Letter to the Editor

Percutaneous microwave ablation-induced pulmonary artery pseudoaneurysm: a case description and literature analysis

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Introduction

Pulmonary artery pseudoaneurysm (PAP) is a rare medical emergency associated with a high risk of rupture that may lead to life-threatening hemoptysis. If left untreated, the risk that rupture will lead to a life-threatening exceeds 50%; therefore, prompt intervention is crucial (1).

Iatrogenic injury has long been recognized as a common cause of PAP and may arise in the context of thermal ablation for pulmonary tumors. A few PAP cases due to radiofrequency ablation (RFA) have been previously reported (2,3), but only 1 case of PAP case been reported as a complication of microwave ablation (MWA) relating to delayed endobronchial coil migration after endovascular embolization (4). Herein, we present 2 cases of MWA-induced PAP treated with endovascular embolization and alert clinicians to this rare but fatal complication.

Case presentation

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for the publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

Case 1

The first patient was a 53-year-old man with a history of hypertension and diabetes mellitus. He was referred to Beijing Hospital for a mass with a 5.0 cm maximum diameter in the lower right lung lobe in August 2020. He had previously received a bronchoscopy at another hospital. The pathologic findings suggested poorly differentiated carcinoma, but the pathologic type was not identified. First, a multidisciplinary consultation was conducted. The patient was recommended to undergo concurrent chemoradiotherapy but refused to undergo radiotherapy. Therefore, the multidisciplinary team decided first to reduce the tumor burden by MWA and to follow this with combined systemic therapy. The patient did not have any abnormal blood or coagulation function and did not receive any anticoagulant therapy. To achieve definitive diagnosis and local control of the tumor, he received percutaneous computed tomography (CT)-guided lung biopsy and MWA synchronously. The pathological result confirmed the diagnosis of large cell neuroendocrine carcinoma (cT2bN3M0 IIIB).

The mass in the posterior basal segment of the right lower lobe was directly adjacent to the posterior basal segmental branch of the right pulmonary artery (PA; *Figure 1A*). We performed percutaneous MWA using 2 antennae (Vision Medical Devices R&D Center, Nanjing, China; *Figure 1B*). For this tumor, we repositioned the

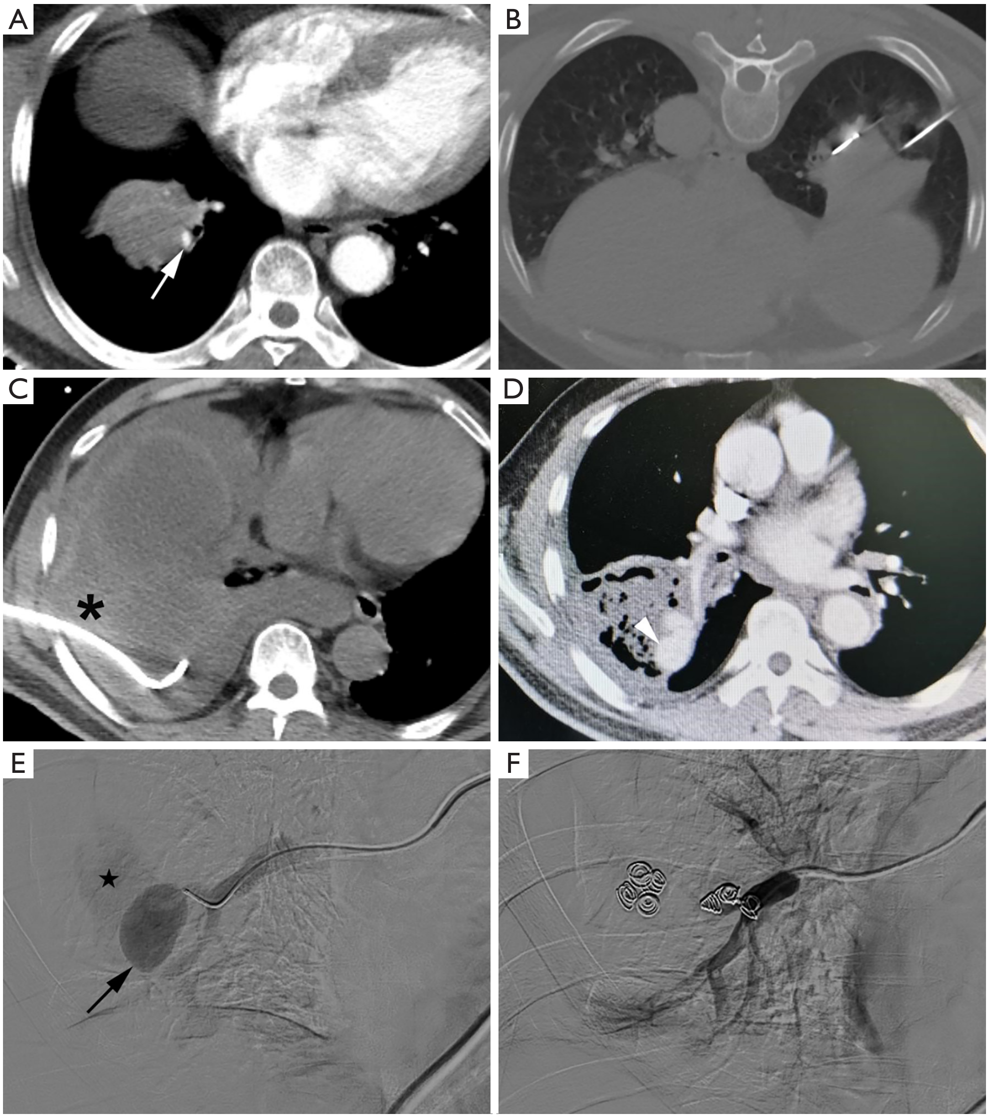

Figure 1 A 53-year-old man received MWA for pulmonary large cell neuroendocrine carcinoma. (A) The chest CT image before the MWA showed a mass (5.0 cm maximum diameter) adjacent to the posterior basal segmental branch of the PA (white arrow) in the right lower lobe. (B) MWA with 2 antennae. Note that 1 antenna pierced the branch of the PA. (C) A massive hemothorax (asterisk) was present on the CT image 48 hours after MWA, and percutaneous drainage was performed using a 10-French catheter. (D) Emergent contrast-enhanced chest CT revealed a pseudoaneurysm (arrowhead) arising from the posterior basal segmental branch of the PA. (E) Selective PA angiography confirmed a PAP (black arrow) with a maximum diameter of 3.2 cm. Active extravasation of contrast was revealed (star). (F) Microcoils were placed using a 2.6-French microcatheter into and proximal to the pseudoaneurysm. PA angiography after coil embolization demonstrated no further filling of the pseudoaneurysm. MWA, microwave ablation; CT, computed tomography; PA, pulmonary artery; PAP, pulmonary artery pseudoaneurysm.

needles 5 times at different sites. The released power was 50 W, and the ablation duration was 11 minutes. No intraprocedural symptoms were reported by this patient.

The patient reported having dyspnea 48 hours after the procedure, and an instant chest CT revealed a massive hemothorax. Percutaneous drainage was performed using a 10-French drainage catheter (*Figure 1C*). The patient did not exhibit any hemodynamic abnormalities or hemoptysis. Therefore, the risk of PAP was overlooked, and further contrast-enhanced CT was not performed.

The patient was discharged on day 8 with the hemothorax resolved. However, he was readmitted to our institution 2 months later due to experiencing hemoptysis of 350 mL, which occurred only once. Contrast-enhanced CT imaging revealed the presence of PAP (*Figure 1D*). Subsequently, angiography was immediately performed, and a pseudoaneurysm was shown in the right lower lobe PA (*Figure 1E*). A microcatheter (2.6 French, Masters Parkway HF; Asahi Intecc, Seto, Japan) was advanced into the pseudoaneurysm through a 5-French catheter. Seven microcoils (6/2 mm in diameter; Tornado Embolization Microcoils; Cook Medical Inc; Bloomington, IN, USA) were subsequently deployed into and proximal to the pseudoaneurysm. Repeated arteriography was performed immediately after coil embolization and revealed no further filling of the pseudoaneurysm (*Figure 1F*). The patient's clinical course was uneventful, and the patient was discharged 2 days after coil embolization without any complications. The patient was then switched to systemic chemotherapy with etoposide and cisplatin (EP), in combination with immunotherapy with programmed cell death 1 blockade of sintilimab. The patient showed no evidence of any recurrence of bleeding for more than 15 months.

Case 2

The second patient was a 67-year-old man with a 3.3-cm mass in the right lower lobe. He was identified as having small cell lung cancer via a biopsy in September 2020. He initially received chemotherapy with EP without major complications. The patient achieved a partial response. In March 2021, he exhibited local tumor progression. This prompted a change in his chemotherapy to lobaplatin and etoposide with atezolizumab beginning in April 2021. After 4 cycles of chemotherapy, he exhibited local tumor progression again. Given this, multidisciplinary consultation recommended using lung MWA to achieve local tumor control. The patient did not have any abnormal blood or coagulation function and did not receive any anticoagulant therapy.

Contrast-enhanced chest CT before the MWA revealed a 3.6-cm mass located in the posterior basal segment of the right lower lobe (*Figure 2A*). Percutaneous CT-guided MWA was performed using 2 antennae (Vision-China Medical Devices R&D Center) under local anesthesia. The needles were repeatedly repositioned (*Figure 2B*). The released power was 40 W, and the ablation duration was 13 minutes. The chest CT examination 24 hours later showed a small quantity of right pleural effusion. The patient did not report any symptoms, and he was discharged.

Three days after undergoing MWA, the patient demonstrated blood-stained sputum and developed frank blood expectoration. Contrast-enhanced chest CT was performed, which revealed a pseudoaneurysm (*Figure 2C,2D*). Subsequently, the patient was moved to the angiographic suite. Angiography revealed a pseudoaneurysm in the lower right lobe PA (*Figure 2E*). A 5-French catheter (MP A1 Performa; Merit Medical Systems, South Jordan, UT, USA) was advanced into the feeding artery. Transcatheter coil embolization from the distal to the proximal region of the parent artery was performed using 6 coils (MWCE-35-5-8; Tornado Embolization Coil; Cook Medical, Bloomington, IN, USA). Coils were first deployed at a distant location to block outflow and then delivered proximally while the catheter was pulled back to achieve full occlusion. The final arteriography demonstrated the absence of contrast flow into the pseudoaneurysm (*Figure 2F*). He was discharged with an uneventful course. No complications associated with embolization, such as pulmonary infarction, pleural effusion, or migration, were observed during the follow-up period. No evidence of recurrence of bleeding was detected 6 months after the procedure.

Discussion

We reviewed all reports on PAP complications, focusing on the features that may aid clinicians in detecting and managing these fatal events (*Table 1*). The majority of published studies were retrospective case reports.

PAP is a rare complication caused by percutaneous CT-guided thermal ablation for lung tumors. To date, PAP following CT-guided lung ablation has only been reported in 10 patients, including our 2 cases. There have been no reports of PAP resulting from transbronchial thermal ablation, which is an emerging technology for lung tumor treatment. Two previous reports showed a very low prevalence of PAP (0.15–0.2%) following lung ablation (2,3). The incidence at our institution was 0.13% (2/1,500 sessions), which was in line with the previous studies (2,3). The outcome is often unfavorable if left untreated, with a mortality rate as high as 50% (1).

PAP caused by thermal ablation is still not completely understood. The most likely causes are mechanical and thermal injuries to the PA (2,3,7). It is generally understood that structures within 0.5–1.0 cm of the tumor margin are

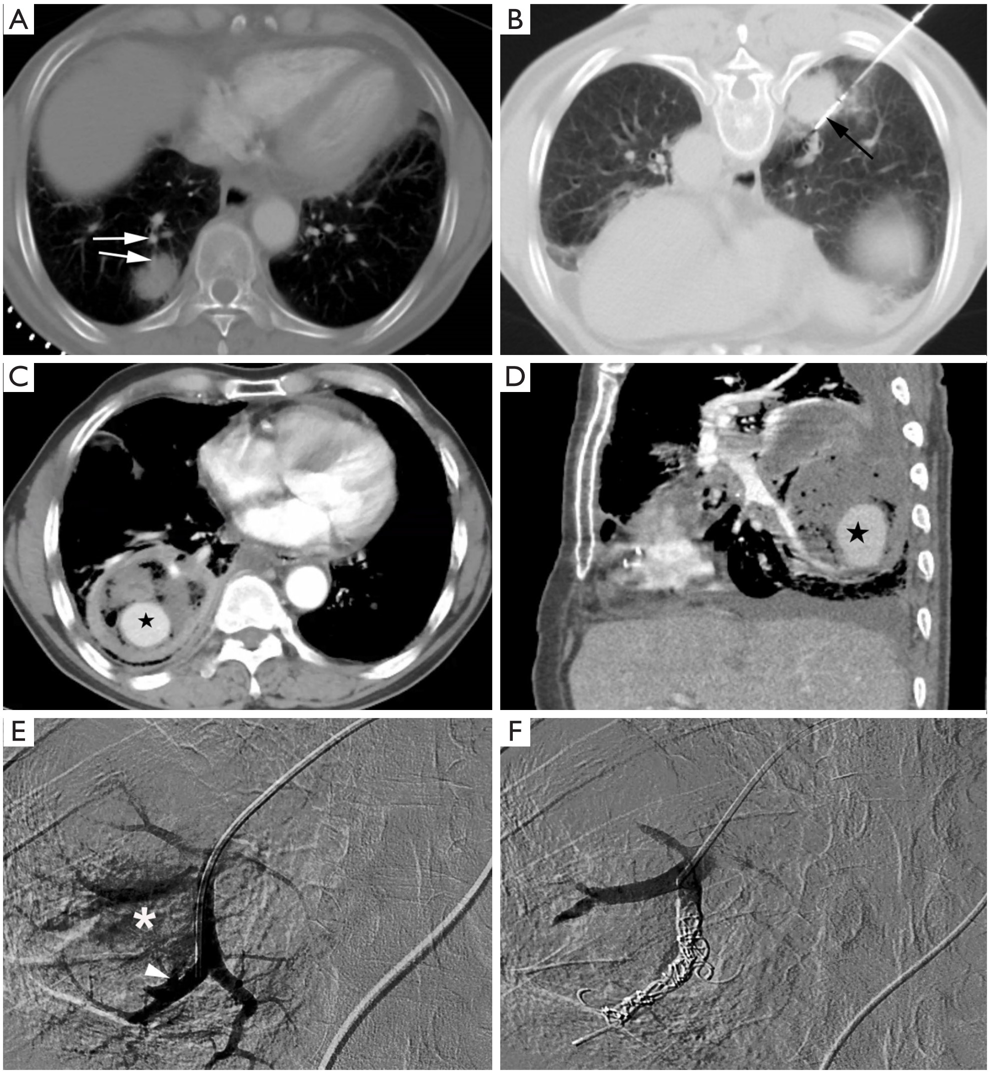

Figure 2 A 67-year-old man with small cell lung cancer. (A) The chest CT image before the MWA showed a tumor adjacent to the posterior basal segmental branch of the PA (white arrow) in the right lower lobe. (B) The chest CT image during the MWA revealed that the antenna (black arrow) penetrated the posterior basal segmental branch of the PA. (C,D) The contrast-enhanced chest CT image obtained 5 days after MWA. A pseudoaneurysm 2.8 cm in diameter (star) arising from the posterior basal segmental branch of the PA was revealed. (E) Selective arteriography showed PAP and active extravasation (asterisk). The arrowhead indicated the feeding artery. (F) Pulmonary arteriography immediately after coil embolization. Coils were placed distal and proximal to the feeding PA. The PAP was excluded successfully. CT, computed tomography; MWA, microwave ablation; PA, pulmonary artery; PAP, pulmonary artery pseudoaneurysm.

vulnerable to heat damage. In a porcine study analyzing the safety of pulmonary MWA near the heart, Carberry *et al.* (9) reported that half (17/34) of the ablations with the antenna positioned fewer than 5 mm from the heart resulted in histologic evidence of cardiac tissue injury. There is a potential risk of inducing thermal vascular injury for lung tumors adjacent to pulmonary vessels. The pulmonary arterial wall may become necrotic and fragile and cannot withstand the relatively low pressure of the PA, especially when directly piercing the vessel during the ablation (2). Both direct penetration and thermal injury to the PA branch occurred in our 2 cases.

There might be several risk factors involved in this extremely rare complication. Using multi-tines of expandable arrays for RFA is a risk factor. It was noted that expandable tines were used in 4 of the 10 reported cases.

Table 1 Literature review of case reports of pulmonary artery pseudoaneurysm after ablation

Ref.	Age/Sex	Modality	Presentation		Diagnosis		Management	Outcome	
			Symptom	Onset time	CT	Angiography		Follow-up	Rebleeding
Sakurai *et al.* (2)	57/M	RF, Le veen	MH	17 days	Yes	No	Coil embolization	20 months	No
Yamakado *et al.* (3)	75/M	RF Cool-tip	MH Hemothorax	7 days	Yes	Yes	Coil embolization	5 months	No
Soh *et al.* (5)	75/F	RF Cool-tip	Hemothorax Shock	35 h	Yes	Yes	Coil embolization and surgery	24 months	No
Hiraki *et al.* (6)	–	RF, Le veen	MH	10 days	Yes	–	–	–	–
Borghol *et al.* (7)	74 M	RF, Le veen	Hemoptysis	72 hours	Yes	No	Surgery	36 months	No
	80/M	RF, Le veen	MH	24 hours	Yes	Yes	Coil embolization	15 days, Death	Yes
Nakata *et al.* (8)	69/M	RF	Hemothorax	9 days	Yes	Yes	Coil embolization and surgery	20 months	No
Schwertner *et al.* (4)	54/M	MW Antenna	MH	4 months	Yes	Yes	Coil embolization	9 months	Yes
Current cases	53/M	MW Antenna	Hemothorax MH	2 months	Yes	Yes	Coil embolization	15 months	No
	67/M	MW Antenna	MH	3 days	Yes	Yes	Coil embolization	6 months	No

M, male; F, female; RF, radiofrequency ablation; MW, microwave ablation; MH, massive hemoptysis.

Sakurai *et al.* (2) suggested taking care to not penetrate the vessel wall with expandable tines or using straight electrodes for the prophylaxis of PAPs. Borghol *et al.* (7) showed that a long ablation duration and multiple repositionings of the electrode might be risk factors associated with PAP. They inferred that these 2 factors induced an increased risk for vessel wall injuries. In our 2 cases, direct puncture of the vessel was observed during the repositioning of the antenna. Multiple repositionings of the antenna increased the risk of accidental insertion into the branch of PA adjacent to the tumor. Theoretically, the ablation can be completed on a single point for a tumor ≤3 cm in size. Two antennae or electrodes can be applied for tumors larger than 3 cm in size to reduce the number of times the needle is repositioned. However, in practice, repeated needle placement is necessary to achieve adequate margins due to the operator's experience, different modalities, and the adjacent relationship of the tumor. Therefore, proper route planning and precise punctures are essential to avoid vascular injury.

PAPs are easy to recognize because their clinical presentation is obvious. In most reported cases, massive hemoptysis is the most common symptom. Hemoptysis can be either acute or delayed. Borghol *et al.* (7) reported that massive hemoptysis developed 24 and 72 h after RFA in their 2 cases. It should be noted that hemoptysis may occur days to months after ablation. Hemoptysis occurred 3 days and 2 months after ablation in our 2 cases. Schwertner *et al.* (4) reported a case that exhibited massive hemoptysis as late as 4 months following lung tumor MWA. Soh *et al.* (5) presented the first case of PAP that caused a massive hemothorax without apparent hemoptysis after lung RFA. Nakata *et al.* (8) also reported a case of hemothorax induced by a PAP after RFA. Therefore, referring physicians should be cautious of the possibility of this fatal complication when hemothorax is present following lung ablation.

Prompt and correct diagnosis is important to improve the prognosis. Pulmonary arteriography is the gold standard for diagnosing PAP and offers a means to perform endovascular intervention simultaneously. However, it is no longer used for simple diagnostic purposes because it is invasive and may fail to identify the PAP. Sakurai *et al.* (2) reported a case who was readmitted due to massive hemoptysis following RFA. The CT imaging revealed a small PAP (5 mm in diameter) that was not clearly visualized in subsequent pulmonary arteriography. Borghol *et al.* (7) also reported on a case of PAP after lung RFA that was revealed on emergent contrast-enhanced CT but was invisible in subsequent pulmonary angiography.

CT angiography (CTA) is currently recommended instead of pulmonary angiography for diagnosis of PAP, because it can be used to identify a PAP that would not be detectable in pulmonary arteriography. PAPs may not be detected in pulmonary arteriography because the peripheral position of the PAP, the presence of a flap of vascular tissue acting as a valve, the formation of thrombus within the sac, or the slow exchange of blood between the PA and PAP results in an insufficient amount of contrast medium filling of the pseudoaneurysm (10,11). With the rapid advances in multidetector CTA, it is easy to detect and precisely locate PAPs. Multiplanar reformations (MPRs), mainly sagittal and coronal reformations, and maximal intensity projection can provide essential information about the correct anatomic location, size, and feeding artery of PAPs. This information is crucial in devising treatment plans for endovascular treatment or surgery. If a PAP is suspected after pulmonary ablation, CTA should be performed, especially in patients with massive or prolonged hemoptysis (6). CTA is not routinely recommended immediately after pulmonary ablation to screen for potential PAP because of the rarity of PAP. However, it may be helpful to perform CTA immediately after lung ablation to detect possible PAP before it leads to fatal consequences in patients with high-risk factors, such as lesions adjacent to vessels, evidence of vascular injury, and prolonged ablation.

Prompt treatment is crucial given the high mortality rate of approximately 50% in untreated patients. Endovascular management is now the first-line treatment option for PAPs because it is less invasive, has lower morbidity and mortality, and has reduced general anesthesia complications. Endovascular treatment entails direct coil embolization, embolization of the feeding artery, or stent placement. Many embolic agents can be used for endovascular embolization, including coils, liquid embolic agents, gelatin particles, and covered stents. No consensus has been reached regarding the optimal type of embolic substances to be used for endovascular occlusion. The most widely used agent is the coil (12,13).

Transcatheter embolization with coils is a practical, effective, and safe therapeutic option. It is reported that endovascular embolization succeeds in 75% of PAP cases, with a rebleeding rate of about 20% (14). Of the 10 reported cases induced by lung ablation, 8 received transcatheter coil embolization. Embolization was successful in 6 patients, with no recurrence of bleeding. Unfortunately, the remaining 2 patients developed new massive hemoptysis after embolization, and 1 died a few hours after rebleeding while the other received a left pneumonectomy that resolved the hemoptysis.

Conclusions

PAPs are rare complications following lung tumor ablation and are associated with a high mortality rate. A PAP may result from thermal and mechanical injuries to the PA and result in fatal hemoptysis. Prompt diagnosis of a PAP requires awareness and suspicion of its clinical presentations and imaging features among clinicians. Timely management is essential for a good prognosis. Endovascular intervention with coil embolization is a safe and effective choice. Clinicians should be very cautious not to penetrate the artery to reduce the incidence of PAP caused by thermal ablation for tumors adjacent to PA branches.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-22-608/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for the publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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