Hemoptysis

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Background

Hemoptysis can be derived from various pulmonary conditions, including inflammatory and neoplastic disease. Massive hemoptysis is defined as an expectoration of blood more than 600ml in 48 hours, which may be a life threatening mainly due to asphyxiation (1). Massive hemoptysis is an emergent clinical condition for which vascular interventionalists can contribute to a treatment. Transarterial embolization is a well-accepted treatment for the management of the patients with massive hemoptysis. For the effective treatment, physicians should consider the underlining conditions, anatomy of the culprit arteries, angiographic findings, and techniques. In this lecture, essentials for the safe and effective treatment will be summarized especially focusing on the pathophysiology of hemoptysis, arterial anatomy, and embolization techniques.

Pathophysiology of hemoptysis

There can be many causes of hemoptysis (Table 1). Among them, chronic inflammatory condition is a common cause of it, including tuberculosis, aspergillosis, bronchiectasis from COPD or cystic fibrosis. These inflammatory processes recruit vascular proliferation from systemic arteries. Bronchial artery and other systemic arteries supply bronchial wall, pleura and chest wall. The fragility of the recruited arteries results to rupture. Pulmonary vascular disease, including pulmonary/bronchial arterial aneurysm, arteriovenous malformation, and iatrogenic pulmonary vascular injury, are also known as uncommon causes of massive hemoptysis. Neoplastic conditions with systemic arterial recruitment, such as the advanced lung cancer and hypervascular metastatic tumors, may also cause massive hemoptysis.

Table 1 Causes of hemoptysis

pulmonary disease	malignant tumor	cardiovascular disease	pulmonary arteriovenous malformation (PAVM)
	bronchitis		pulmonary embolism
	bronchiectasis		pulmonary hypertension
	sarcoidosis		Aortic / bronchial arterial aneurysm
	chronic obstructive pulmonary disease (COPD)		pulmonary arterial aneurysm
	pneumonia		vasculitis
	tuberculosis		aortobronchial fistula
	aspergillosis	other causes	iatrogenic
	pulmonary abscess		coagulopathy/coagulation disorder
	pneumoconiosis		trauma
	cystic fibrosis		foreign body
			congenital pulmonary or cardiovascular abnormality

Diagnosis

The detailed clinical information, including the history and laboratory data, should be evaluated prior to the treatment. The bronchoscopy can help to identify the cause and to localize the bleeding point. However, bronchoscopy often fail to identify the bleeding point caused by poor condition of patients and poor visibility due to bleeding and other inflammatory changes. The overall accuracy of the bronchoscopy for identifying the bleeding point has been reported as 40-50% (2,3). The contrast-enhanced CT is also a useful tool for identifying the bleeding point. The multiphasic CT at arterial and delayed phases is required for detection of systemic arterial bleeding. The reported accuracy of localization of the bleeding point ranges from 63 to100 % (4).

Anatomical consideration

Bronchial artery usually originates from the descending thoracic aorta between the levels of 4^{th} and 8^{th} thoracic vertebrae. The classification of the bronchial arterial branching patterns was reported by Caudwell et al (5)(figure 1). They classified the patterns into four types: right intercostobronchial trunk and two left bronchial arteries (type 1), right intercostobronchial trunk and one left bronchial artery (type 2), right intercostobronchial trunk, one right bronchial artery, and 2 left bronchial

arteries (type 3), and right intercostobronchial trunk, one right bronchial artery and 1 left bronchial artery (type 4). The reported frequencies were 40, 21, 20, and 9% respectively. The aberrant bronchial arteries arising from aortic arch, subclavian artery, brachiocephalic artery, internal mammary artery, thyro-cervical trunk, inferior phrenic artery, and pericardiophrenic artery can be uncommonly seen (6). Bronchial artery gives off branches for other organs including middle third of esophagus, diaphragm, mediastinal visceral pleura, and vasa vasorum of the aorta and pulmonary artery. Among them, most critical organs supplied by the bronchial artery are the myocardium and the spinal cord. The spinal artery may arise from the intercostal branch of the intercosto-bronchial trunk with an incidence of 10% (7). Hemoptysis may involve other non-bronchial systemic arteries, such as intercostal artery (most common), internal mammary artery, branches of thyrocervical trunk, and other subclavian or axillar arterial branches supplying chest wall. The knowledge of these vascular anatomy is essential for the safe and effective treatment.

Embolization techniques

The thoracic aortography is often useful for catheterize the bronchial artery. However, the pre-treatment assessment of the contrast-enhanced CT becomes more important than the aortography to identify the origin of the bronchial artery. For the catheterization of bronchial artery, the 4 or 5 French-sized shepherd hook, cobra, or Mikaelsson shape catheter is often used. The other catheters may also be selected for the bronchial artery having aberrant origin and other systemic arteries. The optimal size and shape should be selected based on the diameter of the descending aorta, angulation and size of the targeted artery. The patients must also be positioned to obtain a correct frontal view. The correct frontal view is required to identify the anterior spinal artery which runs longitudinally on the midline of the spine.

The digital subtraction angiogram via the bronchial artery often shows the hypervascularity with/without systemic-pulmonary shunt or pseudoaneurysm at the bleeding point (figure2). It is rare to identify the extravasation of the contrast media in about 3-10% of cases (2, 8), therefore these angiographic signs help us to suggest the possible source of the bleeding. When the abnormal angiographic findings are seen on the bronchial or other systemic arteriography, a microcatheter must be advanced as close as possible with covering the targeted artery beyond origins of normal branches. Even when the spinal artery is not visualized via the proximal contrast injection, ones should be aware that the bronchial artery possibly gives off the spinal branch which may be obscured due to the distal hypervascularity.

After the navigation of a microcatheter, embolic materials must be chosen based on the angiographic findings. In general, particle materials such as polyvinyl alcohol, gelatin sponge and microsphere are preferable to occlude the hypervascular lesion fed by multiple branches. The appropriate size of particles should be selected for the

embolization. The larger size than the abnormal branches may lead to the insufficient embolization. In contrast, the too much small size has a risk of the bronchial wall necrosis and of the pulmonary infarction or other systemic infarction due to migration of the embolic materials through the systemic-pulmonary shunt. When the bleeding is caused by the true/pseudo- aneurysm which can be selectively approached using a microcatheter, and microcoils and liquid embolic material are sometimes useful to obliterate the lesion (fig 2).

Complications

Complications related to the bronchial artery embolization are various, which occur in approximately 1-6% (9). Common and non-serious complications include chest pain, dyspnea, and fever. Of all, the most serious one is the spinal cord infarction. Other ischemic complications in non-targeted organs (e.g. pulmonary lung, abdominal organs, and extremities) may be derived by the procedure. The secure positioning of the microcatheter and the careful fluoroscopic monitoring during the procedure are mandatory.

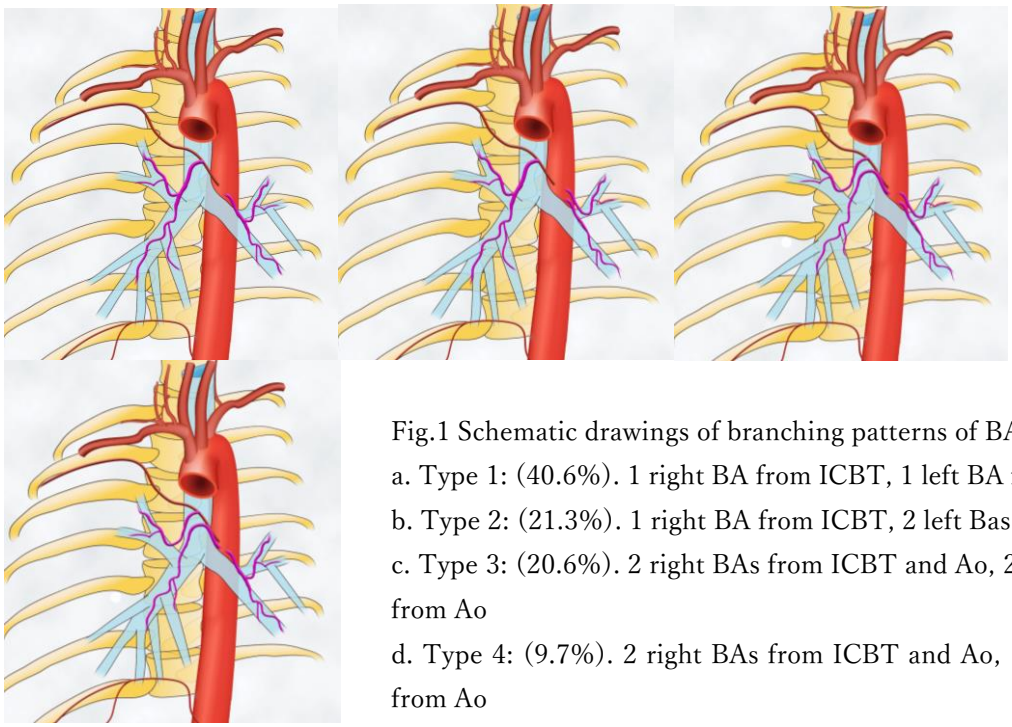
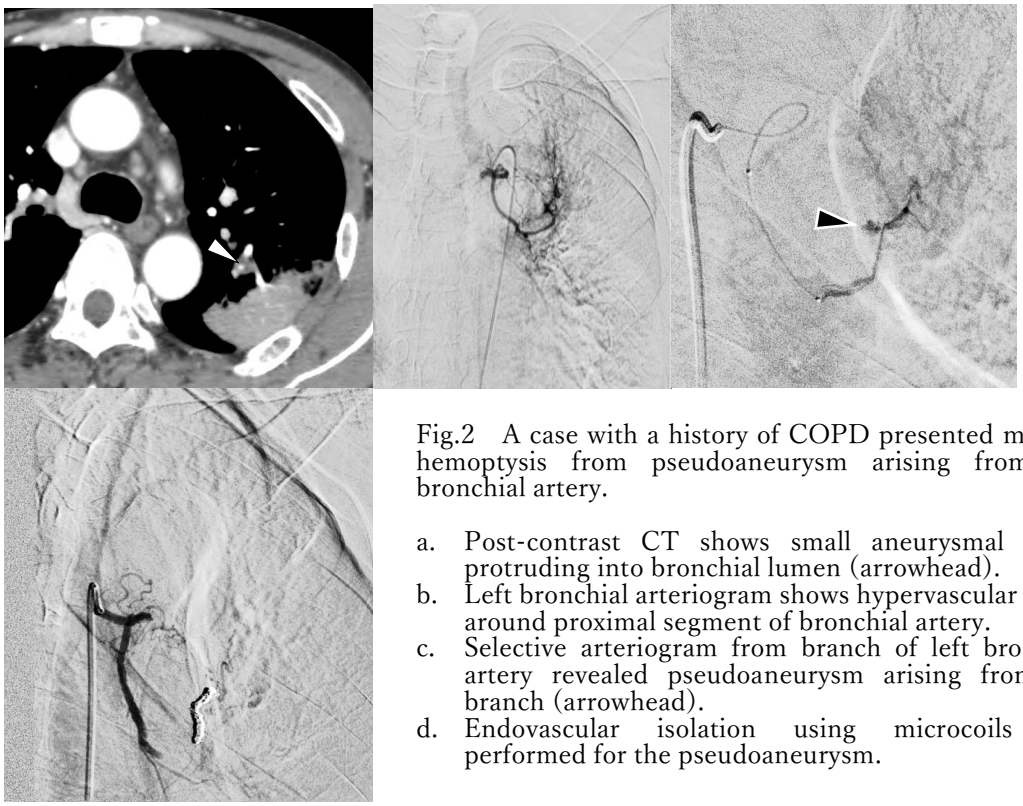


Fig.1 Schematic drawings of branching patterns of BA.
a. Type 1: (40.6%). 1 right BA from ICBT, 1 left BA from Ao
b. Type 2: (21.3%). 1 right BA from ICBT, 2 left Bas from Ao
c. Type 3: (20.6%). 2 right BAs from ICBT and Ao, 2 left BAs from Ao
d. Type 4: (9.7%). 2 right BAs from ICBT and Ao, 1 left BA from Ao



a b c
d

Fig.2 A case with a history of COPD presented massive hemoptysis from pseudoaneurysm arising from left bronchial artery.

a. Post-contrast CT shows small aneurysmal lesion protruding into bronchial lumen (arrowhead).
b. Left bronchial arteriogram shows hypervascular lesion around proximal segment of bronchial artery.
c. Selective arteriogram from branch of left bronchial artery revealed pseudoaneurysm arising from the branch (arrowhead).
d. Endovascular isolation using microcoils was performed for the pseudoaneurysm.

Conclusion

The transarterial embolization for the massive hemoptysis can provide high immediate clinical success rate. In addition, associated angiography reveals main and alternative bleeding sources such as non-bronchial systemic artery and/or pulmonary artery. For the safe and effective treatment, careful image analysis and treatment methods are required.

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