rep* 2020;31:101245.